



## RESEARCH PAPER

# The horned Australian burrowing mayfly *Jappa* (Ephemeroptera: Leptophlebiidae)

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**Abstract**

The horned Australian burrowing mayfly genus *Jappa* Harker (Leptophlebiidae) is revised based on adult and larval material collected throughout Australia. Five named species [*J. campbelli* Bae & Finlay, *J. edmundsi* Skedros & Polhemus, *J. furcifera* (Eaton), *J. serrata* Skedros & Polhemus and *J. strigata* (Eaton 1871) (= *J. bicornis* Ulmer 1916; = *J. kutera* Harker 1954, syn. n.)] are recognised, and two new species [*J. harkeriae* n. sp. and *J. suteri* n. sp.] are described. Descriptions, diagnoses, line-drawings and images of key characters, distributional information, taxonomic remarks and keys to adults and larvae are provided. The species *Jappa tristis* Harker 1954 is transferred to the genus *Tillyardophlebia* Dean.

**Key words:** Australia, Ephemeroptera, *Jappa harkeriae* n. sp., *Jappa suteri* n. sp., Leptophlebiidae, taxonomy.

**Introduction**

Larvae of the horned Australian burrowing mayfly genus *Jappa* are unique among mayflies because the characteristic frontal processes on the head (cephalic tusks) and fossorial behaviour are adaptations which are convergent with the burrowing mayfly family Potamanthidae from the northern hemisphere (Campbell 1990; Bae & McCafferty 1991, 1995). The “true” burrowing mayflies or Ephemeroidea are absent from Australia.

Harker (1954) established the genus *Jappa*, while Riek (1970) and Peters and Campbell (1991) included some general information and figures of the genus in the textbook “The Insects of Australia”. Dean (1999) provided a larval diagnosis of *Jappa* and a key to larvae of three nominal and four unnamed species. Bae *et al.* (2004) refined the generic concepts of *Jappa* and its sister genus, the non-horned Australian burrowing mayfly genus *Ulmerophlebia* Demoulin 1955. The monophyletic relationships of the *Jappa*-*Ulmerophlebia* clade in the Australian Leptophlebiidae were well supported by Bae *et al.* (2004), Christidis (2005) and Finlay and Bae (2008). Currently, four nominal species, *Jappa kutera* Harker 1954, *J. edmundsi* Skedros & Pol-

hemus 1986, *J. serrata* Skedros & Polhemus 1986 and *J. campbelli* Bae & Finlay 2003 are known. When establishing the genus, Harker (1954) also described *Jappa tristis* from Tasmania, but we concur with the suggestion by Dean (1999) that this species does not belong in the genus *Jappa*. The original descriptions of the species *Deleatidium strigatum* (Eaton) 1871 and *Euphyurus bicornis* Ulmer 1916 indicate that they also belong in the genus *Jappa*.

The purposes of this study are to revise the species of the genus and to provide descriptions or redescrptions of previously unknown or poorly known stages with identification keys to both adults and larvae.

**Materials and methods**

Type and voucher specimens and additional fresh material of *Jappa* housed predominantly in the Museum of Victoria (MV), the Australian National Insect Collection in Canberra (ANIC) and Monash University (MU) were examined for this study.

In the descriptions, eye size can be measured by the ratio (B/D) of shortest distance between compound eyes to longest dorsal diameter of a compound eye. Gill expansion

rate can be defined by the ratio of vertical height of apico-medial expansion of gill lobe (measured by the direct line of height from base of apical filament of gill to apex of expansion) against gill lobe length from base of gill to base of apical filament of gill. Other terminology, measurement and general methods follow those of Bae and McCafferty (1991), Dean (1999) and Bae *et al.* (2004). Types, voucher specimens and additional fresh material of *Jappa* have been examined. Repositories for much of this material are the Museum of Victoria (MV), the Australian National Insect Collection in Canberra (ANIC), Monash University (MU) and the personal collection of John Dean (JDC). Other abbreviations are as follows.

**Collections.** Australian National Voucher Collection of larvae, Museum of Victoria (ANVC), Conservation and Land Management, Western Australia (CALM), Entomology, Florida A & M University (FAMU), Griffith University, Queensland (Griff U), James Cook University, Queensland (JCU), John Dean Collection (JDC), Victorian Voucher Collection of larvae, Museum of Victoria (VVC). **Collectors.** Queensland Department of Natural Resources and Mines (DNRQ), Environment Protection Authority, Victoria (EPA VIC) and Environment Protection Authority, New South Wales (NSW EPA). **Developmental stages.** MI (male imago), FI (female imago), MS (male subimago), FS (female subimago), L (larva) and E (egg). **Localities:** Br (Bridge), Ck (Creek), Crs (Crossing), d/s (downstream), E (East), Hwy (Highway), Is (Island), Jct (Junction), Mt (Mountain), N (North), NP (National Park), nr (near), Pk (Park), R (River), Rd (Road), S (South), u/s (upstream) and W (West). **States:** NSW (New South Wales), NT (Northern Territory), QLD (Queensland), VIC (Victoria) and WA (Western Australia).

## Taxonomic accounts

Genus *Jappa* Harker

*Jappa* Harker 1954: 257 (MI, L); Williams 1968: 170 (L key); Dean & Suter 1996: 44 (L); Dean 1999: 34 (L); Bae *et al.* 2004: 3 (MI, FI, L & E).

Type species. *Jappa strigata* (Eaton 1871) [= *J. bicornis* (Ulmer 1916); = *J. kutera* Harker 1954, n. syn.].

**Redescription.** Imago. Body length 8.1–18.0 mm. General body colour light yellow to light brown, with darker purplish brown markings. Male head with upper lobes of compound eyes orange, in contact dorsally; basal compound eyes black. Forewing length 8.8–15.6 mm; C-Sc crossveins suffused with brown, numbering 20–30, with brown markings of varying size and intensity at fork of MA, at bulla and covering stigmatic area in most species; crossveins in stigmatic area not anastomosed; MP<sub>2</sub> basally connected to MP<sub>1</sub> and CuA (angle between MP<sub>2</sub> and crossvein MP<sub>2</sub>-MP<sub>1</sub> larger than angle between MP<sub>2</sub> and crossvein MP<sub>2</sub>-CuA); ICu<sub>1</sub>

basally connected to CuA and CuP (angle between ICu<sub>1</sub> and crossvein ICu<sub>1</sub>-CuP larger than angle between ICu<sub>1</sub> and crossvein ICu<sub>1</sub>-CuA). Hindwing length 2.3–3.4 mm, with 6–9 C-Sc crossveins, relatively evenly distributed over length of wing in most species. Legs light yellow, with purplish brown markings in most species; tarsal claws dissimilar. Genital forceps with basal segment parallel-sided, narrowing abruptly at 1/2–2/3 length; penes Y-shaped or V-shaped, apically separated; each lobe with ventrolateral setae in some species. Terminal filament as long as cerci. Female abdominal sternum IX excised.

**Larva.** Body length 10.3–23.8 mm, cephalic tusks 1.0–3.5 mm. General body colour light yellow to light brown, with darker purplish brown markings. Antennal segments heavily setose. Cephalic tusks elongate, c. 1.0–2.0 x length of head, weakly to strongly arched (curvature 15–25°), apically convergent and directed upward, with basodorsal tubercle, with tufts of basomedial and basolateral hairlike setae, with or without apical tuft of hairlike setae; surface of tusks smooth or with small to large spines along dorsal ridge and/or lateral margin. Labrum relatively straight sided, distally wider, heavily setose; anterior margin concave with prominent median tubercle; anterior and lateral margins with long hairlike setal row; dorsal surface with basal and subapical hairlike setal rows (basal setae longer than subapical setae; subapical setae mesally shorter); ventral surface with dense hairlike setal field along anterior margin, with row of c. 15–30 stout setae subanteriorly, with paired tufts of central hairlike setae (number of setae 30–50) located opposite to median line. Mandibles with outer margins densely setose; outer incisors robust, triangular, larger than inner incisor. Maxillae with palps relatively long; terminal segment short, subtriangular. Labium with glossae dorsoventrally elongated and ventrally stalked; submentum with lateral margins heavily setose. Pronotum with long hairlike setae along lateral margins. Legs heavily setose; tarsal claws with ventral row of small denticles. Abdominal segments with dense fringe of setae on lateral margins, with numerous long hairlike setae along median surface of abdominal terga. Gills on abdominal segments I–VII; each gill with upper and lower lamellae; each lamella broad with a single apical filament; gill margins densely clothed with fine hairlike setae. Caudal filaments with whorls of hairlike setae.

**Diagnosis.** The genus *Jappa* can be distinguished from all other mayfly genera by the combination of characters given above. Although there are no fundamental adult key characters to distinguish *Jappa* from the sister genus *Ulmerophlebia*, the adults of *Jappa* possess a greater number of C-Sc crossveins (20–30) in the forewing and relatively evenly distributed C-Sc crossveins in the hindwing, while adults of *Ulmerophlebia* possess fewer C-Sc crossveins (12–19) in the forewings and apically concentrated C-Sc

crossveins in the hindwings (Bae *et al.* 2004). The larvae of *Jappa* can be readily distinguished from those of *Ulmerophlebia* and all other mayfly genera by the presence of cephalic tusks. The body size of *Jappa* is generally larger than that of *Ulmerophlebia*.

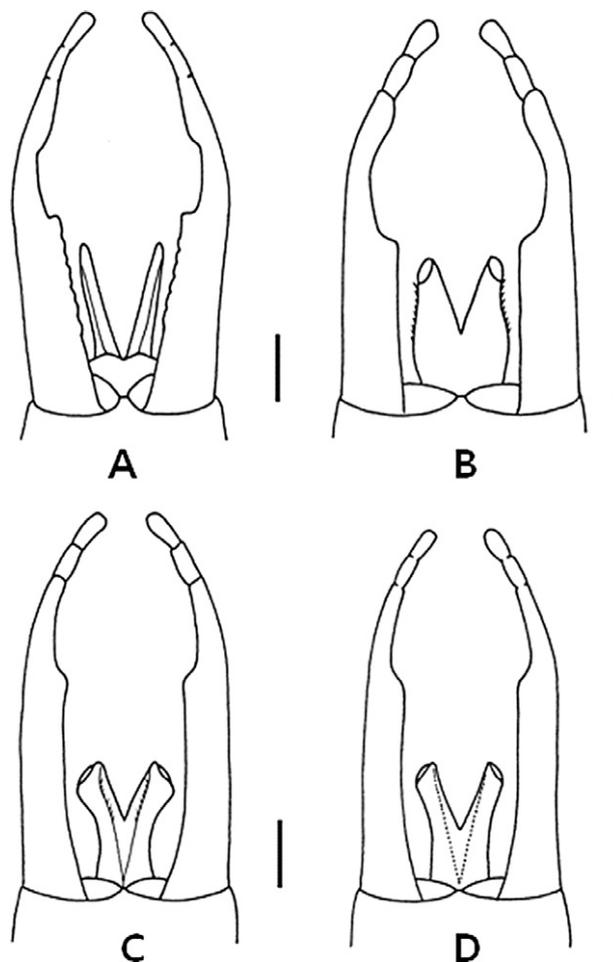
**Distribution.** Northern WA, NT, QLD, NSW, VIC.

