Australian Dragonfly (Odonata) Larvae: Descriptive history and identification

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Abstract


To improve the reliability of identification for Australian larval Odonata, morphological and geographic information is summarised for all species. All known references that contain information on characters useful for identification of larvae are presented in an annotated checklist. For polytypic genera information is provided to clarify whether each species can already, or cannot yet, be distinguished on morphological characters, and whether and under which conditions geographic locality is sufficient to make a diagnosis. For each species the year of original description and of first description of the larva, level of confidence in current identifications, and supportive information, are included in tabular form. Habitus illustrations of generally final instar larvae or exuviae for more than 70% of the Australian dragonfly genera are presented.

Keywords

Odonata, Australia, larvae, descriptive history, identification

Introduction

The size, colour, tremendous flight abilities and unusual reproductive behaviours of dragonflies make them one of the most attractive and conspicuous orders of insects. Larval dragonflies are aquatic and usually associated with clean water making them useful biological indicators of water quality. Thus information on the presence, abundance, diversity and reproductive ability are in high demand for assessments and modelling connected with river health, biodiversity, conservation, climate change and other environmental issues. Although flying adults are generally more likely to be encountered specific habitat data from larvae, which are confined to freshwater environments, provides extremely valuable and inclusive information on the health of aquatic ecosystems. For at least 20 years numerous nation- and state-wide, as well as regional monitoring programs have incorporated dragonfly larvae, amongst other macroinvertebrates, in their aquatic sampling protocols.

Unfortunately, while adult dragonflies can usually be reliably identified from a number of national and regional field guides and keys (e.g. Watson et al. (1993), Theischinger & Hawking (2006), Theischinger & Endersby (2009)), the situation is quite different for larvae. Although a wealth of information useful for identification of Australian odonate larvae is available, it is currently scattered throughout the literature, often in rather obscure journals. The descriptive literature on dragonfly larvae ranges from brief descriptions or line drawings of single structures in single species to comprehensive revisions (including colour photos and keys) of large taxonomic groups. The most comprehensive treatments come from Tillyard (1916a, 1926), Watson (1962), Theischinger (1982, 1998d, 2000b, 2001a, 2002, 2007a), Theischinger & Watson (1984), Hawking (1986, 1993), Hawking & Theischinger (1999) and Theischinger and Endersby (2009). However, morphological characters of larvae are more variable within single species and therefore less diagnostic than those of adults. They can also change significantly with development from early to late instars, and sometimes with habitat conditions. In addition, keys are usually constructed only for final instars and require more or less perfect and complete specimens, and some characters included in descriptions and keys have proved less consistent than originally envisaged. In monitoring programs early instar larvae are much more frequently collected than final instars. As well, the fragile larvae of zygopteran species often lose body parts during the collection process. Reliable specific identifications are rarely possible when diagnostic morphological characters are not available or when sympatric congeneric species have undescribed larvae. And even for parts of a geographic range where a species is supposedly the only member of its genus or species group, there is always a chance that we have underestimated the geographical range of other closely related species.
We have more than forty years of experience with the identification of Australian dragonfly larvae (including checking identifications in many voucher collections) and must emphasize the importance of considering the above variables when making identifications. Therefore we feel it is necessary to complement the basic descriptive information on known Australian dragonfly larvae by providing a realistic view of achieving accurate species identifications. It must be stressed here that it is the final instar (larva or exuvia) that is referred to in the literature, and that distribution-based identifications need to be treated with some caution. However the known geographical ranges of species should not be neglected when making identifications because greater reliability in identification is possible by finding larval exuviae in association with adults and by having the best possible knowledge of the regional fauna where the specimens are found.

Map 1. The regions of Australia referred to in text and table (from Watson et al. (1991). SWA = south-western Australia; SES = south-eastern South Australia; VIC = Victoria; TAS = Tasmania; SEN = south-eastern New South Wales; NEN = north-eastern New South Wales; SEQ = south-eastern Queensland; NEQ = north-eastern Queensland; CY = Cape York Peninsula; NNT = top end of Northern Territory; KIM = Kimberley region; NWA = north-western Australia; IN = inland New South Wales; SIQ = southern inland Queensland; NIQ = northern inland Queensland; IA = inland Australia.)
Methods

All known species of Australian dragonflies are listed following the family order of the World Systematic Consensus of Dijkstra et al. (2013) (with the additions of Kalkman & Theischinger (2013)), and all references that include descriptive details and/or illustrations/photos of larvae are given in chronological order, not in the order of usefulness for identifications. The reliability/difficulty of generic identifications is indicated under the family headings. Following the species of each polytypic genus/subgenus (marked with an asterisk *) a brief summary is presented of the potential for reliable specific identification. Line drawings (Figs 1-81) and colour photographs (Figs 82-94) of at least one species per family are presented followed by a table giving references for descriptive information, the basis for reliable identification of each species, the present state of knowledge and the level of confidence for species identification. We construct and present a graph that shows the chronological growth of specific descriptive information on Australian dragonfly larvae, and a summary of all information included in the paper is given. Maps 1 and 2 are taken from Watson et al. (1991) and Watson & Theischinger (1984), and distributional details are based on the dot maps in Theischinger & Endersby (2009) and additional unpublished information.

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Descriptive literature on the larvae of Australian dragonfly species, with remarks on species identification within polytypic genera

Order Odonata

Two suborders, clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

Suborder Zygoptera

Eight families, clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

Family Hemiphlebiidae

Monotypic family, distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

Hemiphlebia mirabilis Selys, 1869

Fig. 1

Tillyard (1928); Hawking (1995); Williams (1980); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.

Family Synlestidae

Three genera clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

Chorismagrion risi Morton, 1914

Fraser (1956); Theischinger et al. (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.
Figs 1-12. Final instar larvae of Australian Zygoptera: (1) *Hemiphlebia mirabilis* (Hemiphlebiidae); (2) *Synlestes weyersii* (Synlestidae); (3) *Austrolestes annulosus* (Lestidae); (4) *Diphlebia euphoeoides* (Lestoideidae); (5-8) Argiolestidae: (5) *Archiargiolestes parvulus*; (6) *Austroargiolestes icteromelas*; (7) *Griseargiolestes griseus*; (8) *Miniargiolestes minimus*; (9) *Austrosticta soror* (Isostictidae); (10) *Nososticta pilbara* (Platycnemididae); (11, 12) Coenagrionidae: (11) *Caliagrion billinghursti*; (12) *Ischnura heterosticta*. 
**Episynlestes albicauda** (Tillyard, 1913)
Theischinger *et al.* (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking *et al.* (2013).

**Episynlestes cristatus** Watson & Moulds, 1977
Fraser (1956), as *Synlestes tropicus*; Theischinger *et al.* (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Episynlestes intermedius** Theischinger & Watson, 1985
Theischinger *et al.* (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus Episynlestes* Kennedy, 1920
Specific identifications based on morphology need confirmation by distributions (Theischinger *et al.* 1993). North of Paluma-Eungella gap: *E. cristatus*; Eungella area: *E. intermedius*; south of Paluma-Eungella gap: *E. albicauda*.

**Synlestes selysi** Tillyard, 1917
Theischinger *et al.* (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Synlestes tropicus** Tillyard, 1917
Theischinger *et al.* (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009); The description of *S. tropicus* by Fraser (1956) refers to *Episynlestes cristatus*.

**Synlestes weyersii** Selys, 1869
Fig. 3
Ris (1910), as larva A; Lieftinck (1960); Watson (1962); O’Farrell (1970); Allbrook (1979); Nuttall (1982); Hawking (1986); Watson & O’Farrell (1991); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009, 2013).

*Genus Synlestes* Selys, 1869
At present specific identifications based on morphology need confirmation by distributions (Theischinger *et al.* 1993). North of Paluma-Eungella gap: *S. tropicus*; from Eungella area south to approximately 36ºS: *S. selysi/weyersii*; south of approximately 36ºS: *Synlestes weyersii*.

Family Lestidae
Three genera clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking *et al.* 2013).
Austrolestes psyche (Hagen, 1862)
Tillyard (1917a, 1717b); Lieftinck (1960); Allbrook (1979); Nuttall (1982); Hawking (1986, 1995); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009). Watson (1962) has to be referred to Austrolestes aleison.

*Genus Austrolestes* Tillyard, 1913
Morphology based identifications need geographical confirmation for two species: South-western Australia: *A. aleison*; south-eastern Australia: *A. psyche*. *A. insularis* (larva still undescribed) should be the only species across most of northern Australia (Theischinger & Endersby 2009).

Indolestes alleni (Tillyard, 1913)
Larva not yet recognized.

Indolestes obiri Watson, 1979
Larva not yet recognized.

Indolestes tenuissimus (Tillyard, 1906)
Lieftinck (1960); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Indolestes* Fraser, 1922
Morphology based identifications of *Indolestes* from north-eastern Queensland may include both *I. tenuissimus* and *I. alleni*, those from the north of Northern Territory *I. alleni* and *I. obiri* (Theischinger & Endersby 2009).

Lestes concinnus Hagen, 1862
Lieftinck (1960); Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013), as Lestes. Sole species of the genus in Australia.

Family Lestoideidae
Two genera clearly distinguishable on morphology and size (Theischinger & Hawking 2006, Theischinger & Endersby 2009, both under Diphlebiidae and Lestoideidae; Hawking et al. 2013).

Lestoidea barbara Watson, 1967
Larva probably not available

Lestoidea brevicauda Theischinger, 1996
Larva not identifiable at the present.

Lestoidea conjuncta Tillyard, 1913
Fraser (1956); Hawking (1995); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Larva not identifiable at present.

Lestoidea lewisiana Theischinger, 1996
Larva not yet recognized.

*Genus Lestoidea* Tillyard, 1913
The available descriptions by Fraser (1956); Theischinger & Hawking (2006) and Theischinger & Endersby (2009) enable firm identification of *Lestoidea* sp. only. *L. lewisiana* may be endemic to, and the only *Lestoidea* species in, the Mt Lewis area.

Diphlebia coerulescens Tillyard, 1913
Stewart (1980); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Diphlebia euphoeoides Tillyard, 1907
Fig. 4
Stewart (1980); Watson & O’Farrell (1991); Watson et al. (1991); Hawking (1995); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Diphlebia hybridoïdes Tillyard, 1912
Stewart (1980); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Diphlebia lestoides (Selys, 1853)
Tillyard (1909b, 1912, 1915a, 1917b, 1926); Stewart (1980); Williams (1980); Hawking (1986); Hawking & Smith (1997); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

Diphlebia nymphaoides Tillyard, 1912
Tillyard (1912); Stewart (1980); Hawking (1986); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus Diphlebia* Selys, 1869
On the basis of the available information on morphology (Stewart 1980) confident identifications were hitherto found impossible. *D. euphoeoides* and *D. hybridoïdes* are known only from north of the Paluma-Eungella gap; *D. coerulescens* from the Eungella area south to approximately 30ºS, whereas both *D. lestoides* and *D. nymphaoides* seem to inhabit only eastern Australia south of 24ºS, but with only *D. nymphaoides* inhabiting Carnarvon N.P. (Theischinger & Endersby 2009).

Family Argiolestidae
Five genera clearly distinguishable on morphology (Theischinger & Hawking 2006, Theischinger & Endersby 2009, both under Megapodagrionidae; Hawking et al. 2013).

Archiarigolestes parvulus (Watson, 1977)
Fig. 5

**Archiargiolestes pusillissimus** Kennedy, 1925
Theischinger (1998b).
Larva not identifiable at present.

**Archiargiolestes pusillus** (Tillyard, 1908)
Larva not identifiable at present.

*Genus* **Archiargiolestes** Kennedy, 1925

Even though larval details of all three species are available specific identifications are not possible at the present (Theischinger & Endersby 2009).

**Austroargiolestes alpinus** (Tillyard, 1913)
Larva not yet recognized.

**Austroargiolestes amabilis** (Förster, 1899)
Larva not yet recognized.

**Austroargiolestes aureus** (Tillyard, 1906)
Larva not identifiable at present.

**Austroargiolestes brookhousei** Theischinger & O’Farrell, 1986
Larva not yet recognized.

**Austroargiolestes calcaris** (Fraser, 1958)
Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013). Larva not identifiable at present.

**Austroargiolestes christine** Theischinger & O’Farrell, 1986
Larva not yet recognized.

**Austroargiolestes chrysoides** (Tillyard, 1913)
Larva not identifiable at present.

**Austroargiolestes elke** Theischinger & O’Farrell, 1986
Larva not yet recognized.

**Austroargiolestes icteromelas** (Selys, 1862)
Fig. 6
Tillyard (1917a, 1917b, 1926, 1932); O’Farrell (1970), all as Argiolestes icteromelas; Lieftinck (1976), Nuttall (1982), as Austroargiolestes sp. 1; Hawking (1986, 1995); Watson & O’Farrell (1991, 1994); Watson et al. (1991); Hawking & Smith (1997); Theischinger (1998b); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).
Larva not identifiable at present.

**Austroargiolestes isabellae** Theischinger & O’Farrell, 1986
Murray (1995); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).
Larva not identifiable at present.

*Genus* **Austroargiolestes** Kennedy, 1925

With *A. icteromelas* potentially coexisting with any other of its extremely similar congeners, generally the only confident identification appears to be *Austroargiolestes* sp. (Theischinger & Endersby 2009) even though most of the usually collected larvae belong to *A. icteromelas*.

**Griseargiolestes albsceus** (Tillyard, 1913)
Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Griseargiolestes bucki** Theischinger, 1998
Theischinger (1998c); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Griseargiolestes eboracus** (Tillyard, 1913)
Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

**Griseargiolestes fontanus** (Tillyard, 1913)
Larva not yet recognized.

**Griseargiolestes griseus** (Hagen, 1862)
Fig. 7
Tillyard (1914, 1917a), Hawking (1986), both as Argiolestes griseus; (Theischinger 1998b); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Griseargiolestes intermedius** (Tillyard, 1913)
Fig. 83
Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Griseargiolestes metallicus** (Sjöstedt, 1917)
Larva not yet recognized.
*Genus **Griseargiolestes** Theischinger, 1998

It should be easy to identify the larva of *G. metallicus* once it is found as it is the only *Griseargiolestes* species known from north of the Paluma-Eungella gap. The larva of *G. fontanus* is expected to be found most likely near springs of subtropical rainforest streams. Distributions may be needed to establish/confirm the identification of *G. griseus* and *G. intermedius* with only *G. intermedius* present in the alpine region and *G. griseus* mostly north and east of it (Theischinger & Endersby 2009).

**Miniargiolestes minimus** (Tillyard, 1908)

Fig. 8

Watson (1962), Hawking (1995), both as *Argiolestes minimus*; Theischinger (1998b); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Podopteryx selysi** (Förster, 1899)

Watson & Dyce (1978); Hawking (1995); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Family Isostictidae**

Eight genera clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

**Austrosticta fieldi** Tillyard, 1908

Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Austrosticta frater** Theischinger, 1997

Larva not yet recognized.

**Austrosticta soror** Sjöstedt, 1917

Fig. 9


*Genus **Austrosticta** Tillyard, 1908

Because of the possible sympatric existence of the three species, larvae of this genus without associated imago can only be identified as *Austrosticta* sp. (Theischinger & Endersby 2009).

**Eurysticta coolawanyah** Watson, 1969

Watson (1969); Watson et al. (1991); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Eurysticta coomalie** Watson, 1991

Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Eurysticta kununurra** Watson, 1991


**Eurysticta reevesi** Theischinger, 2001

Larva not yet recognized.

*Genus **Eurysticta** Watson, 1969

It appears that the known larvae of this genus can be identified to species in spite of the possible sympatric existence of *E. coomalie* and *E. kununurra* (Theischinger & Endersby 2009).

**Labidiosticta vallisi** (Fraser, 1955)

Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Lithosticta macra** Watson, 1991

Hawking (1993, 1995); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Neosticta canescens** Tillyard, 1913

Tillyard (1914, 1917a, 1917b); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Neosticta fraseri** Watson, 1991

Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Neosticta silvarum** (Sjöstedt, 1917)

Larva not yet recognized.

*Genus **Neosticta** Tillyard, 1913

Based on distributions, larvae from south-eastern Australia can be identified as *N. canescens*, whereas *Neosticta* larvae from north of the Paluma-Eungella gap may be the common *N. fraseri* or the more local and uncommon *N. silvarum* (Theischinger & Endersby 2009).

**Oristicta filicicola** Tillyard, 1913

Fraser (1956); Williams (1980); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.

**Rhadinosticta banksi** (Tillyard, 1913)

Hawking (1993), as *Rhadinosticta handschini*; Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Rhadinosticta simplex** (Martin, 1901)
Tillyard (1914, 1917a, 1917b, 1926); Hawking (1986), all as Isosticta simplex; Hawking (1995); Hawking & Smith (1997); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Rhadinosticta* Watson, 1991

A good generic character is the presence of 6 dark spots on the otherwise pale labium. The two species are identifiable based on morphology. Larvae from south-eastern Australia can be confirmed by distribution as *R. simplex* (Theischinger & Endersby (2009).

*Genus Selysioneura* sp.

Theischinger (2009). Sole species of the genus in Australia. It appears that only one and as yet undescribed *Selysioneura* species exists in tropical Queensland.

Family *Platycnemididae*


*Nososticta baroalba* Watson & Theischinger, 1984

Larva not yet recognized.

*Nososticta coelestina* (Tillyard, 1906)

Larva not yet recognized.

*Nososticta fraterna* (Lieftinck, 1933)

Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Nososticta kalumburu* Watson & Theischinger, 1984

Larva not yet recognized.

*Nososticta koolpinyah* Watson & Theischinger, 1984

Larva not yet recognized.

*Nososticta koongarra* Watson & Theischinger, 1984

Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Nososticta liveringa* Watson & Theischinger, 1984

Larva not yet recognized.

*Nososticta mouldsi* Theischinger, 2000

Larva not yet recognized.

*Nososticta pilbara* Watson, 1969

Fig. 10


*Nososticta solida* (Hagen, 1860)


*Nososticta solitaria* (Tillyard, 1906)

Larva not yet recognized.

*Nososticta taracumbi* Watson & Theischinger, 1984

Larva not yet recognized.

*Genus Nososticta* Hagen in Selys, 1860

Because of the sympatric existence of two or more species across much of northern Australia and rather weak characters, *Nososticta* larvae cannot be identified to the species at present except for larvae from New South Wales and Victoria that can be referred to *N. solida*, the sole *Nososticta* species occurring there (Theischinger & Endersby (2009).

Family *Coenagrionidae*

13 genera distinguishable on morphology, two of them, *Austroagrion* and *Xanthagrion*, difficult (see there), larva of *Archibasis* unknown (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

*Aciagrion fragile* (Tillyard, 1906)

Hawking (1993); Theischinger (2000a); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of the genus in Australia.

*Agriocnemis argentea* Tillyard, 1906

Larva not yet recognized.

*Agriocnemis dobsoni* Fraser, 1954

Larva not yet recognized.

*Agriocnemis femina* (Brauer, 1868)

Lieftinck (1962).

*Agriocnemis kunjina* Watson, 1969

Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Agriocnemis pygmaea* (Rambur, 1842)

Allbroook (1979); Nuttall (1982); Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).
Agriocnemis rubricauda Tillyard, 1913
Larva not yet recognized.

*Genus Agriocnemis* Selys, 1877
With the larvae of most species still undescribed, and the available larvae having few diagnostic characters, the only reliable specific identifications possible at present are *A. femina* with its range in Australia restricted to Cape York and *A. pygmaea* if collected in New South Wales (Theischinger & Endersby 2009).

Archibasis mimetes (Tillyard, 1913)
Larva not yet recognized. Sole species of the genus in Australia.

Argiocnemis rubescens Selys, 1877
Tillyard (1917a, 1917b), Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of the genus in Australia.

Austroagrion exclamationis Campion, 1915
Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Austroagrion pindrina Watson, 1969
Larva not yet recognized.

Austroagrion watsoni Lieftinck, 1982
Tillyard (1917a), Allbrook (1979), Nuttall (1982), all as Austroagrion cyane; Hawking (1986, 1993); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Austroagrion* Tillyard, 1913
The larva of *A. exclamationis* can confidently be identified. Based on morphology larvae from south-western Australia and South Australia can confidently be referred to *A. cyane*, larvae from south-eastern Australia to *A. watsoni*, and larvae from the Pilbara area in north-western Australia to *A. pindrina* (Theischinger & Endersby 2009). However, there is an overlap of *A. cyane* and *A. watsoni* in the extreme west of Victoria (Richter 2014). The diagnostic characters of *Austroagrion* (from *Xanthagriion erythroneurum*) of the median caudal gill seem to work only for final instar larvae. More distinctly ringed antennae and a narrower labium usually distinguish younger *Austroagrion* larvae from *Xanthagriion*.

Austrocnemis maccullochi (Tillyard, 1926)
Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Austrocnemis obscura Theischinger & Watson, 1991
Larva not yet recognized.