**Remarks.** The genus *Jappa* Harker 1954 was established based on the type species *J. kutera* Harker 1954. We herein synonymise *J. harkutera* Harker with *J. strigata* (Eaton 1871) (see Remarks in *J. strigata*, below).

Larvae of *J. kutera* Harker 1954, the nominated type species of *Jappa*, are distributed throughout much of eastern and northern Australia. We have been unable to distinguish between material from New South Wales and material from Cape York Peninsula and the Kakadu region of the Northern Territory. The larva of this species is unique in eastern Australia in having a thin black line along the midline of all abdominal sterna; a character also present in the imago and subimago. *Jappa strigata* (Eaton 1871), originally described from “North Australia”, and *J. bicornis* (Ulmer 1916), originally described from Christmas Creek in north Queensland, also feature a thin black line along the venter of the abdomen, and we herein recognise *J. bicornis* (Ulmer) and *J. kutera* Harker as junior synonyms of *J. strigata* (Eaton). *Jappa bicornis* (Ulmer) has previously been synonymised with *J. strigata* (Eaton) by Harker (1950).

On the basis of a single male imago and a single female imago, Harker (1954) described the species *Jappa tristis* from Tasmania. This placement within the genus *Jappa* was questioned by Dean (1999), who suggested that the species should probably be transferred to *Tillyardophlebia* Dean. Despite an extensive biological monitoring program conducted throughout Tasmania in the last decade, there appear to be no records of the conspicuously horned larvae of *Jappa* ever having been collected. We believe that the genus is not present in Tasmania. Harker’s original description and figures of *J. tristis* include several diagnostic features of *Tillyardophlebia* (the penes lobes are extremely long and slender, reaching the apex of the first segment of the forceps, and the female “subanal plate (is) large with an almost straight tip”). This contrasts with the genus *Jappa*, in which the penes lobes do not extend beyond the abrupt narrowing at 2/3 the length of the basal segment of the forcep, and the female subanal plate is deeply notched. In addition, there are numerous records of male imagos and larvae of *Tillyardophlebia* from Tasmania (J. Dean, personal communication). The species *J. tristis* Harker is, therefore, formally transferred to the genus *Tillyardophlebia*.

We suggest that species of the genus *Jappa* be known by the common name “horned Australian burrowing mayflies”.



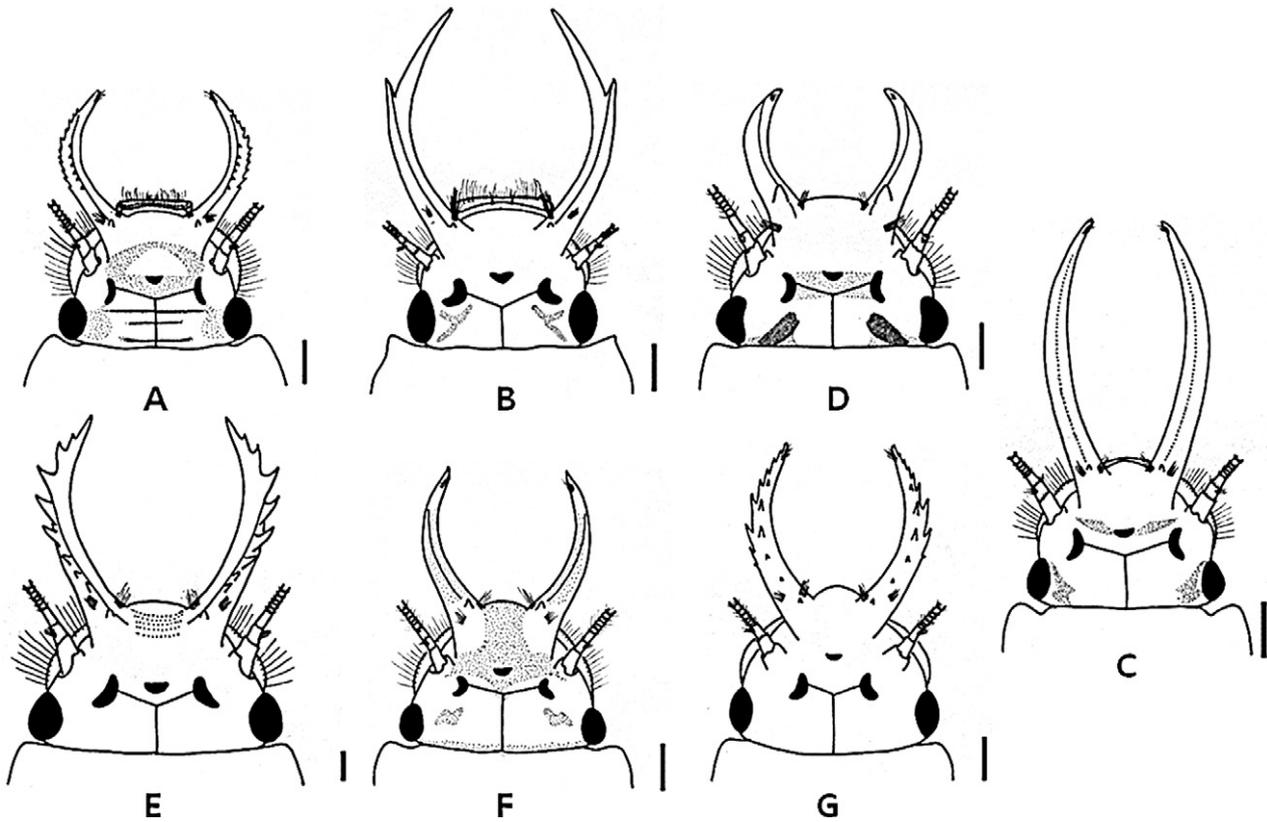
**Figure 1** Male imago genitalia: **A** *Jappa campbelli*; **B** *J. furcifera*; **C** *J. serrata*; **D** *J. strigata*. Scale bars = 0.2 mm.

### ***Jappa campbelli* Bae & Finlay (Figs 1A, 2A, 3A)**

*Jappa* sp. AV4: Dean 1999: 35 (L key, figure).

*Jappa campbelli* Bae & Finlay 2003: 91 (MI, FI, L & E) [Holotype stage: MI; locality: Victoria, Australia; repository: MV].

**Redescription.** Male imago. Body length 10.7 mm. General body colour dark purplish brown. Compound eyes upper lobes yellowish brown in alcohol, in contact dorsally; basal compound eyes yellowish brown. Thoracic nota dark purplish brown with light yellow areas medially; metanotum postero-medial hump dark brown; pleura and sterna dark purplish brown with light yellow areas. Forewing length 10.7 mm, width 3.4 mm, with small dark brown markings at base of costal margin, surrounding bulla, on stigmatic area and at the base of MA fork; longitudinal veins light purplish brown; crossveins blackish brown; crossveins C-Sc 21, Sc-R<sub>1</sub> 17, R<sub>1</sub>-R<sub>2</sub> 15, all strongly infuscated. Hindwing length 2.3 mm, width 1.4 mm, without markings; veins hyaline; crossveins



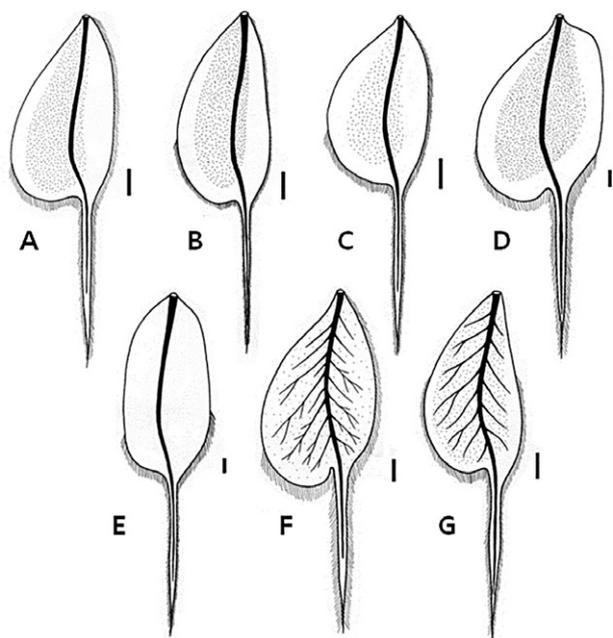
**Figure 2** Larval head: **A** *Jappa campbelli*; **B** *J. edmundsi*; **C** *J. furcifera*; **D** *J. harkerae*; **E** *J. serrata*; **F** *J. strigata*; **G** *J. suteri*. Scale bars = 0.5 mm.

C-Sc 11, apically concentrated. Legs light yellow with dark purplish brown markings near base, at midlength and near apex of femora, apical tibiae, tarsal segment 1, each tarsal joint and at claws; forefemora 2.10 mm, foretibiae 2.90 mm, foretarsal segment 1 0.13 mm, segment 2 1.25 mm, segment 3 1.15 mm, segment 4 0.85 mm, segment 5 0.38 mm and foreclaws 0.15 mm. Abdominal terga purplish brown to dark purplish brown, with a pale longitudinal band along median line, narrowing and slightly darkening towards anterior on most segments, and on either side of median line a light yellow triangle abutting posterior margin and extending forward 1/3-1/2 segment length; segment IX with moderately developed posterolateral projections. Abdominal sterna dark purplish brown medially and light brown laterally; medial dark band on each segment overlaid by two pairs of pale spots (anterior pair larger than posterior pair). Penes (Fig. 1A) V-shaped, slender, 0.33 mm in length, c. 1/2 x length of forceps segment 1; each lobe light yellow medially and purplish brown laterally, apically round, without setae; forceps segment 1 0.92 mm, segment 2 0.12 mm and segment 3 0.12 mm; forceps segment 1 dark purplish brown basally and light purplish brown apically, narrowing abruptly at 3/5 length; forceps segments 2 and 3 indistinctly demarcated.

Caudal filaments 15.0 mm, light yellow, with dark purplish brown joints (every 2nd joint thicker).

Female imago. Body length 12.0 mm. General body colour and markings similar to male. Compound eyes 0.33 mm in width; distance between compound eyes 1.53 mm ( $B/D = 4.7$ ). Forewings length 11.3 mm, width 3.6 mm, venation similar to male; veins dark purplish brown (distal veins lighter in colour); crossveins C-Sc, Sc-R<sub>1</sub> and R<sub>1</sub>-R<sub>2</sub> basally 1/2 infuscated. Hindwings length 2.5 mm, width 1.2 mm; veins hyaline. Forefemora 3.0 mm, foretibiae 3.7 mm and foretarsi 1.7 mm. Abdomen colour and markings similar to male.

Larva. Male body length 10.3 mm; cephalic tusks 1.0 mm; caudal filaments 7.0 mm. Female body length 10.4–12.7 mm; cephalic tusks 1.0–1.4 mm; caudal filaments 7.2–9.2 mm. General body colour light yellow with dark brown markings. Head light brown, length 1.55 mm, width 2.20 mm, with dark brown transverse stripes at vertex and dark brown areas near compound eyes and between lateral ocelli. Antennae 5.3 mm. Cephalic tusks (Fig. 2A) as long as head, strongly arched (curvature c. 24°), with moderately developed basodorsal tubercle, with distinct dorsal ridge; surface of tusks with series of 4–6 rudimentary dorsal spines



**Figure 3** 4th gill, dorsal lamella: **A** *Jappa campbelli*; **B** *J. edmundsi*; **C** *J. furcifera*; **D** *J. harkerae*; **E** *J. serrata*; **F** *J. strigata*; **G** *J. suteri*. Scale bars = 0.25 mm.

and 10–13 lateral fine crenulations on ridges, with apical setal tuft (number of setae c. 40). Labrum with distinct marginal ridge dorsally; dorsal area between clypeus and labrum with row of c. 40 long hairlike setae. Pronotum light yellow, with submedian irregular longitudinal dark brown stripes extended onto mesonotum and forewingpads. Forefemora 2.50 mm, foretibiae 3.00 mm, foretarsi 1.00 mm and foreclaws 0.35 mm; femora of all legs with dark brown banding at midlength and near apex. Abdominal terga I–IX with large anteromedian dark purplish brown markings and sublateral longitudinal dark brown stripes overlaying a pale median band (band posteriorly wider); segments VIII and IX with well developed posterolateral projections. Abdominal sterna with moderately broad dark brown median stripe; two pair of pale spots (anterior spots larger and wider) within median stripe on each segment. Gills light purplish brown, white marginally, with dark purplish brown median tracheae, without conspicuous lateral tracheae, with fine setae on apical 1/4 of inner margin and entirely on outer margin, with weakly developed apical expansion (gill 4 expansion rate c. 0.03) (Fig. 3A). Caudal filaments light yellow.

**Diagnosis.** The male imago of *J. campbelli* can be distinguished from other species of *Jappa* by the abdominal colour pattern and the V-shaped and slender penes (Fig. 1A). The larva of *J. campbelli* can be distinguished by the cephalic tusks which have a row of fine crenulations along the lateral ridges (Fig. 2A), the abdominal colour pattern and

the form of the abdominal gills which lack lateral tracheae and have a weakly developed apical expansion (gill 4 expansion rate c. 0.03) (Fig. 3A).

**Type material.** Holotype: Male imago (reared, with larval exuvium, T-17939), Victoria, Licola, Wellington R, 3 km upstream from Alpine National Park entrance, collected 6 Jan 2002, emerged 13 Jan 2002, K.J. Finlay, Y.J. Bae & N. Ainsworth [MV]. Paratypes: 2 male imagos, 2 female imagos (reared, with larval exuviae, T-17940 to T-17943), same data as holotype [MV]; 10 larvae (T-17944 to T-17953), same data as holotype [MV].

**Other material.** QLD: 2 L, Running Ck, Drynans, 4 Oct 1994, DNRQ; 1 L, Buaraba Ck, Ritchies, 13 Nov 1996, DNRQ. NSW: 4 L, Upper Kangaroo R, 22 July 1972, J. Dean [MV]; 1 L, Tuross R, 5 miles S of Nerringundah, 1 Feb 1977, J. Dean [MV]; 1 L, Blicks R, nr Dundurrabin, 30°12'S 152°33'E, 28 Nov 1998, J. Dean & P. Suter [JDC]; 1 L, Rosewood Ck, 30°24' S 152°46' E, 1981–82, G.J. Morgan [MV]; 1 L, Manning R, Charity Crs, 11 Oct 1995, NSW EPA; 1 L, Brogo R, u/s Brogo Dam, 13 Oct 1994, NSW EPA; 1 L, Clyde R, Blue Gum Flat, 13 Mar 1995, NSW EPA; 1 L, Clyde R, Yadboro Flat, 13 Mar 1995, NSW EPA; 1 L, Buckenboursa R, u/s Ford, 13 Oct 1994, NSW EPA; 2 L, Hastings R, Koreae Is, 16 Apr 1996, NSW EPA; 2 L, Hastings R, The Crest, 10 Apr 1995, NSW EPA; 1 L, Williams R, Thalba Br, 18 Oct 1995, NSW EPA; 1 L, Eight Mile Ck, Blowhole, 30 Sep 1994, NSW EPA; 1 L, Manning R, Charity Crs, 11 Oct 1995, NSW EPA; 3 L, Shoalhaven R, Yalwal Ck, 21 Dec 1995, NSW EPA; 1 L, Shoalhaven R, Fossickers Flat, 11 Jun 1997, NSW EPA. VIC: 50 L, same locality as Holotype, 18 Mar 2001, Y.J. Bae, F. Govedich & B. Bain, 16 Apr 2001, Y.J. Bae & K.J. Lim [MU]; 30 L, Wellington R, approx. 10 km upstream from Alpine NP entrance at 2nd Br, 12 May 2001, Y.J. Bae, K.J. Finlay & N. Ainsworth [MU]; 1 L, Culloden, Freestone Ck, 20 km NE of Maffra, 5 Sep 1977, A. Neboiss [MV]; 1 L, Avon R, Bushy Pk, 5 Nov 1977, A. Neboiss [MV]; 1 L, Freestone Ck, 20 km NE Maffra, 5 Nov 1977, A. Neboiss; 3 L, Nicholson R, Stone Ck Track, 9 Nov 2005, EPA VIC; 1 L, Nicholson R, u/s Morgans Ck, 4 Mar 1998, EPA VIC; 1 L, Wonnongatta R, Crooked R, 21 Oct 1994, EPA VIC.

**Distribution.** QLD, NSW, VIC.

**Remarks.** Bae and Finlay (2003) provided detailed descriptions and biological information for this species, while Dean (1999) included the larva as *Jappa* sp. AV4 in his key to species.

The suggested common name is the “small serrate horned *Jappa*”.

### ***Jappa edmundsi* Skedros & Polhemus (Figs 2B, 3B)**

*Jappa edmundsi* Skedros & Polhemus 1986: 311 (L); Campbell 1988: 20 (catalogue); Campbell 1990: 151 (figure);

Hubbard & Campbell 1996: 26 (catalogue); Dean 1999: 35 (L key).

*Redescription.* Imago and Subimago. Unknown.

Larva. Male body length 12.5 mm; cephalic tusks 1.7 mm; caudal filaments 5.9 mm. Female body length 12.9 mm; cephalic tusks 2.3 mm; caudal filaments 8.0 mm. General body colour light yellow with dark purplish brown markings. Head (Fig. 2B) light purplish brown, length 1.56 mm, width 2.06 mm, with dark purplish brown markings on vertex and between ocelli. Antennae 6.0 mm. Cephalic tusks c. 2.0 x length of head, strongly arched (curvature c. 25°); surface smooth except for single large dorsal prong at about midlength, with distinct dorsal ridge, with small basodorsal tubercles, without apical setal tuft. Labrum dorsally with distinct marginal ridge; dorsal area between clypeus and labrum relatively wide (c. 0.08–0.10 mm), sclerotized, with submedian hairlike setal fields (number of setae 10–15). Pronotum light yellow with submedian, subanterior and sublateral dark brown markings. Legs light yellow, without darker markings. Forefemora 2.06 mm, foretibiae 2.38 mm, foretarsi 0.75 mm and foreclaws 0.24 mm. Abdominal terga light brown, sublaterally somewhat darker in colour and laterally white, with submedian longitudinal narrow dark brown stripes (each stripe posteriorly somewhat thicker); segments VIII and IX with moderately developed posterolateral projections. Abdominal sterna light yellow, without clear markings. Gills light brownish grey, white marginally, with dark purplish brown median tracheae, without conspicuous lateral tracheae, with fine setae on apical 1/3 of inner margin and entirely on outer margin, with weakly developed apical expansion (gill 4 expansion rate c. 0.02) (Fig. 3B). Caudal filaments white.

*Diagnosis.* The larva of *J. edmundsi* can be readily distinguished by the bifurcate cephalic tusks (Fig. 2B) and the abdominal gills which lack lateral tracheae and possess weakly developed apical expansions (Fig. 3B).

*Type material.* Holotype: Mid-grown female larva, Australia, Queensland, Hutchinson Creek, Cape Tribulation road, north of Daintree Landing, 17 Aug 1983, D.A. & T.J. Polhemus [ANIC]. Paratypes: 2 larvae, same data as holotype [ANIC]; 6 larvae, same data as holotype [FAMU].