Austrocnemis splendidula (Martin, 1901)
Tillyard (1917a); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Austrocnemis* Tillyard, 1913
The larvae of *A. maccullochi* can confidently be identified based on morphology, of the remaining larvae those from eastern Australia can confidently be referred to *A. splendidula*, those from the Kimberley to *A. obscura* (Theischinger & Endersby 2009).

Austrocoenagrion lyelli (Tillyard, 1913)
Allbrook (1979), where it appears that the caudal gill is described upside down; Nuttall (1982); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013); all under *Coenagrion lyelli*. Genus monotypic.

Caliagrion billinghursti (Martin, 1901)
Fig. 11

Ceriagrion aeruginosum (Brauer, 1869)
Lieftinck (1936); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of the genus in Australia.

Ischnura aurora (Brauer, 1865)

Ischnura heterosticta (Burmeister, 1839) (Fig. 12)
Tillyard (1917a, 1917b), Watson (1962); O’Farrell (1970); Allbrook (1979); Nuttall (1982); Hawking (1986, 1993, 1995); Watson & O’Farrell (1991), Ingram et al. (1997); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

Ischnura pruinescens (Tillyard, 1906)
Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).
*Genus *Ischnura* Charpentier, 1840

Distributions do not confirm any identification based on morphology of the often sympatric species but size and morphology of final instars should be sufficient for reasonably confident identifications (Theischinger & Endersby 2009).

**Pseudagrion aureofrons** Tillyard, 1906


**Pseudagrion cingillum** (Brauer, 1869)

Larva not yet recognized.

**Pseudagrion ignifer** Tillyard, 1906

Theischinger (2000a); Theischinger & Hawking (2006); Theischinger & Endersby (2009). Reference to this species by Hawking & Theischinger (1999) probably refers to *P. microcephalum*.

**Pseudagrion jėdda** Watson & Theischinger, 1991

Larva not yet recognized.

**Pseudagrion lucifer** Theischinger, 1997

Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Pseudagrion microcephalum** (Rambur, 1842)

Lieftinck (1962); Watson *et al.* (1991); Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus *Pseudagrion* Selys, 1876:

The known larvae of the Australian *Pseudagrion* species can be confidently distinguished from each other by the combination of morphological characters and distributions. However, only *P. aureofrons, P. microcephalum* and *P. ignifer* from eastern Australia south of about latitude Rockhampton can be confidently identified because *P. cingillum* and *P. jėdda* coexist in the same areas as *P. aureofrons, P. ignifer, P. microcephalum* and *P. lucifer* in northern Australia (Theischinger & Endersby 2009) and their as yet undescribed larvae may be indistinguishable from one or two of them.

**Teinobasis rufithorax** (Selys, 1877)

Larva not yet recognized. Sole species of the genus in Australia.

**Xanthagrion erythroneurum** (Selys, 1876)

Fig. 84

Watson (1962); Allbrook (1979); Nuttall (1982); Hawking (1986, 1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.* (2013). Sole species of the genus in Australia. The diagnostic characters (from *Austroagrion*) of the median caudal gill seem to work only for final instar larvae. Less distinctly ringed antennae and a wider labium usually distinguish younger *X. erythroneurum* larvae from *Austroagrion*.

**Suborder Anisoptera**

Eight families + one group of genera incertae sedis, clearly distinguishable on morphology (Theischinger & Hawking 2006, under Epiproctophora; Theischinger & Endersby 2009, under Epiprocta; Hawking *et al.* 2013).

**Family Austropetalidae**

Two genera clearly distinguishable on morphology (Theischinger & Hawking 2006, under Archipetalidae and Austropetalidae; Theischinger & Endersby 2009; Hawking *et al.* 2013).

**Archipetalia auriculata** Tillyard, 1917

Fig. 13

Albrook (1979); Gooderham & Tsyrlin (2002); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.* (2013). Genus monotypic.

**Austropetalia annaliese** Theischinger, 2013

Larva not yet recognized.

**Austropetalia patricia** (Tillyard, 1910)

Fig. 14

Tillyard (1910a, 1916a, 1917b, 1926); Hawking (1986, 1995), has to be referred to *A. tonyana*; Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Theischinger & Tang (2012).

**Austropetalia tonyana** Theischinger, 1995


*Genus *Austropetalia* Tillyard, 1916

The easiest specific identification for *Austropetalia* larvae is by the probably exclusive distributions. North of the Hunter River: *A. annaliese* (larva as yet not available); south of the Hunter River to approximately 35ºS: *A. patricia*; south of approximately 35ºS: *A. tonyana* (Theischinger 2002; Theischinger & Endersby 2009; Theischinger & Tang 2013).
Figs 13-24. Final instar larvae/exuviae of Australian Anisoptera: (13, 14) Austropetaliidae: (13) Archipetalia auriculata; (14) Austropetalia patricia; (15-23) Aeshnidae: (15) Adversaeschna brevistyla; (16) Anax gibbosulus; (17) Austrogynacantha heterogena; (18) Dendroaeschna conspersa; (19) Acanthaeschna victoria; (20) Austroaeschna (Pulchaeschna) muelleri; (21) Austrophlebia costalis; (22) Spinaeschna tripunctata; (23) Telephlebia brevicauda; (24) Petalura hesperia (Petaluridae).
Family Aeshnidae

13 genera and several subgenera clearly distinguishable on morphology (Theischinger & Hawking 2006, under Aeshnidae and Telephlebiidae; Theischinger & Endersby 2009, under Aeshnidae, Brachytronidae and Telephlebiidae; Theischinger 2012).

Adversaeschna brevistyla (Rambur, 1842)

Fig. 15

Agyractana dirupta (Karsch, 1889)
Larva not yet recognized. Sole species of the genus in Australia.

Anaciaeschna jaspidea (Burmeister, 1839)
Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of the genus in Australia.

Anax georgius Selys, 1872
Watson & Theischinger (1987); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Anax gibbosulus Rambur, 1842
Fig. 16
Watson & Theischinger (1987); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Anax guttatus (Burmeister, 1839)
Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Anax papuensis (Burmeister, 1839)
Fig. 85
Tillyard (1916a, 1916b, 1917b, 1932); Calvert (1934); Watson (1962, 1968); Allbrook (1979); Hawking (1986, 1993, 1995), Hawking & Smith (1997); Ingram et al. (1997); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002), as Aeschna brevistyla; Theischinger (2002); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013). Up to 2006 most generally referred to as Hemianax papuensis.}

Genus Anax Leach, 1815
Morphological characters are insufficient to distinguish among species. Identifications of larvae from southern, inland and central Australia can be confirmed by distribution as A. papuensis. In northern Australia the other three species may coexist with each other (A. georgius most restricted and morphologically distinct) and A. papuensis (Theischinger 2002; Theischinger & Endersby 2009).

Austrogynacantha heterogena Tillyard, 1908
Fig. 17
Hawking (1993); Hawking & Theischinger (1999); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.

Gynacantha dobsoni Fraser, 1951
Tillyard (1916a, 1917b), as G. rosenbergi; Hawking (1993); Theischinger (2007b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Gynacantha kirbyi Krüger, 1898
Larva not yet recognized.

Gynacantha mocsaryi Förster, 1898
Fraser (1963), somewhat incorrect; Theischinger (2001c, 2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Gynacantha nourlangie Theischinger & Watson, 1991
Hawking (1993); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

Gynacantha rosenbergi Kaup, 1867
Theischinger (2007b); Theischinger & Endersby (2009). Tillyard (1916a), as G. rosenbergi described the larva of G. dobsoni.

*Genus Gynacantha Rambur, 1842
Distributions cannot be used to confirm identifications based on morphology. G. kirbyi and G. mocsaryi appear to be restricted to north-eastern Queensland, but the other more widely distributed species occur there as well (Theischinger & Endersby 2009).

Dendroaeschna conspersa (Tillyard, 1907)
Fig. 18
Tillyard (1914, 1916a, 1916b, 1917b); Hawking (1991); Hawking & Theischinger (1999); Theischinger (2002); Theischinger & Hawking (2006); Peters & Theischinger (2007); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.
*Acanthaeschna victoria* Martin, 1901

*Fig. 19*


*Antipodophlebia asthenes* (Tillyard, 1916)

Watson & Theischinger (1980); Hawking & Theischinger (1999); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.* (2013). Genus monotypic.

*Austroaeschna (Austroaeschna) christine* Theischinger, 1993


*Austroaeschna (Austroaeschna) ingrid* Theischinger, 2008

Theischinger (2008b); Theischinger & Endersby (2009).

*Austroaeschna (Austroaeschna) multipunctata* (Martin, 1901)


*Austroaeschna (Austroaeschna) obscura* Theischinger, 1982


*Austroaeschna (Austroaeschna) parvistigma* (Selys, 1883)

Tillyard (1916a), from notes only; Allbrook (1979); Theischinger (1993, 2002); Hawking (1986); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009).

*Austroaeschna (Austroaeschna) sigma* Theischinger, 1982


*Genus Austroaeschna*, Subgenus *Austroaeschna* Selys, 1883

Only *A. obscura* can be distinguished from congeners on the basis of morphology. Four more species can confidently be identified by their distributions. Eungella area: *A. christine*; south-eastern Queensland and New South Wales N of latitude Sydney: *A. sigma*; south-eastern New South Wales south of approximately 35°30’S and Victoria except for the Grampians: *A. multipunctata*; Grampians: *A. ingrid* *A. parvistigma* is the only species in Tasmania. On the mainland it may, however, coexist in places with *A. sigma*. *A. multipunctata* and *A. ingrid*. But, whereas the larvae of these three species inhabit running water often with rocky substrate, the larva of *A. parvistigma* is usually found only in swampy and boggy situations (Theischinger 2002, 2012; Theischinger & Endersby 2009).

*Austroaeschna (Glaciaeschna) flavomaculata* Tillyard, 1916


*Austroaeschna (Montiaeschna) atrata* Martin, 1901


*Austroaeschna (Montiaeschna) hardyi* Tillyard, 1917

Allbrook (1979); Theischinger (1982, 2002); Theischinger & Hawking (2006); Peters & Theischinger (2007); Theischinger & Endersby (2009).

*Austroaeschna (Montiaeschna) subapicalis* Theischinger, 1982


*Austroaeschna (Montiaeschna) tasmanica* Tillyard, 1916

Allbrook (1979); Theischinger (1982, 2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).


Of the two very similar mainland species, *A. atrata* seems to be restricted to the alpine region, whereas *A. subapicalis* may reach north into Queensland and in the south certainly reaches west to the Grampians. The two Tasmanian species can be identified based on morphology only (Theischinger 2002, 2012).