*Other material.* NT: 12 L, Jim Jim Falls (above falls), 14 Oct 1972, E.F. Riek [ANIC]. QLD: 2 L, Yuccabine Ck, 10 Feb 1984 [MU]; 1 L, Yuccabine Ck, 17 May 1988, S. Bunn [Griff U]; 1 L (EPH-0870), Lacey's Ck, E of El Atish, 23 Nov 1979 [ANVC]; 1 L, Mulgrave R, 3 Oct 1991 [JCU]; 2 L, Sth Johnstone R, u/s Central Mill, 27 Apr 1998, DNRQ; 3 L, Sth Johnstone R, Corsi's, 27 Oct 1994, DNRQ; 3 L, Joongoon Ck, Upper Daradgee Rd, 9 Dec 1998, DNRQ; 1 L, Fisher Ck, Palmerston Hwy, 9 Nov 1998, DNRQ.

*Distribution.* NT, QLD.

*Remarks.* The larva of *J. edmundsi* is herein redescribed based on mature larvae. The six paratype larvae of *J. ed-*

*mundsi*, which were originally lodged in the Department of Biology, University of Utah, have since been transferred to the Entomology Department of Florida A & M University (M. Hubbard, personal communication). All but one of the records for this species is from small streams in tropical rain forests in North Queensland. The single record from Jim Jim Falls in the Northern Territory appears incongruous, and requires confirmation.

The suggested common name for this species is the "bifurcate horned *Jappa*".

### ***Jappa furcifera* (Eaton) (Figs 1B,2C,3C)**

*Leptophlebia furcifera* Eaton 1871: p. 79.

*Atalophlebia furcifera* (Eaton): Eaton 1884: 87 (MI).

*Deleatidium furcifera* (Eaton): Harker 1950: 29 (catalogue).

*Jappa* sp. AV3: Dean 1999: 35 (L key, figure).

*Redescription.* Male imago. Body length 8.1–9.8 mm. General body colour light yellow with darker brown markings. Upper lobes of compound eyes orange in alcohol, in contact dorsally; basal compound eyes black. Thoracic nota light yellow, with weakly developed darker markings. Forewing length 9.4 mm, width 3.3 mm, with small dark brown markings at fork of MA, at bulla and covering stigmatic area; longitudinal veins light purplish brown; crossveins blackish brown; crossveins C-Sc 30, Sc-R<sub>1</sub> 20, R<sub>1</sub>-R<sub>2</sub> 14, all strongly infuscated. Hindwing length 2.7 mm, width 1.4 mm, without markings; longitudinal veins dark purplish brown except costal vein (costal vein white); crossveins dark purplish brown, with C-Sc 12, more or less evenly distributed. Femora light yellow, with purplish brown stripes at midlength and near apex; inter-segmental joints purplish brown; forefemora 2.27 mm, foretibiae 3.25 mm, foretarsal segment 1 0.14 mm, segment 2 1.27 mm, segment 3 1.18 mm, segment 4 0.89 mm, segment 5 0.44 mm and foreclaws 0.16 mm. Abdominal terga with broad W-shaped purplish brown markings on anterior half of each segment. Abdominal sterna with smaller anterosubmedian and larger posterosubmedian markings connected to form broad purplish brown marking. Penis (Fig. 1B) Y-shaped, 0.24 mm in length, basally thicker, apically with large opening, each lobe with single ventrolateral spine; forceps light yellow; segment 1 1.03 mm, segment 2 0.10 mm and segment 3 0.11 mm; basal segment narrowing abruptly at 2/3 length. Caudal filaments 13.8 mm, light yellow, with dark purplish brown joints (every 2nd joint thicker).

Female imago. Unknown.

Larva. Male body length 10.4–11.9 mm; cephalic tusks 1.5–2.4 mm; caudal filaments 7.0–10.5 mm. Female body length 13.8 mm; cephalic tusks 2.8 mm; caudal filaments 9.5 mm. General body colour light yellowish brown with purplish brown markings. Head (Fig. 2C) light yellowish brown, length 1.30 mm, width 1.75 mm, with dark brown

markings on vertex and between ocelli. Antennae 5.3 mm. Cephalic tusks greatly elongated, weakly arched (curvature c. 15°); surface smooth, without crenulations or spines, with indistinct dorsal ridge, with small basodorsal tubercles, with apical setal tuft (number of setae c. 20). Labrum dorsally without distinct marginal ridge. Pronotum light yellow, with poorly developed submedian dark brown markings. Legs light yellow; all femora with broad transverse brown markings at mid-length and apically. Forefemora 2.05 mm, foretibiae 2.25 mm, foretarsi 0.73 mm and foreclaws 0.30 mm. Abdominal terga with large W-shaped purplish brown markings in anterior half of each segment; segments VIII and IX with well developed posterolateral projections. Abdominal sterna with small anterosubmedian and large posterosubmedian markings connected with arms and together forming broad purplish brown longitudinal stripe. Gills (Fig. 3C) light purplish brown, white marginally, with dark purplish brown median tracheae, without conspicuous lateral tracheae, with fine setae on apical 1/3 of inner margin and entirely on outer margin, without apical expansion (gill 4 expansion rate c. 0). Caudal filaments white.

**Diagnosis.** The imago of *J. furcifera* can be distinguished from other species of *Jappa* by the Y-shaped and basolaterally thicker penes (Fig. 1B) and the abdominal colour pattern. The larva of *J. furcifera* can be distinguished by the elongated (c. 1.7 x length of head) and weakly arched cephalic tusks (curvature c. 15°) (Fig. 2C) and by the abdominal gills which have weakly developed lateral tracheae and no apical expansion on the gills (4th gill expansion rate 0) (Fig. 3C).

**Type material.** Holotype: Male imago (pinned, genitalia damaged), Australia, Melbourne, McCoy [MV].

**Other material.** NSW: 2 L, Swampy Plains R, Alpine way, 6 Feb 1985, J. Dean [MV]; 5 L, Mongarlowe R, 100 m W of turnoff to Monga, 35°32'S 149°56'E, 1 Dec 1998, J. Dean & P. Suter; 2 L, Mongarlowe R, 1.8 km d/s Monga Settlement, 35°33'S 149°55'E, 1 Dec 1998, J. Dean & P. Suter. VIC: 1 MI (reared, with larval exuvium), Yarra R, Reefton Rd, 5 Mar 1980, J. Dean [MV]; 1 MI (reared, with larval exuvium), Yarra R, Peninsula Rd, 25 Feb 1983, J. Dean [MV]; 2 L, Yarra R, Reefton Rd, 17 Feb 1978, J. Dean [MV]; 9 L, Yarra R, Hazlewood Rd, 17 Feb 1978, J. Dean [MV]; 1 L, Yarra R, O'Shannassy Rd, 9 Feb 1981, J. Dean [MV]; 11 N, Yarra R, Hazlewood Rd, 17 Feb 1978, J. Dean; 1 L, 1 MI (reared from nymph), Yarra R, O'Shannassy Rd, 9 Feb 1981, J. Dean; 2 L, Tambo R, Wilga Weir, 12 Oct 1999, EPA VIC; 1 MI, 1 FI, Yarra R, Warburton East, 17 Feb 76, A. Neboiss; 1 L, Upper Buckland, 28 Nov 1964, A. Neboiss [MV]; 2MI, 1FI, Wellington River, Carey River junction, 15 Feb 1977, A.A. Calder [MV]; 30 L, Licola, Wellington R., c. 10 km u/s Alpine NP entrance at 2nd Br, 12 May 2001, Y.J. Bae, K.J. Finlay & N. Ainsworth [MU];

10 L, 1 MI (reared, with larval exuvium), Licola, Wellington R, c. 3 km u/s Alpine NP entrance, 6 Jan 2002 (emerged 8 Jan 2002), Y.J. Bae, K.J. Finlay & N. Ainsworth [MU]; 2 L, Wellington R, 4 Feb 1999, K.J. Finlay [MU]; 2 L, Breakfast Ck (branch of Wellington R), 4 Feb 1999, K.J. Finlay [MU]; 3 L, Moroka R, 6 Feb 1999, K.J. Finlay [MU]; 2 L, Rose R, 17 Mar 1999, B. Margery [MU].

**Distribution.** NSW, VIC.

**Remarks.** The male holotype of *J. furcifera* was deposited in the Melbourne Museum (= Museum of Victoria) after being examined and described by Eaton (1871). Bae *et al.* (2004) could not locate the specimen, but it was actually stored in the museum's dry collection as a pinned specimen. It has been examined for this study. The specimen is in poor condition: the left forewing is missing, the trailing edge of the right forewing is damaged in the basal half, the abdomen is laterally compressed, detached from the thorax and twisted, tergum X and the cerci are missing. The only character likely to be useful for identification is the colour pattern of the abdominal terga. There are no recent records of *Jappa* species from near Melbourne, although larvae of *Jappa* sp. AV3 are common in the Yarra River some 70–80 km upstream. Possible scenarios are that *Jappa* sp. AV3 once extended further downstream, that a second species once occurred in the vicinity of Melbourne and became locally extinct as water quality deteriorated, or that the type location "Melbourne" has been used loosely and that the holotype was collected further upstream or even elsewhere in the state. Comparison of the abdominal colour pattern of the holotype with freshly reared material from Victoria leaves no doubt about the identity of this species.

The suggested common name is "elongate horned *Jappa*."

### ***Jappa harkeræ* Bae & Campbell, n. sp. (Figs 2D,3D)**

*Jappa* sp. AV2: Dean, 1999: 35 (L key, figure).

**Description.** Imago. Unknown. Female subimago. Body length 19.2 mm. Forewings with membrane pale yellow-brown; costal and subcostal cells darker; stigmatic area deep reddish brown. Legs yellow, all femora with brown bands at midlength and at apex. Abdominal terga predominantly reddish-brown with darker brown band along midline; each segment with median light yellow triangle abutting posterior margin and with three small pale spots adjacent to anterior margin (appearing as a large W-shaped marking). Abdominal sterna yellow, with broad brown band along medial line; segments II–VIII with two pairs of pale spots within medial brown band and with two brown sublateral markings on either side of medial band; sternum IX deeply notched.