*Austroaeschna (Occidaeschna) anacantha* Tillyard, 1908

Ris (1910), as larva C; Tillyard (1916a), as *Acanthaeschna anacantha*; Watson (1962); Theischinger (1982, 2002, 2012); Watson *et al.* (1991); Theischinger & Hawking (2006); Theischinger & Endersby (2009). Subgenus monotypic. Morphology based identification can be confirmed by distribution: only south-western Australia.
Australian Dragonfly (Odonata) Larvae: Descriptive history and identification

*Austroaeschna (Petersaeschna) cooloola* Theischinger, 1991

*Austroaeschna (Petersaeschna) inermis* Martin, 1901

*Austroaeschna (Petersaeschna) pinheyi* Theischinger, 2001

*Austroaeschna (Petersaeschna) speciosa* Sjöstedt, 1917
Theischinger (1982, 2002); Hawking & Theischinger (2006); Peters & Theischinger (2007); Theischinger & Endersby (2009). Hawking & Theischinger (1999), as *A. unicornis speciosa* should be referred to *A. pinheyi* and *A. unicornis*.

*Austroaeschna (Petersaeschna) unicornis* (Martin, 1901)
Tillyard (1916a), Albrook (1979), both as *A. longissima*; Theischinger (1982, 2002, 2012); Hawking (1986); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009).

*Genus Austroaeschna*, Subgenus *Petersaeschna* Theischinger, 2012
Distributions can at least in part support identification of four of the five species. Tropical Queensland north of Paluma-Eungella gap: *A. speciosa*; inland Queensland: *A. pinheyi*; Cooloola region, Stradbroke Island and Fraser Island: *A. cooloola*; most of eastern Queensland south of Paluma-Eungella gap, eastern New South Wales, Victoria, Tasmania, South Australia: *A. unicornis*. There is no need for confirming identification of *A. inermis* on geography (Theischinger 2002, 2012).

*Austroaeschna (Pulchaeschna) eungella* Theischinger, 1993

*Austroaeschna (Pulchaeschna) muelleri* Theischinger, 1982
Fig. 20

*Austroaeschna (Pulchaeschna) pulchra* Tillyard, 1909

*Genus Austroaeschna*, Subgenus *Pulchaeschna* Peters & Theischinger, 2007
Identification of all species can be confirmed by distributions. Eungella region and Clarke Range: *A. eungella*; Carnarvon Range in southern inland Queensland: *A. muelleri*; most of eastern Australia south of Eungella area: *A. pulchra* (Theischinger 2002, 2012).

*Genus Austroaeschna* Selys, 1883
The five subgenera *Austroaeschna*, *Glaciaeschna*, *Montiaeschna*, *Occidaeschna*, *Petersaeschna* and *Pulchaeschna* are clearly separable on morphological differences (Theischinger 2012).

*Austrophlebia costalis* (Tillyard, 1907)
Fig. 21

*Austrophlebia subcostalis* Theischinger, 1996

*Genus Austrophlebia* Tillyard, 1916
Identification can be confirmed by specific distributions. North of Eungella-Paluma gap: *A. subcostalis*; south of Eungella-Paluma gap: *A. costalis* (Theischinger 2002). However, the adults of both these species fly very well, and overlap in distribution of the two species cannot completely be excluded.

*Dromaeschna forcipata* (Tillyard, 1907)

*Dromaeschna weiskei* (Förster, 1908)

*Genus Dromaeschna* Förster, 1908
Reliable identification of the two often coexisting species can be achieved based on morphology (Theischinger 1982; Theischinger & Endersby 2009).
**Notoaeschna geminata** Theischinger, 1982
Tillyard (1916a), as *N. sagittata*; Theischinger (1982, 2002); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Notoaeschna sagittata** (Martin, 1901)
Fig. 86
O’Farrell (1970); Theischinger (1982, 2002); Hawking (1986); Watson & O’Farrell (1991); Watson et al. (1991); Hawking & Smith (1997); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Notoaeschna* Tillyard, 1916
At present confident identification of the two species is possible only by their specific distributions. North of the Hunter River: *N. geminata*; south of the Hunter River: *N. sagittata* (Theischinger 2002).

**Spinaeschna tripunctata** (Martin, 1901)
Fig. 22
Theischinger (1975, 1982, 2002); Hawking (1986, 1995); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009); Hawking et al. (2013).

**Spinaeschna watsoni** Theischinger, 1982

*Genus Spinaeschna* Theischinger, 1982

**Telephlebia brevicauda** Tillyard, 1916
Fig. 23
O’Farrell (1970); Watson & O’Farrell (1991); Hawking (1986); Hawking & Theischinger (1999); Theischinger (2002); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009); Hawking et al. (2013).

**Telephlebia cyclops** Tillyard, 1916
Hawking & Theischinger (1999); Theischinger (2002); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009).

**Telephlebia godeffroyi** Selys, 1883
Tillyard (1916a); Watson & Theischinger (1980); Hawking & Theischinger (1999); Theischinger (2002); Theischinger & Hawking (2003, 2006); Peters & Theischinger (2007); Theischinger & Endersby (2009).

**Telephlebia tillyardi** Campion, 1916
Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Telephlebia tryoni** Tillyard, 1917
Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Telephlebia undia** Theischinger, 1985
Larva not yet recognized.

*Genus Telephlebia* Selys, 1883
Two ‘species groups’ can be distinguished based on the shape of the paraprocts of male final instar larvae. Geography helps specific identification (Theischinger 2002). Group A: North of Paluma-Eungella gap: *A. tillyardi*; Carnarvon N. P.: *T. undia* (but larva still undescribed); coastal south-eastern Queensland: *T. tryoni*. Group B: Coastal south-eastern Queensland: *T. cyclops*; south-eastern NSW south to approximately 35oS: *T. godeffroyi*; NSW south of 35oS and Victoria: *T. brevicauda*. Telephlebia larvae from north-eastern New South Wales may belong to either *T. cyclops* or *T. godeffroyi*.

**Family Petaluridae**
A single genus clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

**Petalura gigantea** Leach, 1815
Tillyard (1909a, 1910a, 1911a, 1917b, 1926), Schmidt (1941); Watson (1958), incorrect; Williams (1980); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Petalura hesperia** Watson, 1958
Fig. 24
Watson (1958, 1962); Williams (1980); Watson & O’Farrell (1991); Watson et al. (1991); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Petalura ingentissima** Tillyard, 1908
Andress (1998); Theischinger (2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Petalura litorea** Theischinger, 1999
Theischinger (2000a, 2002); Theischinger & Hawking (2006); Theischinger & Endersby (2009).
**Petalura pulcherrima** Tillyard, 1913
Status doubtful (Ware *et al.*, 2014).

*Genus Petalura* Leach, 1815

**Family Gomphidae**
Two subfamilies, seven genera and several subgenera clearly distinguishable on morphology (Theischinger & Hawking 2006, Theischinger & Endersby 2009, both under Gomphidae and Lindeniidae; Hawking *et al.*. 2013).

**Ictinogomphus australis** (Selys, 1873)
Figs 25, 87
Tillyard (1917b); Hawking (1993); Hawking & Smith (1997); Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.*. (2013).

**Ictinogomphus dobsoni** (Watson, 1969)
Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Ictinogomphus paulini** Watson, 1991
Larva not yet recognized.

*Genus Ictinogomphus* Cowley, 1934
Distributions largely support identifications based on morphology (Theischinger 2000b; Theischinger & Endersby 2009). Most of eastern and northern Australia: *I. australis*; Pilbara area and further west in Western Australia: *I. dobsoni*. *Ictinogomphus* larvae from the tip of Cape York may belong to either *I. australis* or *I. paulini*.

**Antipodogomphus acolythus** (Martin, 1901)
Figs 26, 88
Tillyard (1917b), as *Austrogomphus manifestus*; Fraser (1959), most probably as *A. proselythus*; Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

**Antipodogomphus dentosus** Watson, 1991
Hawking (1993); Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Antipodogomphus edentulus** Watson, 1991
Larva not yet recognized.

**Antipodogomphus hodgkini** Watson, 1969
Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Antipodogomphus neophythus** Fraser, 1958
Hawking (1993); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Antipodogomphus proselythus** (Martin, 1901)
Theischinger (2007a); Theischinger & Endersby (2009). Fraser (1959) most probably has to be referred to *A. acolythus*.

*Genus Antipodogomphus* Fraser, 1951
Confident identifications based on morphology are not possible at present. Only *A. hodgkini* has an exclusive range (Western Australia: Pilbara area), and *A. acolythus* seems to be the only species of the genus in New South Wales and Victoria (Theischinger 2000b; Theischinger & Endersby 2009).

**Armagomphus armiger** (Tillyard, 1913)
Fig. 27

**Austroepigomphus** (Austroepigomphus) *praeruptus* (Selys, 1857)
Fig. 28

**Austroepigomphus** (Xerogomphus) *gordoni* (Watson, 1962)
Watson (1962), as *Austrogomphus gordoni*; Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Austroepigomphus** (Xerogomphus) *turneri* (Martin, 1901)
Fig. 89
Hawking (1993); Theischinger (1998d, 2000b; 2004); Theischinger & Hawking (2006); Theischinger & Endersby (2009).
Figs 25-36. Final instar larvae of Australian Gomphidae: (25) Ictinogomphus australis; (26) Antipodogomphus acolythus; (27) Armagomphus armiger; (28) Austroepigomphus paeruptus; (29) Austroepigomphus (A.) australis; (30) A. (A.) cornutus; (31) A. (A.) mjobergi; (32) A. (A.) ochraceus; (33) Austroepigomphus (Pleiogomphus) amphiclitus; (34) Hemigomphus heteroclytus; (35) Odontogomphus donnellyi; (36) Zephyrogomphus lateralis.
*Genus *Austroepigomphus*, Subgenus *Xerogomphus* Watson, 1991

Distributions confirm identifications (on the basis of morphology) of the two species (Theischinger 2000b, 2004). Central and Western Australia: *A. gordoni*; north-eastern and northern Australia: *A. turneri*.

*Genus *Austroepigomphus* Fraser, 1951


*Austrogomphus* (Austrogomphus) *angelorum* Tillyard, 1913

Larva not yet recognized.

*Austrogomphus* (Austrogomphus) *arbustorum* Tillyard, 1906

Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Austrogomphus* (Austrogomphus) *australis* Dale, 1854

Fig. 29

Hawking (1986, 1995); Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Austrogomphus* (Austrogomphus) *collaris* Hagen, 1854


Fig. 30


*Austrogomphus* (Austrogomphus) *doddi* Tillyard, 1909

Larva not yet recognized.

*Austrogomphus* (Austrogomphus) *guerini* (Rambur, 1842)

O’Farrell (1970); Allbrook (1970); Hawking (1986); Watson & O’Farrell (1991); Watson *et al.* (1991); Hawking & Smith (1997), as *A. ochraceus*; Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Gooderham & Tsyrlin (2002); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

*Austrogomphus* (Austrogomphus) *mjobergi* Sjöstedt, 1917

Fig. 31

Hawking (1993); Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Austrogomphus* (Austrogomphus) *mouldsorum* Theischinger, 1999

Larva not yet recognized.

*Austrogomphus* (Austrogomphus) *ochraceus* (Selys, 1869)

Fig. 32

Tillyard (1916b, 1917b, 1926); Hawking (1986); Hawking & New (1996); Theischinger (1998d, 2000b, 2004); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

*Austrogomphus* (Austrogomphus) *pusillus* Sjöstedt, 1917

Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus *Austrogomphus*, Subgenus *Austrogomphus* Selys, 1854

The larvae of two species, *A. angelorum*, probably restricted, if still surviving, to the mature Murray River, and *A. mouldsorum*, a large species possibly endemic to the Kimberley, are still undescribed and assumed to be recognisable when found. Other than that a single species and four twin groups can confidently be separated based on morphology. Three of the twin groups are identifiable to the species by allopatry. Only *A. guerini* and *A. ochraceus* cannot be distinguished at present. Of these two only *A. guerini* is found in South Australia and Tasmania (Theischinger 2000b; Theischinger & Endersby 2009).

*Austrogomphus* (Pleiogomphus) *amphiclitus* (Selys, 1873)

Fig. 33

Theischinger (1998d, 2000b, 2004); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Austrogomphus* (Pleiogomphus) *bifurcatus* Tillyard, 1909

Theischinger (1998d, 2000b, 2004); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Austrogomphus* (Pleiogomphus) *divaricatus* Watson, 1991

Larva not available or inseparable from *A. bifurcatus*.

*Austrogomphus* (Pleiogomphus) *prasinus* Tillyard, 1906

Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Of the four species only *A. amphiclitus* can confidently be identified on morphology, and it is also the only species found over much of eastern and inland Queensland and New South Wales, whereas the other three species are apparently restricted to north-eastern Queensland (Theischinger 2000b; Theischinger & Endersby 2009).

*Genus *Austrogomphus* Selys, 1854

The larvae of the two subgenera *Austrogomphus* and *Pleiogomphus* are clearly separable on morphological differences (Theischinger 2000b; Theischinger & Endersby 2009).

**Hemigomphus atratus** Watson, 1991

Larva not yet recognized.

**Hemigomphus comitatus** (Tillyard, 1909)

Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Hemigomphus coooola** Watson, 1991

Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Hemigomphus gouldii** (Selys, 1854)

Williams (1980); Hawking & New (1996); Hawking & Smith (1997); Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

**Hemigomphus heteroclytus** Selys, 1854

Figs 34, 90

Tillyard (1910a, 1914, 1916b, 1917b); Hawking (1986); Theischinger (1998d, 2000b); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Hemigomphus magela** Watson, 1991

Hawking (1993); Theischinger (1998d, 2000b); Theischinger & Hawking (2006); Peters & Theischinger (2007); Theischinger & Endersby (2009).

**Hemigomphus theischingeri** Watson, 1991


*Genus *Hemigomphus* Selys 1854

*H. coooola* and *H. magela* have characters different from the morphologically rather uniform remaining species. In addition *H. magela* has a restricted geographical range within the Northern Territory, whereas *H. atratus* (larva still unknown), *H. comitatus* and *H. theischingeri* are restricted to north-eastern Queensland and *H. gouldii* and *H. heteroclytus* are more or less confined to south-eastern Australia. Only *H. heteroclytus*, the only *Hemigomphus* occurring in southern inland Queensland, slightly overlaps the range of the three north-eastern species (Theischinger 2000b; Theischinger & Endersby 2009).

**Odontogomphus donnellyi** Watson, 1991

Fig. 35


**Zephyrogomphus lateralis** (Selys, 1873)

Fig. 36

Watson (1962), as *Austrogomphus lateralis*; Theischinger (1998d, 2000b); as *Austrogomphus (Zephyrogomphus) lateralis*; Theischinger (2004); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

**Zephyrogomphus longipositor** (Watson, 1991)


*Genus *Zephyrogomphus* Watson, 1991

Widely disjunct distributions confirm identification based on morphology of the two species (Theischinger 2000b; Theischinger & Endersby 2009).

**Family Synthemistidae**

Eight genera distinguishable on morphology, two of them, *Chorisithemis* and *Eusynthemis* difficult (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

**Archaeosynthemis leachii** (Selys, 1871)

Fig. 37

Watson (1967); Watson et al. (1991); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

**Archaeosynthemis occidentalis** (Tillyard, 1910)

Figs 37-48. Final instar larvae of Australian Anisoptera: (37-44) Synthemistidae (with insert of frontal plate): (37) Archaeosynthemis leachi; (38) Austrosynthemis cyanitincta; (39) Choristhemis flavoterminata; (40) Eusynthemis ursula; (41) Parasynthemis regina; (42) Synthemiopsis gomphomacromioides; (43) Synthemis eustalacta; (44) Tonyosynthemis claviculata; (45) Macromia tillyardi (Macromiidae); (46-48) Corduliidae: (46) Hemicordulia tau; (47) Pentathemis mebranulata; (48) Procordulia jacksoniensis.
Archaeosynthemis orientalis (Tillyard, 1910)

Archaeosynthemis spiniger (Tillyard, 1913)

*Genus Archaeosynthemis Carle, 1995
Confident identifications based on morphology can be achieved for the three south-western Australian species S. leachii, S. occidentalis and S. spiniger; S. orientalis is the only species from south-eastern Australia (Theischinger 2001a; Theischinger & Endersby 2009).

Austrosynthemis cyanitincta (Tillyard, 1908)
Fig. 38

Choristhemis flavoterminata (Martin, 1901)
Fig. 39
Tillyard (1910b); Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

Choristhemis olivaei (Tillyard, 1909)
Theischinger (2003); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus Choristhemis Tillyard, 1910
Confident morphology based identifications should be possible (Theischinger 2001a, 2003), but all larvae from south of the Daintree River, certainly from south of the Paluma-Eungella gap, can be confirmed as C. flavoterminata.

Eusynthemis aurolineata (Tillyard, 1913)
Theischinger (1998e); Hawking & Theischinger (1999); Theischinger (2001); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Eusynthemis barbara (Moulds, 1985)
Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Eusynthemis brevistyla (Selys, 1871)
Hawking (1986, 1995); Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

Eusynthemis deniseae Theischinger, 1977
Theischinger (1977, 2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Eusynthemis guttata (Selys, 1871)
Theischinger (1995, 1998e, 2001a); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009). Tillyard (1910b) and Hawking (1986) have to be referred to E. tillyardi.

Eusynthemis netta Theischinger, 1999
Larva not yet recognized.

Eusynthemis nigra (Tillyard, 1906)
Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

Eusynthemis rentziana Theischinger, 1998
Theischinger (1998e; 2001a); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).

Eusynthemis tenera Theischinger, 1995
Larva not yet recognized.

Eusynthemis ursa Theischinger, 1999
Larva not yet recognized.

Eusynthemis ursula Theischinger, 1998
Fig. 40
Theischinger (2000a, 2001a); Theischinger & Hawking (2000, 2006); Theischinger & Endersby (2009).

Eusynthemis virgula (Selys, 1874)
Fig. 91
Hawking (1986); Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009).
*Genus *Eusynthemis* Förster, 1903

Based on the morphology of the described larvae three groups can be distinguished: *E. ursula*; *E. brevistyla* and *E. virgula*; the remaining species (Theischinger 2001a; Theischinger & Endersby 2009). It is supposed that *E. ursa* (larva still undescribed) will closely resemble *E. ursula* and that *E. netta*, the adults of which are quite distinct, will be recognisable when found. Firm geographical support for specific identification is not available but the specific ranges (Theischinger 2001a; Theischinger & Endersby 2009) should be looked at when morphology based results appear doubtful.

*Parasynthemis regina* (Selys, 1874)

Fig. 41

Tillyard (1910b), Hawking (1986), both as *Synthemis regina*; Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.

*Synthemiopsis gomphomacromioides* Tillyard, 1917

Fig. 42

Theischinger (2000d, 2001a); Gooderham & Tsyrlin (2002), as *Synthemiopsis*; Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Tillyard (1917b), Allbrook (1979), both to be referred to a different synthemistid species. Genus monotypic.

*Synthemis eustalacta* (Burmeister, 1839)

Fig. 43

Tillyard (1910b, 1917b, 1926); O’Farrell (1970); Williams (1980); Hawking (1986); Watson & O’Farrell (1991, 1994); Hawking & Smith (1997); Hawking & Theischinger (1999); Theischinger (2001a, 2010); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Synthemis tasmanica* Tillyard, 1910

Allbrook (1979); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus Synthemis* Selys, 1870

Confirmation of morphology based specific identification by available distributions (Theischinger 2001a; Theischinger & Endersby 2009). Mainland Australia: *S. eustalacta*; Tasmania: *S. tasmanica*. However, *Synthemis* larvae from the west of Victoria and eastern South Australia agree with *S. tasmanica* and may well be this species.

*Tonyosynthemis claviculata* (Tillyard, 1909)

Fig. 44

Theischinger 1998a, 2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Tonyosynthemis ofarrelli* (Theischinger & Watson, 1986)

Theischinger (1998a, 2001a, 2010); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Tonyosynthemis* Theischinger, 1998


Family *Macromiidae*

Only a single genus clearly distinguishable on morphology (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

*Macromia tillyardi* Martin, 1906

Fig. 45

Hawking (1993); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Macromia viridescens* Tillyard, 1911

Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus Macromia* Rambur, 1842

Identifications are reliable based on morphology (Theischinger 2001). It seems clear that *M. viridescens* is restricted to Cape York peninsula but existence there of *M. tillyardi* cannot be excluded.

Family *Corduliidae*

Four genera clearly distinguishable on morphology (Theischinger & Hawking 2006, under Corduliidae and Hemicorduliidae; Theischinger & Endersby 2009; Hawking et al. 2013).