Larva (holotype). Body length of half grown larva 12.2 mm; cephalic tusks 1.2 mm; caudal filaments 9.4 mm. (Body length of reared female exuvium 22.0 mm). General body

colour light brown with dark purplish brown markings. Head (Fig. 2D) light brown, length 1.59 mm, width 2.38 mm, with dark brown markings between ocelli and on vertex. Antennae 5.6 mm in length. Cephalic tusks as long as length of head, strongly arched (curvature c. 21°), with distinct dorsal ridge, with large basodorsal tubercle; surface of tusks smooth, without spines, with apical setal tuft (number of setae c. 10). Pronotum light yellow, with submedian irregular longitudinal dark brown stripes extending to mesonotum and forewingpads. Femora of all legs with dark brown banding at midlength and near apex. Forefemora 2.54 mm, foretibiae 2.78 mm, foretarsi 0.95 mm and foreclaws 0.34 mm. Abdominal terga predominantly brown, darker along midline; each segment with pair of small pale spots near anterior margin, with large pale triangle overlying the midline and abutting posterior margin (appearing as a large W-shaped marking); segments VIII and IX with well developed posterolateral projections. Abdominal sterna with moderately broad dark brown stripe along midline, with two pairs of pale spots within medial stripe on each segment and two dark brown sublateral spots on either side of medial stripe. Gills (Fig. 3D) purplish brown, white marginally, with dark purplish brown median trachea, without lateral tracheae, with fine setae on apical 1/3 of inner margin and on apical 1/4 of outer margin, with strongly developed apical expansion (gill 4 expansion rate c. 0.10). Caudal filaments light yellow and purplish brown basally.

**Diagnosis.** The larva of *J. harkeriae* is distinguished from other species of *Jappa* by the strongly arched (curvature c. 21°) cephalic tusks that lack lateral spines and bear a prominent basal tubercle (Fig. 2D), the characteristic colour pattern on the dorsum and venter of the abdomen, and the form of the gills, which lack pigmented lateral tracheae and have a strongly developed apical expansion (Fig. 3D). The characteristic abdominal colour pattern is carried over to the subimago.

**Type material.** Holotype: Half grown female larva, Australia, southeast Queensland, Lower Stony Creek, Conondale Range, 26 Aug 1997, J. Dean [MV]. Paratypes: 6 larvae, same data as Holotype [MV].

**Other material.** *QLD*: 2 L, same data as Holotype [ANVC]; 2 L, same data as holotype [JDC]; 1 L, Petersen Ck, 17°16' S 145°35' E, 29 Aug 1995, B. Herbert [MV]; 1 L, Canungra Ck, Sarabah, 14 Oct 1994, DNRQ; 1 L, Logan R, Forest Home, 2 Dec 1994, DNRQ; 1 L, Boulder Ck, nr Mt Charlton, 20 Oct 1994, DNRQ; 3 L, Tinana Ck, Bauple East, 27 Nov 1996, DNRQ; 1 L, Coomera R, Tuckers Lane, 5 Nov 1996, DNRQ. *NSW*: 2 L, 1 FS (reared, with larval exuvium), Clouds Ck, Ebor-Grafton Rd, 30°05' S 152°38' E, 28 Nov 1998, J. Dean & P. Suter [JDC]; 1 L, Bellinger R, 23.7 km u/s Thora, 30°28' S 152°35' E, 29 Nov 98, J. Dean & P. Suter [JDC]; 1 L, Mann R, Grafton Rd, 1 Oct 1994, NSW EPA; 2 L, Clarence R, Paddys Flat, 27 Sep 1994, NSW EPA.

**Distribution.** QLD, NSW.

**Etymology.** The species name *harkeriae* is for Dr. Janet E. Harker (Sydney University) in recognition of her pioneering work on mayfly taxonomy in Australia.

**Remarks.** The suggested common name for this species is the “arched horned *Jappa*”.

### ***Jappa serrata* Skedros & Polhemus (Figs 1C, 2E, 3E)**

*Jappa serrata* Skedros & Polhemus 1986: 312 (L); Campbell 1988: 20 (catalogue); Hubbard & Campbell 1996: 26 (catalogue); Dean 1999: 35 (L key).

**Description & redescription.** Male imago. Body length 10.9–11.3 mm. General body colour light yellow with dark purplish brown markings. Thoracic nota with submedian and sublateral dark brown longitudinal stripes; pleura and sterna with irregular dark brown spots. Forewing length 10.8–11.3 mm, width 3.6 mm, without markings; longitudinal veins light yellow; crossveins in basal and anterior areas dark purplish brown; crossveins C-Sc 20, dark brown and strongly infuscated; crossveins Sc-R<sub>1</sub> 16, basally 1/2 dark brown; crossveins R<sub>1</sub>-R<sub>2</sub> 13, basally 1/2 dark brown. Hindwing length 2.3 mm, width 1.3 mm, without markings; veins white; crossveins C-Sc more or less evenly distributed. Femora of all legs with purple bands at midlength and at apex. Abdominal terga entirely purple except posterior and posterolateral margins (appearing as broad W-shaped markings). Abdominal sterna with broad median longitudinal purple stripe with unclearly demarcated margins. Penes (Fig. 1C) Y-shaped, 0.32 mm in length, with large opening apically; each lobe with numerous minute spine-like setae on ventral surface of distal half. Forceps light yellow; forceps segment 1 0.98 mm, segment 2 0.11 mm and segment 3 0.10 mm; forceps segment 1 narrowing abruptly at 2/3 length. Caudal filaments 19.1 mm, light yellow, with narrow and broad bands alternating basally on each segment. Female imago. Body length 14.2–18.0 mm. General body colour and markings similar to male. Compound eyes 0.47 mm in width; distance between compound eyes 1.67 mm (B/D = 3.5). Forewing length 15.6 mm, width 5.3 mm, without markings; crossveins generally dark brown; crossveins C-Sc strongly infuscated. Hindwing length 3.4 mm, width 1.9 mm; veins hyaline. Forefemora 3.8 mm, foretibiae 3.8 mm and foretarsi 2.4 mm. Abdomen colour and markings similar to male. Abdominal sternum IX deeply notched.

Larva. Male body length 16.9 mm; cephalic tusks 2.0 mm; caudal filaments 10.9 mm. Female body length 16.0–23.8 mm; cephalic tusks 2.0–3.5 mm; caudal filaments 12.5–18.1 mm. General body colour purplish yellow with dark purplish brown markings. Head (Fig. 2E) purplish yellow, length 2.38 mm, width 4.13 mm, with dark brown

markings at vertex, near compound eyes and between ocelli. Antennae 5.6 mm. Cephalic tusks c. 1.0–1.5 x length of head, strongly arched (curvature c. 21°), with moderately developed basodorsal tubercle, with distinct dorsal ridge; surface of tusks with single row of 7–8 strongly developed spines aligned dorsally in basal half of tusk and sweeping down to lateral surface near apex, without apical setal tuft. Labrum without distinct marginal ridge dorsally. Pronotum purplish brown, with submedian and sublateral dark purplish brown stripes extended onto mesonotum. Forefemora 4.88 mm, foretibiae 5.63 mm, foretarsi 1.63 mm and foreclaws 0.63 mm; forelegs light purplish brown, darker in colour apically; midlegs and hindlegs lighter in colour. Abdominal terga with W-shaped purplish brown markings, not clearly demarcated; segments VIII and IX with poorly developed posterolateral projections. Abdominal sterna light yellow, with weakly developed brown median and sublateral stripes. Gills (Fig. 3E) whitish grey, with dark brown median trachea, without lateral tracheae, with fine setae on apical 1/4 of inner margin and on apical 1/3 of outer margin, without apical expansion (gill 4 expansion rate 0). Caudal filaments purplish brown basally, light yellow apically, with alternating narrow and broad dark brown stripes.

**Diagnosis.** The male imago of *J. serrata* can be distinguished from other species of *Jappa* by the Y-shaped and moderately slender penes with numerous ventral spines (Fig. 1C) and the colour pattern on the venter of the abdomen. Larvae of *J. serrata* can be distinguished by the cephalic tusks (Fig. 2E), which have a single row of strongly developed spines, the abdominal colour pattern and by the abdominal gills which lack pigmented lateral tracheae and apical expansion (Fig. 3E).

**Type material.** Holotype: Immature larva (wingpads not visible), Queensland, Hutchinson Creek, Cape Tribulation Rd, N of Daintree Landing, 17 Aug 1983, D.A. & T.J. Polhemus [ANIC]. Paratypes: 1 L, same data as holotype [ANIC]; 3 L, same data as holotype [FAMU].

**Other material.** QLD: 20 L, Yuccabine Ck, 6 Sep 1982 [MU]; 2 MI, 1 FI (EPH-0918), Birthday Ck, 3.5 km WNN Paluma, 18°59' S 146°10' E, 19 Jan 1990, R. St.Clair [MV]; 6 MS (EPH-0919), Birthday Ck, 3.5 km WNN Paluma, 18°59' S 146°10' E, 4 Dec 1988 [MV]; 5 MS, 1 FS (EPH-0844), Birthday Ck, 3.5 km WNN Paluma, 18°59' S 146°10' E, 23 Dec 1989 [MV]; 1 L (EPH-1288), Birthday Ck nr Paluma, 29 Aug 1977, D. Cartwright [MV]; 2 FI (EPH-0915), 1 km N of Tully Falls, 8 Jan 1976, A. Walford-Huggins [MV]; 1 L (EPH-0871), small creek on Mission Beach Rd, 5 miles E of Tully, 23 Nov 1979 [ANVC]; 2 L (EPH-0872), Babinda Ck, The Boulders, 24 Nov 1979 [MV]; 1 L, Mulgrave R, 3 Oct 1991 [JCU]; 1 L, Ripple Ck, Benas Rd, 9 July 1998, DNRQ.

**Distribution.** QLD.

**Remarks.** Skedros and Polhemus (1986) described this species based on immature larvae. We herein redescribe the larva based on mature larval material and provide the first descriptions of the male and female imagos. Association of larva and imago is based on locality and similarity of abdominal colour pattern. Three paratype larvae of *J. serrata* were originally lodged in the Department of Biology, University of Utah, but have since been transferred to the Entomology Department of Florida A & M University (M. Hubbard, personal communication).

We suggest this species be known by the common name “large serrate horned *Jappa*”.

### ***Jappa strigata* (Eaton) (Figs 1D, 2F, 3F, 4A–F)**

*Leptophlebia strigata* Eaton 1871: 80 [Holotype: female imago, north Australia, McLachlan collection in British Museum (missing)].