*Hemicordulia australiae* (Rambur, 1842)

Watson (1962), O’Farrell (1970); Allbrook (1979); Williams (1980), Hawking (1986); Watson & O’Farrell (1991); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Hemicordulia continentalis* Martin, 1907

Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Hemicordulia flava* Theischinger & Watson, 1991

Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).
**Hemicordulia intermedia** (Selys, 1871)
Hawking (1993); Hawking & Theischinger (1999); Theischinger & Fleck (2003); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).

**Hemicordulia kalliste** Theischinger & Watson, 1991
Larva not yet recognized.

**Hemicordulia koomina** Watson, 1969
Theischinger & Hawking (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

**Hemicordulia superba** Tillyard, 1911
Hawking & Theischinger (1999); Hawking & Theischinger (2006); Theischinger (2007a); Theischinger & Endersby (2009).

**Hemicordulia tau** (Selys, 1871)
Fig. 46
Tillyard (1914, 1915b, 1916b, 1917b, 1926, 1932); Watson (1962, 1968); O’Farrell (1970); Allbrook (1979); Williams (1980); Hawking (1986, 1993, 1995); Watson & O’Farrell (1991); Watson et al. (1991); Hawking & Smith (1997); Ingram et al. (1997); Hawking & Theischinger (1999); Goodeham & Tsyrlin (2002); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Hemicordulia* Selys, 1870
The larvae of each of *H. australiae*, *H. flava* and *H. superba* can be identified based on morphology (Theischinger 2007a). Of the morpho-group *H. intermedia* and *H. koomina* only *H. intermedia* has a wide geographical range including northern, central and much of eastern Australia so that only identifications from the Pilbara area are doubtful. Of the morpho-group *H. tau*, *H. continentalis* and *H. kalliste* it appears that *H. kalliste* is the only species at, and restricted to, the extreme north of Australia, whereas *H. tau* is the only one occurring in Western Australia, central and most of southern Australia.

**Metaphya tillyardi** Ris, 1913
Larva not yet recognized. Sole species of the genus in Australia. Some information on the larva of *M. elongata* Campion, 1921, made available by Fleck (2007) is produced by Theischinger & Endersby (2009) in order to give an idea of what the still undescribed larva of *M. tillyardi* may look like.

**Pentathemis membranulata** Karsch, 1890
Fig. 47
Hawking (1993); Young (2001); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.

**Procordulia affinis** (Selys, 1871)
Watson (1962); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

**Procordulia jacksoniensis** (Rambur, 1842)
Fig. 48
O’Farrell (1970); Allbrook (1979); Hawking (1986, 1993); Watson & O’Farrell (1991); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Procordulia* Martin, 1907

Identifications of the two species based on morphology are confirmed beyond any doubt by their widely disjunct distributions (Theischinger 2007a). Southwestern Australia: *P. affinis*; eastern Australia and South Australia: *P. jacksoniensis*.

**Family Libellulidae**

Of 27 genera four, *Crocothemis*, *Diplacodes*, *Nannodiapax* and *Neurothemis*, are difficult to distinguish from each other, and of two, *Notolbellula* and *Raphismia*, the larvae are still undescribed (Theischinger & Hawking 2006, under Urothemistidae and Libellulidae; Theischinger & Endersby 2009; Hawking et al. 2013).

**Aethriamanta circumsignata** Selys, 1897
Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013), as *Aethriamanta*.

**Aethriamanta nymphaeae** Lieftinck, 1949
Fig. 49
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Genus Aethriamanta* Kirby, 1889
The known morphological characters (Hawking 1993) appear insufficient to distinguish the two species. Only *A. circumsignata* has hitherto been found to occur in New South Wales (Theischinger 2007a; Theischinger & Endersby 2009).

**Agrionoptera insignis allogenes** Tillyard, 1908
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Genus Agrionoptera* Kirby, 1889

The known morphological characters (Hawking 1993) appear insufficient to distinguish the two species. Only *A. insignis* has hitherto been found to occur in New South Wales (Theischinger 2007a; Theischinger & Endersby 2009).

**Agrionoptera longitudinalis biserialis** Selys, 1879
Fig. 50
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

**Agrionoptera insignis allogenes** Tillyard, 1908
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

**Agrionoptera longitudinalis biserialis** Selys, 1879
Fig. 50
Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).
Figs 49-60. Final instar larvae of Australian Libellulidae: (49) Aethriamanta nymphaeae; (50) Agrionoptera longitudinalis; (51) Austrothemis nigrescens; (52) Brachydiplax denticauda; (53) Camacinia gigantea; (54) Crocothemis nigrifrons; (55) Diplacodes haematodes; (56) Huonia melvillensis; (57) Hydrobasisleus brevistylius; (58) Macrodiplax cora; (59) Nannodiplax rubra; (60) Nannophlebia risi.
*Genus *Agrionoptera* Brauer, 1854

The two species can confidently be identified based only on morphology. Only *A. insignis* ranges south and west beyond tropical Queensland (Theischinger 2007a; Theischinger & Endersby 2009).

*Austrothemis nigrescens* (Martin, 1901)

Fig. 51

Watson (1962); Allbrook (1979); Hawking (1986); Hawking & Smith (1997); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Genus monotypic.

*Brachydiplax denticauda* (Brauer, 1867)

Fig. 52

Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

*Brachydiplax duivenbodei* (Brauer, 1866)

Larva not yet recognized.

*Genus Brachydiplax* Brauer, 1868

Only *Brachydiplax* larvae from south of the Paluma-Eungella gap can with high probability be confirmed as *B. denticauda* (Theischinger 2007a).

*Camacinia othello* Tillyard, 1908

(Fig. 53, *C. gigantea*)

Larva not yet recognized. Sole species of *Camacinia* in Australia. It is assumed that the larva of *C. othello* will be found to be very similar to its closely related congener *C. gigantea* which should be used as a substitute to allow identification of *C. othello* in future (Theischinger & Hawking 2006; Theischinger & Endersby 2009; Hawking et al. 2013).

*Crocothemis nigrifrons* (Kirby, 1894)

Fig. 54

Watson (1962); Hawking (1986, 1993); Hawking & Smith (1997); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Crocothemis* in Australia. Difficult to distinguish from *Diplacodes, Nannodiplax* and *Neurothemis*.

*Diplacodes bipunctata* (Brauer, 1865)

Tillyard (1917b, 1926); Lief tinck (1962); Watson (1962); O’Farrell (1970); Hawking (1986, 1993); Watson & O’Farrell (1991); Watson et al. (1991); Rowe (1992); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Diplacodes haematodes* (Burmeister, 1839)

Fig. 55

Tillyard (1914, 1916b, 1917b); Watson (1962); Williams (1980); Hawking (1986, 1993); Hawking & New (1996); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Diplacodes melanopsis* (Martin, 1901)

Hawking (1986); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

*Diplacodes nebulosa* (Fabricius, 1793)

Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Diplacodes trivialis* (Rambur, 1842)

Lief tinck (1962); Kumar (1977); Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Genus Diplacodes* Kirby, 1889

Morphological differences separate either of *D. haematodes* and *D. melanopsis* from the remainder of this genus and from *Nannodiplax rubra*, whereas *D. bipunctata* morphologically pairs up with *D. trivialis* and *D. nebulosa* pairs up with *N. rubra*. Confident identifications can be achieved for only *D. bipunctata* from Western Australia, central and southern Australia and *N. rubra* from the Kimberley (Theischinger 2007a; Theischinger & Endersby 2009).

*Huonia melvillensis* Brown & Theischinger, 1998

Fig. 56

Theischinger & Brown (2002); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Huonia* in Australia.

*Hydrobasileus brevistylus* (Brauer, 1865)

Fig. 57

Fraser (1963); Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Hydrobasileus* in Australia.

*Lathrecista asiatica festa* (Selys, 1879)

Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009). The larva referred to in these three papers was identified by supposition only. Sole species of *Lathrecista* in Australia.

*Macrodiplax cora* (Kaup, 1867)
Fig. 58
Lieftinck (1962); Watson (1962); Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of Macrodiplax in Australia.

*Nannodiplax rubra* Brauer, 1868
Fig. 59
Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009). Genus monotypic. Larva at present indistinguishable from Diplacodes nebulosa, but can be identified if found in the Kimberley (see under Genus Diplacodes).

*Nannophlebia eludens* Tillyard, 1908
Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Nannophlebia injibandi* Watson, 1969
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Nannophlebia mudginberri* Watson & Theischinger, 1991
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Nannophlebia risi* Tillyard, 1913
Fig. 60
Tillyard (1913); Hawking (1986, 1995); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Nannophlebia* Selys, 1878
Distributions confirm *Nannophlebia* larvae from New South Wales and Victoria as *N. risi*. Larvae from north-eastern Australia may be either *N. risi* or *N. eludens*, whereas larvae from northern and Western Australia may be either *N. eludens*, *N. injibandi* or *N. mudginberri* (Theischinger 2007a; Theischinger & Endersby 2009).

*Nannophya australis* Brauer, 1865
Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007); Theischinger & Endersby (2009).

*Nannophya dalei* (Tillyard, 1908)
Fig. 92
Allbrook (1979); Hawking (1986); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

*Nannophya occidentalis* (Tillyard, 1908)
Watson (1962); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Nannophya paulsoni* Theischinger, 2003
Larva not yet recognized.

*Nannophya* sp.
Fig. 61
Status uncertain; known only from larvae from near Barcaldine, Queensland.

*Genus Nannophya* Rambur, 1842
Distributions confirm most of the identifications based on morphology (Theischinger 2007a). Larvae from the very north of Australia may belong to either *N. australis* or *N. paulsoni* (larva still undescribed).

*Neurothemis oligoneura* Brauer, 1867
Larva not yet recognized.

*Neurothemis stigmatizans* (Fabricius, 1775)
Fig. 62
Lieftinck (1962); Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Difficult to distinguish from Crocothemis, Diplacodes and Nannodiapix.

*Genus Neurothemis* Brauer, 1867
*Neurothemis* larvae from the very north of Australia may belong to either *N. stigmatizans* or to *N. oligoneura*, but only *N. stigmatizans* occurs in the Kimberley and in south-eastern Queensland and north-eastern New South Wales (Theischinger 2007a).

*Notilibellula bicolor* Theischinger & Watson, 1977
Larva not yet recognized. Genus monotypic.

*Orthetrum balteatum* Lieftinck, 1933
Hawking & Theischinger (2002); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009). The larva was identified by supposition only.