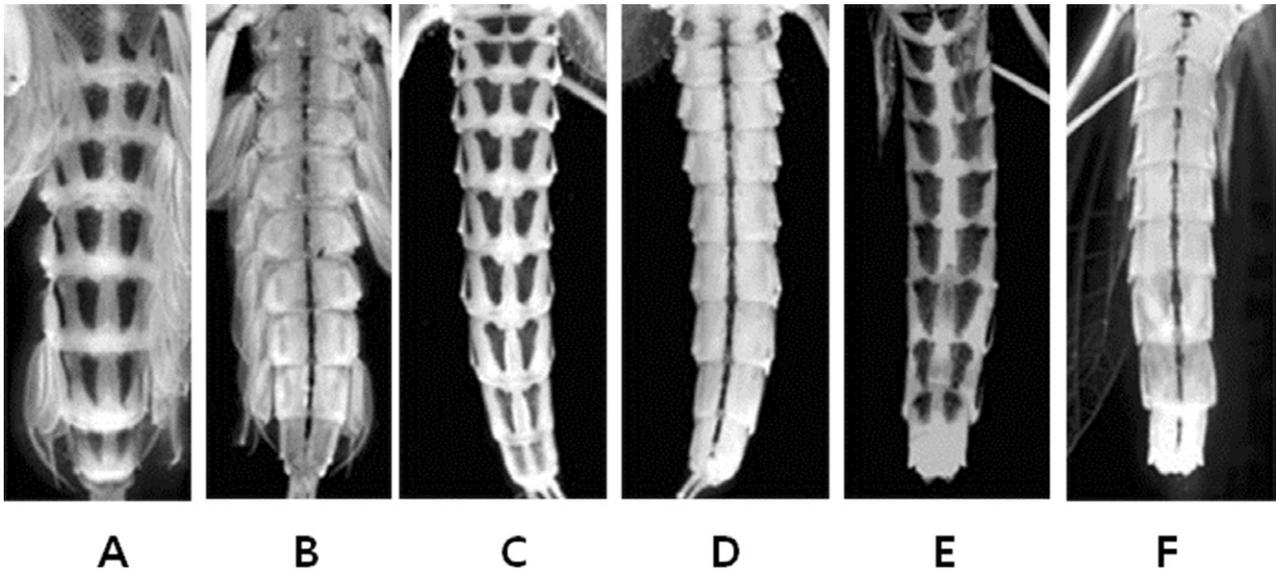
*Atalophlebia strigata* (Eaton): Eaton 1884: 88 (FI).

*Euphyurus bicornis* Ulmer 1916: 15 [Holotype: male imago; locality: Christmas Creek, Queensland; repository: Swedish Museum of Natural History, Stockholm]. (synonymised by Harker 1950).

*Deleatidium strigatum* (Eaton): Harker 1950: 29 (catalogue). [specimen from Dumaresque Cr., Armidale] Harker 1950: 31 [FI & L].

*Jappa kutera* Harker 1954: 257 [Holotype: male imago; locality: New South Wales, Armidale; repository: BMNH]; Campbell 1988: 20 (catalogue); Hubbard & Campbell 1996: 26 (catalogue); Dean 1999: 35 (L key, figure). New synonym.

**Redescription.** Male imago. Body length 10.6 mm. General body colour light yellow with dark purplish brown markings. Thoracic nota light yellow, with dark brown stripes; pleura and sterna with irregular dark brown markings. Forewing length 8.8 mm, width 2.9 mm, without markings; longitudinal veins purplish brown; crossveins dark purplish brown (basal crossveins darker); crossveins C-Sc 21, basal 1/2 strongly infuscated; crossveins Sc-R<sub>1</sub> 16; crossveins R<sub>1</sub>-R<sub>2</sub> 13. Hindwing length 2.9 mm, width 1.3 mm, without markings; longitudinal veins light yellow; crossveins C-Sc, Sc-R<sub>1</sub> and some in distal part dark brown; crossveins C-Sc 9, more or less evenly distributed; crossveins Sc-R<sub>1</sub> 6. Legs light yellow; intersegmental joints dark brown; forefemora with purplish brown markings at 2/3 apically; forefemora 2.22 mm, foretibiae 3.02 mm, foretarsal segment 1 0.13 mm, segment 2 1.08 mm, segment 3 1.00 mm, segment 4 0.76 mm segment 5 0.40 mm and foreclaws 0.24 mm. Abdominal terga with submedian and sublateral longitudinal dark brown stripes (as in Figs 4C,4E); submedian stripes marginally purple. Abdominal sterna with narrow median dark purplish brown stripe (as in Figs 4D,4F). Penes (Fig. 1D) Y-shaped, 0.40 mm in length, light yellow, slightly



**Figure 4** Abdomen of *Jappa strigata*: **A** larva, dorsal; **B** larva, ventral; **C** female subimago, dorsal; **D** female subimago, ventral; **E** female imago, dorsal; **F** female imago, ventral.

darker laterally, with large opening apically; each lobe with single ventrolateral spine; forceps light yellow; forcep segment 1 0.98 mm, segment 2 0.08 mm and segment 3 0.13 mm; segment 1 narrowing abruptly at 2/3 length; segments 2 and 3 indistinctly demarcated. Caudal filaments 18.1 mm, light yellow, with purplish brown joints (every 2nd joint thicker).

**Female imago.** Body length 12.0 mm. General body colour and markings similar to male. Compound eyes 0.33 mm in width; distance between compound eyes 1.53 mm ( $B/D = 4.7$ ). Forewing length 11.3 mm, width 3.6 mm, without markings; veins dark purplish brown (distal veins lighter in colour); crossveins C-Sc, Sc- $R_1$  and  $R_1$ - $R_2$  basal 1/2 infuscated. Hindwing length 2.5 mm, width 1.2 mm; veins hyaline. Forefemora 3.0 mm, foretibiae 3.7 mm and foretarsi 1.7 mm. Abdomen colour and markings (Figs 4E,4F) similar to male.

**Larva.** Male body length 10.4–11.7 mm; cephalic tusks 1.0–1.6 mm; caudal filaments 7.3–8.1 mm. Female body length 10.6–15.5 mm; cephalic tusks 1.4–2.2 mm; caudal filaments 6.9–12.0 mm. General body colour light brown with dark purplish brown markings. Head (Fig. 2F) light brown, length 1.51 mm, width 1.83 mm, with dark brown markings. Female compound eyes dorsally 0.32 mm in width and 1.51 mm in distance between compound eyes ( $B/D = 4.75$ ). Antennae 5.0 mm in length. Cephalic tusks moderately arched (curvature  $18^\circ$ ), with distinct dorsal ridge, with moderately large basodorsal tubercle; surface of tusks without dorsolateral row of spines, with apical hair-like setal field (number of setae c. 10). Pronotum purplish brown, with submedian and sublateral dark purplish brown

stripes. Mesonotum with submedian dark purplish brown stripes; mesosternum with transverse dark brown stripe anteriorly. Forefemora 1.67 mm, foretibiae 1.67 mm, foretarsi 0.71 mm and foreclaws 0.24 mm; forelegs light purplish brown to dark purplish brown, darker in colour apically; foreclaws black apically, with c. 10 tiny teeth 3/4 basally. Midlegs and hindlegs lighter in colour. Abdominal terga light purplish brown, with submedian and sublateral dark purplish brown stripes (submedian stripes posteriorly somewhat attenuating) (Fig. 4A); segments VIII and IX with well developed posterolateral projections. Abdominal sterna light yellow, with dark purplish brown narrow stripe along median line (Fig. 4B). Gills (Fig. 3F) light purplish brown, white marginally, with dark purplish brown median trachea and with distinct lateral tracheae, with fine setae on apical 1/5 of inner margin and entirely on outer margin, with strongly developed apical expansion (gill 4 expansion rate c. 0.10). Caudal filaments purplish brown basally, light yellow apically.

**Diagnosis.** The imago of *J. strigata* can be distinguished from other species of *Jappa* by the abdominal colour pattern, the narrow continuous dark stripe along the median line on the venter of the abdomen (Fig. 4F), the lack of distinct brown markings on the forewings and, in the male, by the shape of the penes (Fig. 1D). The larva of *J. strigata* can be distinguished by the moderately arched (curvature c.  $18^\circ$ ) cephalic tusks, which have a smooth surface and lack spines but have a moderately large basal tubercle (Fig. 2F), the abdominal colour pattern (including the heavily pigmented but narrow stripe along the midline of the abdominal sterna) (Fig. 4B), the presence of lateral tracheae

on the gills and the strong apical expansion of the gills (Fig. 3F).

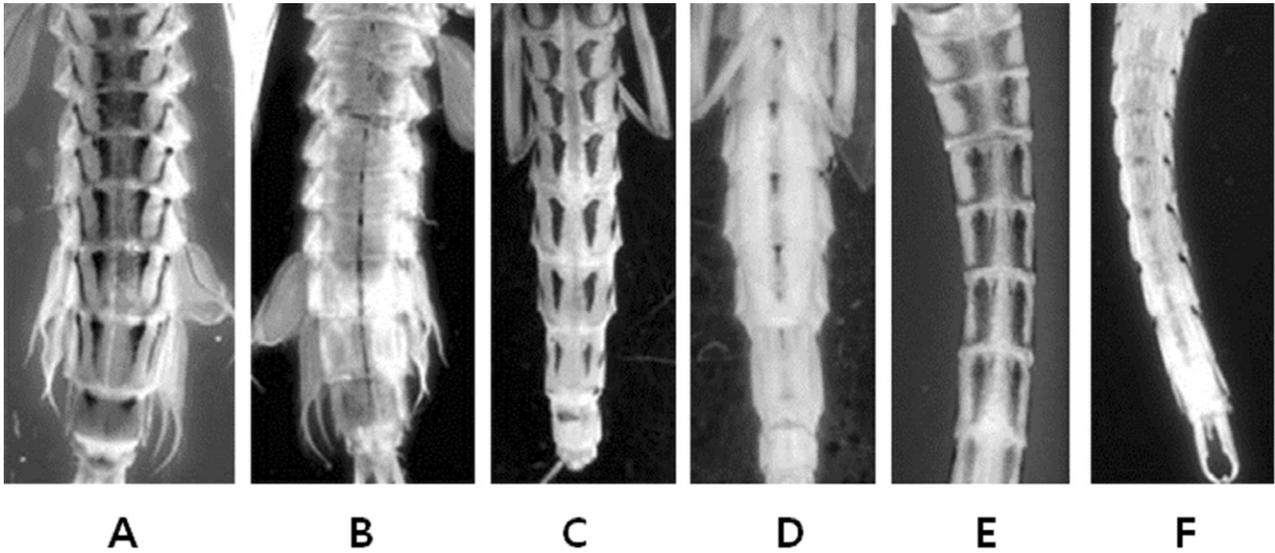
*Type material.* Neotype: Male imago (reared, with larval exuvium, EPH-0881), Queensland, McDonnell Creek, 250 m downstream of Cockatoo Creek junction, 11°39' S 142°28' E, 13 Feb 1992, D. Cartwright & A. Wells [MV].

*Other material.* NT: 1 L, S Alligator R, nr Fisher Ck Jct, 1 May 1990, D. Cartwright [MV]; 2 L, S Alligator R, Gimbat, 13°35' S 132°36' E, 24 May 1988, P. Suter; 3 L, S Alligator R, Gimbat, 13°35' S 132°36' E, 2 May 1990, D. Cartwright [MV]; 1 L, Dinner Ck, tributary of S Alligator R., 2 May 1990, D. Cartwright [MV]; 2 L, 1 MI (reared from nymph), Kambolgie Ck, 13°31' S 132°23' E, 16 Aug 1999, J. Dean; 1 L, creek 2 Km N of Bukbukluk Lookout, Kakadu Hwy, 13°29' S 132°15' E, 19 Aug 1999, J. Dean; 2 L, Grave-side Gorge, 13°18' S 132°32' E, 17–18 July 1988, P. Suter. QLD: 17 L, McDonnell Ck & Cockatoo Ck Jct, 80 m u/s, 11°39' S 142°28' E, 13 Feb 1992, D. Cartwright & A. Wells [MV]; 3 L, 1 MI, McDonnell-Cockatoo Ck Jct, 11°39' S 142°28' E, 13 Feb 1992, D. Cartwright & A. Wells; 2 FI (EPH-0883, eggs examined with SEM), Claudie R, Iron Range NP, 25 Km NW Lockhart R, 10 Nov 1988, MV light, K. Walker [MV]; 1 MI, Coen R, Coen, 13°58' S 143°12' E, 31 Oct 1988, K. Walker; 18 L, 1 MS, 2 FS, Cockatoo Ck, Telegraph Crs, 11°39' S 142°27' E, 5 Feb 1992, D. Cartwright & A. Wells [MV: ANVC]; 8 L, 2 MS, Eliot Ck, u/s Jct Canal Ck, 11°23' S 142°25' E, 6–7 Feb 1992, D. Cartwright & A. Wells [MV]; 9 L, 2 MS, 1 FI, Canal Ck, u/s Eliot Ck, 11°23' S 142°25' E, 6 Feb 1992, D. Cartwright & A. Wells; 10 L, 5 MS, 8 FI, Dulhunty R, Telegraph Crs, 11°50' S 142°30' E, 10, 15 Feb 1992, D. Cartwright & A. Wells [MV]; 4 L, Bertie Ck, Telegraph Crs, 11°50' S 142°30' E, 12 Feb 1992, D. Cartwright & A. Wells [MV]; 1 L, Rollingstone Ck, beside New Rd, 20 Aug 1988, R. St.Clair [MV]; 6 L, Bertie Ck, Telegraph Crs, 12 Feb 1992, D. Cartwright & A. Wells; 1 N, Burdekin R, 15 Sept 1991 [JCU]; 2 L, Logan R, Rathdowney, 3 Nov 1998, DNRQ; 3 L, Fitzroy R, Wattlebank, 27 Oct 1994, DNRQ; 1 L, Brisbane R, Savages Crs, 19 July 1996, DNRQ; 6 L, Mary R, Bellbird Ck, 3 Nov 1994, DNRQ; 2 L, MacIntyre Brook, Inglewood, 6 Oct 1999, DNRQ; 6 L, Mary R, Duncombes, 12 Oct 1999, DNRQ; 4 L, Teemburra Ck, Captains Crs, 28 Oct 1999, DNRQ; 2 MS, 1 FS, Hann R, 70 miles S of Coen, 23 Jun 1970, Le Souef; 2 L, Mazlin Ck, 17°14' S 145°33' E, 1 Aug 1995, B. Herbert; 3 MI, 1 FI, Glastonbury Ck, 15 km W of Gympie, 27 Oct 1980, A. Neboiss; 3 L, Murgon, site 1, Bjelke-Petersen Dam Study, 1 Sep 1989, S. Bunn. NSW: 2 L, Brays Ck nr Mt Warning, 7 Dec 1979, D. Cartwright [MV]; 7 L, Billabong Ck, Hume Hwy c. 18 km NE of Holbrook, 36°37' S 147°29' E, 13 Feb 2001, Y.J. Bae & P. Suter [MU]; 1 L, Dumaresq Ck, Weir Rd u/s Armidale, 30°29' S 151°37' E, 25 Nov 1998, J. Dean & P. Suter; 8 L, 1 MS (reared from nymph), Woolomombi R, nr Kilcoy Cemetery, 30°26' S

151°59' E, 25 Nov 1998, J. Dean & P. Suter; 4 L, 1 FI (reared from nymph), Gara R, Thalgarrah Field Study Centre, 30°26' S 151°49' E, 25 Nov 1998, J. Dean & P. Suter; 2 L, 1 FS, Gara R, Guyra-Dorrigo Rd, 30°12' S 151°43' E, 26 Nov 1998, J. Dean & P. Suter; 9 L, Commissioners Waters, 4 km E of Armidale, 30°33' S 151°43' E, 24 Nov 1998, J. Dean & P. Suter; 7 MS, 3 FS, Doon Doon Ck, Tweed R, 28 Apr 1979; 3 L, Hastings R, Korie Is, 31.4551 S 152.6611 E, 7 Apr 1995, NSW EPA; 2 L, Hastings R, The Crest, 31.4639 S 152.6032 E, 10 Apr 1995, NSW EPA; 1 L, Ellenborough R, u/s Ellenborough, 31.4608 S 152.4706 E, 20 Apr 1996, NSW EPA; 1 L, Williams R, Thalba Br, 32.4689 S 151.7603 E, 18 Oct 1995, NSW EPA; 1 L, Goulburn R, nr Tunbridge Ck, 32.3086 S 150.2386 E, 3 Apr 1996, NSW EPA; 1 L, Upper Hunter R, u/s Moonan Flat, 31.9074 S 151.2603 E, 9 Apr 1995, NSW EPA; 1 L, Pages R, Blandford, 31.7891 S 150.8971 E, 15 Apr 1997, NSW EPA; 2 L, Abercrombie R, u/s Isabella R, 34.03 S 149.4944 E, 20 Mar 1996, NSW EPA; 1 L, Rocky Br Ck, u/s Piesleys Ck, 33.8573 S 149.1371 E, 24 Mar 1995, NSW EPA; 2 L, Lachlan R, d/s Humes Ck, 34.7398 S 149.2971 E, 18 Mar 1996, NSW EPA; 2 L, Grabben Gullen Ck, u/s Lachlan R, 34.5386 S 149.1576 E, 15 Nov 1995, NSW EPA; 5 L, Lachlan R, Narrawa Mt, 34.3726 S 149.1098 E, 15 Nov 1995, NSW EPA; 3 L, Boorowa R, Prossers Crs, 34.1439 S 148.8092 E, 21 Mar 1996, NSW EPA; 1 L, Towamba R, N of Burragate, 36.9913 S 149.608 E, 25 Oct 1995, NSW EPA; 2 L, Towamba R, Coolangubra, 36.8971 S 149.4612 E, 16 Oct 1994, NSW EPA. VIC: 1 L, Samaria Ck, Mt Samaria Rd, 7 Oct 1999, EPA VIC; 3 L, Samaria Ck, Mt Samaria Rd, 3 Mar 1999, EPA VIC; 6 L, Home Ck, Old Yarck Rd, 9 Apr 1997, EPA VIC; 1 L, Spring Ck, Maroondah Hwy, 28 Oct 1997, EPA VIC.

*Distribution.* NT, QLD, NSW, VIC.

*Remarks.* In the original description of *Leptophlebia strigata* Eaton (1871), Eaton made it clear that the undersurface of the abdomen of the holotype (female imago) featured “a median black ventral line extending its whole length” (see Fig. 4F). The only other species of the genus which display this feature are *J. bicornis* (Ulmer 1916), *J. kutera* Harker 1954 and *J. suteri* Bae & Finlay n. sp., all of which occur in northern Australia. However, the ventral abdominal stripe in imagos (Fig. 5F) and subimagos (Fig. 5D) of *J. suteri* is less strongly developed and the distributional range of *J. suteri* is limited to the western half of northern Australia. Apart from *J. suteri*, we have been unable to distinguish between material from New South Wales, Cape York Peninsula and the Kakadu region of the Northern Territory. We therefore synonymise both *J. bicornis* (Ulmer) and *J. kutera* Harker with *J. strigata* (Eaton). *Jappa bicornis* (Ulmer) was previously synonymised with *J. strigata* (Eaton) by Harker (1950) without explanation.



**Figure 5** Abdomen of *Jappa suteri*: **A** larva, dorsal; **B** larva, ventral; **C** female subimago, dorsal; **D** female subimago, ventral; **E** male imago, dorsal; **F** male imago, ventral.

The holotype of *Leptophlebia strigata* Eaton, supposedly housed in the McLachlan Collection of British Museum, is apparently missing (K.J. Finlay, unpublished data). The male and female type specimens of *Euphyurus bicornis* Ulmer (1916), housed in the Swedish Museum of Natural History in Stockholm, could not be located in 2004 (K.A. Johanson, personal communication). It has previously been reported that the holotype male of *J. kutera* Harker was lodged in the Australian Museum (Campbell 1988). This, however, may be erroneous. When describing the species, Harker (1954: p. 257) stated that the material was “In the Australian Museum Collection, in spirit”. But this can be interpreted as referring solely to the material Harker had listed in the previous sentence, namely the Allotype female, morphotype subimago and nymph. These had been described but not named in a previous publication (Harker 1950: pp. 31–32). While holotypes of species described in Harker (1950) were lodged in the Australian Museum, species described in Harker (1954) were based in the “Tillyard Collection” which was housed in the British Museum and designated holotypes would be expected to remain in that institution. Indeed, in her checklist, Harker (1954: p. 266) specifically states that the type of *J. kutera* Harker is lodged in the British Museum. The holotype of *J. kutera*, however, cannot be located in either repository and for the present must be considered lost. Despite the absence of type material, the identities (and synonymies) of the three above species are confirmed by the original descriptions. In the absence of the holotypes, we herein nominate a reared male imago from north Queensland as the neotype of *Jappa strigata* (Eaton).