*Orthetrum boumiera* Watson & Arthington, 1978
Watson & Arthington (1978), with error as pointed out in Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009).
Figs 61-72. Final instar larvae of Australian Libellulidae: (61) *Nannophya* sp. (from Barcaldine); (62) *Neurothemis stigmatizans*; (63) *Orthetrum caledonicum*; (64) *Pantala flavescens*; (65) *Potamarcha congener*; (66) *Rhodothemis lieftincki*; (67) *Rhyothemis princeps*; (68) *Tetrathemis irregularis*; (69) *Tholymis tillarga*; (70) *Tramea stenoloba*; (71) *Urothemis aliena*; (72) *Zyxomma elgneri*. 
Orthetrum caledonicum (Brauer, 1865)
Figs 63, 93
Tillyard (1916b, 1917b); Watson (1962); O'Farrell (1970); Watson & Arthington (1978); Hawking (1986, 1993, 1995); Watson & O'Farrell (1991); Hawking & New (1996); Hawking & Smith (1997); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger & Endersby (2009); Hawking et al. (2013).

Orthetrum migratum Lieftinck, 1951
Watson & Arthington (1978); Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

Larva not identifiable at present.

Orthetrum sabina (Drury, 1770)
Needham (1904); Watson & Arthington (1978); Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

Orthetrum serapia Watson, 1984
Larva not yet recognized.

Orthetrum villosovittatum (Brauer, 1868)

*Genus Orthetrum* Newman, 1833
Distributions confirm identifications on morphological basis from New South Wales and Victoria as *O. sabina* and *O. villosovittatum* and from north-western Australia as *O. migratum*. Larvae from northern Australia identified based on morphology as *O. sabina* may belong to either *O. sabina* or *O. serapia*. *O. caledonicum* can also be confidently identified if the larvae do not come from coastal south-eastern Queensland and coastal north-eastern New South Wales where *O. boumiera* occurs in dune situations (Theischinger 2007a).

Pantala flavescens (Fabricius, 1798)
Fig. 64
Cabot (1890), Lieftinck (1962); Watson (1962); Hawking (1993); Hawking & Ingram (1994); Hawking & Smith (1997); Hawking & Theischinger (1999); Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Pantala* in Australia.

Potamarcha congener (Rambur, 1842)
Fig. 65
Kumar (1977); Van Tol (1992); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Potamarcha* in Australia.

Raphismia bispina (Hagen, 1867)
Larva not yet recognized. Sole species of *Raphismia* in Australia.

Rhodothemis lieftincki Fraser, 1954
Fig. 66
Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Rhodothemis* in Australia.

Rhyothemis braganza Karsch, 1890
Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

Rhyothemis graphiptera (Rambur, 1842)
Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

Rhyothemis phyllis (Sulzer, 1776)
Lief tinck (1962); Hawking & Theischinger (1999); Theischinger (2000a, 2007a); Theischinger & Endersby (2009).

Rhyothemis princeps Kirby, 1894
Fig. 67
Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

Rhyothemis resplendens Selys, 1878
Larva not yet recognized.

*Genus Rhyothemis* Hagen, 1867
Larvae from tropical Queensland identified as either *R. braganza*, *R. graphiptera*, *R. phyllis* or *R. princeps* may belong to *R. resplendens* the larva of which is still undescribed, whereas *Rhyothemis* larvae collected outside of tropical Queensland can confidently be identified on morphology (Theischinger 2007a).

Tetrathemis irregularis cladophila Tillyard, 1908
Fig. 68
Theischinger & Fleck (2003); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of *Tetrathemis* in Australia.
Theischinger & I. Endersby

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Tholymis tillarga (Fabricius, 1798)

Fig. 69

Lieftinck (1962); Hawking (1993); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of Tholymis in Australia

Tramea eurybia Selys, 1878

Larva not yet recognized.

Tramea loewii Kaup, 1866

Tillyard (1917b, 1926); Hawking (1986, 1993), all as Trapezostigma loewii; Theischinger & Hawking (2003, 2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

Tramea propinqua Lieftinck, 1942

Lieftinck (1962); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

Tramea stenoloba (Watson, 1962)

Fig. 70

Watson (1962), Hawking (1993), both as Trapezostigma stenoloba; Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

Larva not identifiable at present.

*Genus Tramea Hagen, 1861

Distributions confirm only identification of Tramea larvae from southern New South Wales and Victoria as T. loewii. Tramea larvae from north-eastern New South Wales may belong to either T. loewii or T. eurybia, from inland (including northern) and Western Australia either to T. loewii or T. stenoloba, whereas all four Tramea species may have to be considered in north-eastern Australia (Theischinger 2007a).

Urothemis aliena Selys, 1878

Fig. 71

Hawking (1993); Burwell & Theischinger (2003); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013). Sole species of the genus in Australia.

Zyxomma elgneri Ris, 1913

Fig. 72

Hawking (1993); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009); Hawking et al. (2013).

Zyxomma multinervorum Carpenter, 1897

Larva not yet recognized.

Zyxomma petiolatum Rambur, 1842

Lieftinck (1962); Hamada & Inoue (1985), not conforming to Lieftinck (1962); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Genus Zyxomma Rambur, 1842

The larva of Z. multinervorum is still unknown and non-conforming descriptive information is available for Z. petiolatum. All three species inhabit northern Queensland and Northern Territory, but only Zyxomma elgneri occurs in southern Queensland, New South Wales and north-western Australia (Theischinger 2007a).

Genera Incertae Sedis

Nine genera clearly distinguishable on morphology; several very distinct units distinguishable but without general taxonomic recognition (Theischinger & Hawking 2006, under Gomphomacromiidae, Pseudocorduliidae, Austrocorduliidae, Cordulephyidae and Oxygastridae; Theischinger & Endersby 2009, under Gomphomacromiidae, Pseudocorduliidae, Austrocorduliidae and Cordulephyidae; Hawking et al. 2013).

Archaeophya adamsi Fraser, 1959

Fig. 73

Theischinger & Watson (1984); Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

Archaeophya magnifica Theischinger & Watson, 1978

Theischinger (1978), as Gomphomacromiinae sp.; Williams (1980), as Archaeophya; Theischinger & Watson (1984); Hawking (1995); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

*Genus Archaeophya Fraser, 1959

Identifications based on morphology can be confirmed by the widely disjunct distributions (Theischinger 2001a). Tropical Queensland: A. magnifica; greater Sydney area: A. adamsi. (Theischinger et al. 2011)

Pseudocordulia circularis Tillyard, 1909

Fig. 94

Larva not identifiable/?available.

Pseudocordulia elliptica Tillyard, 1913

Fig. 94

Larva not identifiable/?available.
Figs 73-81. Final instar larvae of Australian Libelluloidea of genera incertae sedis: (73) Archaeophya adamsi; (74) Cordulephya pygmaea; (75) Apocordulia macrops; (76) Austrocordulia leonardi; (77) Austrophya mystica; (78) ?Austrophya sp.; (79) Hesperocordulia berthoudii; (80) Lathrocordulia metallica; (81) Micromidia convergens.
*Genus *Pseudocordulia* Tillyard, 1909

Watson (1982), Theischinger & Watson (1984), Theischinger (2001a, 2010), Theischinger & Hawking (2006), Theischinger & Endersby (2009), Hawking *et al.* (2013), all as *Pseudocordulia* sp. The adults of the two *Pseudocordulia* species are extremely similar, and apparently the two species usually coexist (Theischinger & Watson 1978). Specific identification will probably be difficult even when larvae associated with adults of both species become available.

*Cordulephya bidens* Sjöstedt, 1917

Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Cordulephya divergens* Tillyard, 1917

Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Cordulephya montana* Tillyard, 1911

Tillyard (1911b, 1917b); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a); Theischinger & Endersby (2009).

*Cordulephya pygmaea* Selys, 1870

Fig. 74

Tillyard (1911b, 1914, 1916b, 1917b); Williams (1980); Hawking (1986); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger (2007a, 2010); Theischinger & Endersby (2009); Hawking *et al.* (2013).

*Genus *Cordulephya* Selys, 1870

*Cordulephya* larvae identified from north of the Paluma-Eungella gap can be confirmed by distribution as *C. bidens*. *C. pygmaea* is probably the only species in Queensland south of the Paluma-Eungella gap (Theischinger 2007a). *C. pygmaea*, *C. divergens* and *C. montana* may coexist in south-eastern Australia and distinguishing *C. pygmaea* from *C. divergens/ montana* from there is difficult and often doubtful. Separating larvae of *C. divergens* and *C. montana* is not possible at present.

*Apocordulia macrops* Watson, 1980

Fig. 75


Genus monotypic.

*Genus Austrocordulia* Tillyard, 1909

Fig. 76


*Austrocordulia leonardi* Theischinger, 1973

Theischinger (1973, 2001a, 2010); Theischinger & Watson (1984); Hawking & Theischinger (1999); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Theischinger *et al.* (2009).

*Austrocordulia refracta* Tillyard, 1909


*Austrocordulia territoria* Theischinger & Watson, 1978

Theischinger & Watson (1984); Hawking (1993); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.* (2013).

*Genus* *Austrocordulia* Tillyard, 1909

A significant disjunction exists between the ranges of *A. territoria* (north of Northern Territory) and *A. leonardi* (eastern New South Wales). A disjunction also exists between the ranges of *A. territoria* and *A. refracta* (eastern Australia) which in eastern New South Wales coexists in places with *A. leonardi*. However, exclusive geographical ranges are not necessary for confident identifications of the three species (Theischinger 2001a).

*Austrophya mystica* Tillyard, 1909

Fig. 77

Theischinger & Watson (1984); Theischinger (2001a, 2010); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.* (2013). Genus possibly monotypic.

*Austrophya* sp.

Fig. 78

Theischinger (2001a), as Genus “L”, species “m”.

*Genus* *Austrophya* Tillyard, 1909

There are marked morphological and size differences between *A. mystica* and *A. sp. It is not considered certain that *A. sp.* is congeneric with *A. mystica*.

*Hesperocordulia berthoudi* Tillyard, 1911

Fig. 79

Ris (1910), as larva E; Watson (1962); Theischinger & Watson (1984); Theischinger (2001a, 2010); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking *et al.* (2013). Genus monotypic.
Figs 82-94. Larvae of Australian Odonata: (82) Synlestes weyersii (Synlestidae); (83) Griseargiolestes intermedius (Argiolestidae); (84) Xanthagrion erythroneurum (Coenagrionidae); (85, 86) Aeshnidae: (85) Anax papuensis; (86) Notoaeschna sagittata; (87-90) Gomphidae: (87) Ictinogiomphus australis; (88) Antipodogomphus acolythus; (89) Austroepigomphus (Xerogomphus) turneri; (90) Hemigomphus heteroclytus; (91) Eusynthemis virgula (Synthemistidae); (92, 93) Libellulidae: (92) Nannophya dalei; (93) Orthetrum caledonicum; (94) Pseudocordulia sp. (Libelluloidea genera incertae sedis).
Lathrocordulia garrisoni Theischinger & Watson, 1991
Larva not available.

Lathrocordulia metallica Tillyard, 1911
Fig. 80
Watson (1962); Theischinger & Watson (1984); Theischinger (2001a, 2010); Theischinger & Hawking (2006); Theischinger & Endersby (2009); Hawking et al. (2013).

*Genus Lathrocordulia Tillyard, 1911
The significant disjunction between the ranges of *L. metallica* (south-western Australia) and *A. garrisoni* (tropical Queensland) should be sufficient to establish or support confident identification of the two species once the larva of *L. garrisoni* is discovered (Theischinger 2001a; Theischinger & Endersby 2009).

Micromidia atrifrons (McLachlan, 1883)
Theischinger (1978), as Gomphomacromiinae sp.; Theischinger & Watson (1984); Hawking & Theischinger (1999); Theischinger (2001a); Theischinger & Hawking (2006); Theischinger & Endersby (2009).

Micromidia rodericki Fraser, 1959
Larva not available.

*Genus Micromidia Fraser 1959
The island distribution (Thursday Island, Torres Strait) will most probably confirm the identification of the larva of *M. rodericki* once it is available (Theischinger 2001a). Distributional support is not needed to distinguish the larvae of the other two species. It appears that *M. atrifrons* is not present in southern inland Queensland, whereas there are no records of *M. convergens* from north-eastern Queensland (Theischinger & Endersby 2009).

Table 1. Australian odonate species and their larvae: original description, first descriptions of larva, confidence in identifications, supportive information

<table>
<thead>
<tr>
<th>Taxon</th>
<th>ORDER ODONATA</th>
<th>SUBORDER ZYGOPTERA</th>
<th>FAMILY Hemiphlebiidae</th>
<th>FAMILY Synlestidae</th>
<th>FAMILY Lestidae</th>
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<td>3 genera clearly distinguishable on morphology</td>
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<th>Taxon</th>
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<th>IDR (*=for species, + =for group of species) based on M</th>
<th>Total geographical range or, indicated by P, part of it where I based on M is reliable or supported</th>
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<tbody>
<tr>
<td>Hemiophlebia mirabilis</td>
<td>1869</td>
<td>1928</td>
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<td>1914</td>
<td>1956</td>
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<td>1993</td>
<td>Thea</td>
<td>*</td>
<td>* s and i Qld, ne NSW</td>
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<td>1956</td>
<td>Fr</td>
<td>*</td>
<td>* Qld N of P-E gap</td>
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<td>1993</td>
<td>Thea</td>
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<td>1993</td>
<td>Thea</td>
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<td>* P: Qld: Eungella area</td>
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<td>1914</td>
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<td>* P: Qld: Carnarvon N.P., Victoria</td>
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<td>1962</td>
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<td>1999</td>
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<td>*  P: alpine region</td>
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Family Isostictidae 8 genera clearly distinguishable on morphology

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Family Platycnemididae 1 genus distinguishable on morphology

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## Australian Dragonfly (Odonata) Larvae: Descriptive history and identification

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<td>Total geographical range or, indicated by P, part of it where I based on M is reliable or supported</td>
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<td>* non-coastal se Qld, most of NSW</td>
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<td>1962</td>
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Abbreviations used in the table. General terms: OD=year of original description of adult; Ld=first description/descriptive detail of larva; Au=author/s of Ld; M=morphological disparity; G=distributional disparity; g=partial distributional disparity; e=ecological particular; n=larva not available (given by 0); IDR=reliable Identification possible. Geographical terms: A=Australia; CY=Cape York Peninsula; e=eastern; i=inland; n (in table head)= no descriptive information available at the present time (indicated by 0); n (in distribution column) northern; N=north; ne=north-eastern; P-E gap=Paluma-Eungella gap; s=southern; S=south; se=south-eastern; NG=New Guinea; NSW=New South Wales; NT=Northern Territory; Qld=Queensland; SA=South Australia; si=southern inland; WA=Western Australia; Vic=Victoria. Distributional data are included only with species for which these details markedly improve the reliability of identification. Authors: Al=Allbrook; An=Andress; Ca=Cabot; Fr=Fraser; Ha=Hawking; HaTh=Hawking & Theischinger; Ku=Kumar; Li=Lieftinck; Mu=Murray; Ne=Needham; Nu=Nuttall; OF=O’Farrell; St=Stewart; Th=Theischinger; ThBr=Theischinger & Brown; ThFl=Theischinger & Fleck; ThHa=Theischinger & Hawking; Ti=Tillyard; WaWatson; WaAr=Watson & Arthington; WaDy=Watson & Dyce; WaOF=Watson & O’Farrell; WaTh=Watson & Theischinger; Wi=Williams.

Geographical range or part of is only given if it markedly effects the reliability of identification. Full geographical ranges are written in bold; part of the range for which reliable identification is written in normal subsequent to P:

Some species are, within their genus, not listed in alphabetical order to better show morphological or geographical mutualities by the symbol + in cells ‘merged’ down the subcolumns M and G of column IDR.

Reasonably reliable identifications can be achieved at least for part of their ranges for 235 of the 325 species if the individuals to be identified are in good shape and close to final instar, and if their origin is known. Of these 215 are marked in column IDR by the symbol *, the remaining 20 by the symbol / . Identifications for 90 of the 325 species are at present hardly possible and therefore not marked with any symbol in the column IDR. Should larvae be identified as belonging to a species without an icon in the column IDR, it is strongly recommended that the details be thoroughly checked by repeating the identification procedure.
Conclusions and outlook

This compilation of the information regarding Australian dragonfly larvae and the possibility for accurate identification provides some interesting results. Of 325 Australian Odonata species, larvae are known for 263 species, or about 80% of the total fauna. No descriptive information is available for the larvae of 62 species (marked with the symbol 0 in column n of Table 1).

Reliable identifications, based on morphology alone are possible for 136 species, an additional 47 species can be identified reliably using a combination of morphological and distributional data. On top of that identifications of 30 more species are reliable within particular parts of their ranges, and one more can be identified based on its ecology. Considering these factors, it should also be possible to reliably identify another 20 species once their larvae are available.

The larvae of four Australian dragonfly genera, *Archibasis*, *Camacinia*, *Notolibellula* and *Raphismia* are unknown or undescribed.

These numbers show that the ratio ‘Number of identifiable species/Total number of species’ is markedly higher for Anisoptera (170/214) than for Zygoptera (64/111) and makes the Platycnemididae, Lestoideidae and Argiolestidae (in that order) the families for which progress in larval taxonomy is most urgently needed. This is of course also a reflection of the larval taxonomic difficulties of these groups. To improve the situation remains a big challenge for identification certifiers and taxonomists and would also make, perhaps in connection with more applied and timely issues, great topics for regional or Australia-wide PhD studies. Also DNA-matching of adults and larvae/exuviae will be a powerful method of confirming identifications in future.

### Table 2. Distribution of knowledge sufficient for specific identifications across families

<table>
<thead>
<tr>
<th>Family</th>
<th>Species identifiable</th>
<th>Total species</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platycnemididae</td>
<td>1</td>
<td>12</td>
<td>0.08</td>
</tr>
<tr>
<td>Lestoideidae</td>
<td>3</td>
<td>9</td>
<td>0.33</td>
</tr>
<tr>
<td>Argiolestidae</td>
<td>8</td>
<td>22</td>
<td>0.36</td>
</tr>
<tr>
<td>Gomphidae</td>
<td>23</td>
<td>38</td>
<td>0.61</td>
</tr>
<tr>
<td>Isostictidae</td>
<td>11</td>
<td>16</td>
<td>0.69</td>
</tr>
<tr>
<td>Libellulidae</td>
<td>40</td>
<td>57</td>
<td>0.70</td>
</tr>
<tr>
<td>Coenagrionidae</td>
<td>23</td>
<td>30</td>
<td>0.77</td>
</tr>
<tr>
<td>Lestidae</td>
<td>11</td>
<td>14</td>
<td>0.79</td>
</tr>
<tr>
<td>Lib. incertae sedis</td>
<td>16</td>
<td>20</td>
<td>0.80</td>
</tr>
<tr>
<td>Corduliidae</td>
<td>10</td>
<td>12</td>
<td>0.83</td>
</tr>
<tr>
<td>Aeshnidae</td>
<td>46</td>
<td>50</td>
<td>0.92</td>
</tr>
<tr>
<td>Synthemistidae</td>
<td>24</td>
<td>26</td>
<td>0.92</td>
</tr>
<tr>
<td>Hemiphlebiidae</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Synlestidae</td>
<td>7</td>
<td>7</td>
<td>1.00</td>
</tr>
<tr>
<td>Austropetaliiida</td>
<td>4</td>
<td>4</td>
<td>1.00</td>
</tr>
<tr>
<td>Petaluridae</td>
<td>5</td>
<td>5</td>
<td>1.00</td>
</tr>
<tr>
<td>Macromiidae</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>235</strong></td>
<td><strong>325</strong></td>
<td><strong>0.72</strong></td>
</tr>
</tbody>
</table>

Figure 95. Accumulation curve illustrating the increase in descriptive information for Australian odonate larvae between 1880 and 2014.
Summary
This paper summarises the morphological and geographic information for the larvae of all species of Australian dragonflies. We present an annotated checklist giving all known references which provide information on the identification characters of each species. For each genus that includes more than one species there is a paragraph which discusses if species can already, or cannot yet, be distinguished on morphological characters. We also include information on whether, and under which conditions, geographic locality helps or is enough to make a diagnosis. A table provides the year of original description and of first description of the larva of each species. It also indicates the level of confidence of identifications from available keys and other supportive information. The paper is fully referenced and includes, for more than 70% of the Australian dragonfly genera, illustrations of final stage larvae or exuviae (“shells”).

We wrote this paper to improve the reliability of identification of the larvae of Australian species of dragonflies. It brings together references to all available information on the identification of larvae of any Australian dragonfly species. This encourages access to original sources and to confirm results of identifications by using several ways of diagnosing when in doubt. In particular it emphasizes the geographical aspect of making identifications. Geographical information can improve confidence of inconclusive morphological identifications of larvae by reducing the number of possible options and improves the chances for reliable identification of even relatively early larval stages. Identifications are only valuable if they are accurate and reliable, so the paper will be helpful in many current issues including biodiversity, conservation, river health, climate change and others.

References


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Australian Dragonfly (Odonata) Larvae: Descriptive history and identification