The suggested common name of this species is the “common horned *Jappa*”

***Jappa suteri* Bae & Finlay, n. sp.**  
(Figs 2G, 3G, 5A–F)

*Jappa* sp. 1: Suter 1992: 20 (L key, figure).

*Jappa* sp. AV1: Dean 1999: 35 (L key, figure).

**Description.** Male imago. Body length 11.2–11.8 mm. Forewings with membrane predominantly hyaline, stigmatic area opaque white, brown pigmentation absent apart from slight suffusion around costal crossveins in basal half of wing. Legs light yellow, all femora without banding. Abdominal terga pale yellow along midline; either side of midline with two elongate brown streaks, a relatively narrow submedian streak and a thinner, oblique sublateral streak (Fig. 5E); anterior width of submedian streak < 1/3 length. Abdominal sterna pale yellow; brown pigment overlying midline usually not prominent, restricted to anterior part of each segment (Fig. 5F). Penes Y-shaped; each lobe moderately slender, widely separated, apically upturned with lateral ridge, without subapical spine (as in Fig. 1D).

Female subimago. Body length 17.5 mm. Wings uniformly pale grey-yellow; darker markings restricted to costal crossveins in basal half. Abdominal colour pattern (Figs 5C, 5D) similar to imago.

Larva (holotype). Body length 14.8 mm; cephalic tusks 1.7 mm; caudal filaments 10.6 mm. General body colour light yellow to light brown with dark purplish brown markings. Head (Fig. 2G) light brown, with irregular dark brown

markings; length 1.91 mm, width 2.54 mm. Antennae 6.3 mm in length. Cephalic tusks moderately arched (curvature c. 18°), with indistinct dorsal ridge, with small basodorsal tubercle; surface of tusks with dorsal row of 6–7 spines and lateral row of 6–7 spines, with apical hairlike setal field (number of setae c. 15–20). Pronotum light yellowish brown with large paired C-shaped dark purplish brown markings opposite to median line. Forefemora 2.75 mm, foretibiae 4.50 mm, foretarsi 1.13 mm and foreclaws 0.38 mm; forefemora light yellow, without markings. Midlegs and hindlegs lighter in colour. Abdominal terga light purplish brown, with submedian and sublateral dark purplish brown stripes, submedian stripes narrow, somewhat attenuating posteriorly (Fig. 5A); segments VIII and IX with well developed posterolateral projections. Abdominal sterna light yellow, with dark purplish brown narrow stripe along median line (Fig. 5B). Gills (Fig. 3G) light purplish brown, white marginally, with dark purplish brown median trachea and with distinct lateral tracheae, with fine setae on apical 1/2 of inner margin and on apical 1/2 of outer margin, with weakly developed apical expansion (gill 4 expansion rate c. 0.03). Caudal filaments light yellow.

**Diagnosis.** The imago and subimago of *J. suteri* can be distinguished from other species of *Jappa* by the absence of brown markings on the forewings (apart from small suffusions around the costal crossveins in the basal half of the wing), the relatively narrow submedian streak on the dorsum of each abdominal segment and the reduction of the median line on the venter of the abdominal segments. The larva can be distinguished by the moderately arched (curvature c. 18°) cephalic tusks, which possess a series of spines along both the dorsal ridge and the lateral surface, the relatively small basodorsal tubercle, the dark line along the midline of the venter of the abdomen, the usually conspicuous lateral tracheae and moderately developed apical expansion of the gills (Fig. 3G).

**Type material.** Holotype: Almost fully grown larva (EPH-0942), Australia, Western Australia, Drysdale R, Kalumburu Road Crs, 15°42' S 126°22' E, 28 Aug 1996, I. Edwards [MV]. Paratype: 1 larva, same data as holotype [ANVC].

**Other material.** WA: 3 L, Meda R, nr Leonard R Gorge, 10 May 1995, CALM; 5 L, Meda R, Richenca Gorge, 12 Oct 1995, CALM; 1 L, King Edward R, Kalumburu, 11 Oct 1995, CALM; 3 L, King Edward R, Kalumburu, 21 May 1996, CALM; 1 L, King Edward R, Upper King Edward, 21 May 1996, CALM; 4 L, Mitchell R, Upper Mitchell, 11 Oct 1995, CALM; 2 L, Drysdale R, upper reaches, 16°09' S 125°58' E, 7 Sep 1996, I. Edwards; 2 L, Drysdale R, Kalumburu Rd, 15°42' S 126°22' E, 28 Aug 1996, I. Edwards; 1 L, Emma Gorge, 30 km N El Questro, 15°46' S 127°58' E, 27 Aug 1996, I. Edwards; 1 L, Mitchell R Falls, 14°47' S

125°40' E, 2 Sep 1996, I. Edwards; 1 L, Pearsons Ck, 16°01' S 125°35' E, 5 Sep 1996, I. Edwards; 2 L, Adcocks Gorge, Kimberley, 27 Jul 1994, D. Cartwright; 2 MS, 1 FS, Drysdale R, upper reaches, 16°09' S 125°58' E, 7 Sep 1996, I. Edwards; 1 MS, 1 FI, King Edward R, 14°54' S 126°12' E, 3 Sep 1996, I. Edwards; 1 MS, 1 FS, Bell Gorge, Melaleuca Hole, 17°01' S 125°14' E, 13 Sep 1996, I. Edwards; 1 MS, Ord R, 9 km N of Kunnanurra, 19 Sep 1979, J. Blyth. **NT.** 5 L, d/s Florence Falls, Litchfield NP, 13°06' S 130°47' E, 31 Aug 1999, J. Dean; 1 FS (reared from nymph), 1 L, Walker Ck, Litchfield NP, 13°05' S 130°42' E, 31 Aug 1999, J. Dean; 1 L, u/s Tolmer Falls, Litchfield NP, 13°12' S 130°43' E, 31 Aug 1999, J. Dean; 1 MI (reared from nymph), Grave-side Gorge, 13°18' S 132°32' E, 29 May 1988, P. Suter; 1 MI (reared from nymph), 2 L, Graveside Gorge, 13°18' S 132°32' E, 17–18 July 1988, P. Suter; 1 L, Magela Ck, u/s Magela Falls, 12°47' S 133°06' E, 29 May 1988, P. Suter; 1 L, Magela Ck, 1.5 km d/s Bowerbird Billabong, 12°46' S 133°02' E, 28 May 1988, P. Suter.

**Distribution.** NT, WA (Kimberley region).

**Etymology.** This species is named for Dr. Phil Suter (La Trobe University), who first collected and recognized this species.

**Remarks.** The suggested common name is the “double serrate horned *Jappa*”.

## Key to the species of *Jappa*

### Adult.

1. Male penes V-shaped; each lobe elongate and very slender (Fig. 1A); ventral abdomen with broad longitudinal stripe containing a pair of larger anterior spots and a pair of smaller posterior spots on each segment; QLD, NSW, VIC.....*J. campbelli*  
– Male penes Y-shaped; each lobe moderately slender (Figs 1B, 1C, 1D); ventral abdomen colour pattern diverse.....2
2. Male penes basolaterally thicker (Fig. 1B); ventral abdomen each segment with smaller anterosubmedian and larger posterosubmedian markings connected with arms and together forming broad purplish brown marking in almost entire area; NSW, VIC.....*J. furcifera*  
– Male penes basolaterally not thicker (Figs 1C, 1D); ventral abdomen either with broad median stripe or narrow median stripe.....3
3. Ventral abdomen with broad median stripe; QLD.....*J. serrata*  
– Ventral abdomen with narrow median stripe (Figs 4D, 4F, 5D, 5F).....4
4. Ventral abdomen with distinct median stripe (Figs 4D, 4F); NT, QLD, NSW, VIC.....*J. strigata*  
– Ventral abdomen with indistinct median stripe (Figs 5D, 5F); WA, NT.....*J. suteri*

*Larva.*

1. Cephalic tusks without lateral spines or fine crenulations (Figs 2C,2D,2F)..... 2
  - Cephalic tusks with lateral spines or fine crenulations (Figs 2A,2B,2E,2G)..... 4
2. Cephalic tusks greatly elongated (c. 1.7 x length of head) and weakly arched inward (curvature c. 15°) (Fig. 2C); NSW, VIC..... *J. furcifera*
  - Cephalic tusks moderately elongated (c. 0.8–1.0 x length of head) and moderately to strongly arched inward (curvature c. 18–21°) (Figs 2D,2F)..... 3
3. Cephalic tusks moderately arched inward (curvature c. 18°); cephalic tusk basal tubercle relatively small (Fig. 2F); gills lateral tracheae distinct (Fig. 3F); venter of abdomen with narrow stripe along median line (Fig. 4B); NT, QLD, NSW, VIC..... *J. strigata*
  - Cephalic tusks strongly arched inward (curvature c. 21°); cephalic tusk basal tubercle relatively large (Fig. 2D); gills lateral tracheae indistinct (Fig. 3D); venter of abdomen with broad band overlying the median line; NSW, QLD..... *J. harkeriae*
4. Cephalic tusks with prominent lateral prong at 2/3 length appearing tusks bifurcate (Fig. 2B); NT, QLD..... *J. edmundsi*
  - Cephalic tusks without prominent lateral prong, with row of spines or fine crenulations (Figs 2A,2E,2G)..... 5
5. Cephalic tusks with single row of strongly developed spines appearing tusks serrate (Fig. 2E); QLD..... *J. serrata*
  - Cephalic tusks with two rows of small spines or fine crenulations on dorsal and lateral ridges (Figs 2A,2G)..... 6
6. Dorsal and lateral ridges on cephalic tusks distinct, with rudimentary spines on dorsal ridge and fine crenulations on lateral ridge (Fig. 2A); gills lateral tracheae indistinct (Fig. 3A); NSW, QLD, VIC..... *J. campbelli*
  - Dorsal and lateral ridges on cephalic tusks indistinct, with distinctive spines on dorsal and lateral ridges (Fig. 2G); gills lateral tracheae distinct (Fig. 3G); NT, WA..... *J. suteri*

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