

**A NEW SPECIES OF AN  
AUSTRALIAN BURROWING MAYFLY  
(LEPTOPHLEBIIDAE, EPHEMEROPTERA)**

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*Abstract.*—A new species of Australian burrowing mayfly, *Jappa campbelli* sp. n. (Leptophlebiidae, Ephemeroptera) is described from reared adults, larvae, and eggs. Line drawings and SEMs of key characters are included. This species is the first in the genus to be described from temperate eastern Australia. In the adult it can be characterized by V-shaped and slender penes and purple-brown markings surrounding the bulla and base of MA fork in the forewing. In the larva it can be characterized by double serrate cephalic horns and a marginally ridged labrum in the head. Distributional and ecological notes are provided.

*Key Words.*—*Jappa campbelli*, Leptophlebiidae, Ephemeroptera, taxonomy, Australia.

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INTRODUCTION

The endemic Australian burrowing mayfly genus *Jappa* Harker (Leptophlebiidae, Ephemeroptera), although rare, is relatively well known among members of the family due to its unique larval morphology that is associated with hyporheic adaptation in streams (Riek 1970, Campbell 1990, Peters & Campbell 1991). The larvae possess characteristic cephalic horns that are analogous to the mandibular tusks in the burrowing mayfly family Potamanthidae from the northern hemisphere (Bae & McCafferty 1991, 1995; Edmunds & McCafferty 1996, Bae et al. 2003). The larvae are usually found in pools of mid-sized to large streams where the substrate consists of cobble or boulder-sized stones embedded in gravel, sand and silt (Riek 1970, Peters & Campbell 1991). There have also been reports of *J. kutera* associated with springs comprising mud substrate, moss and other low vegetation (Edmunds & McCafferty 1996).

The generic concept of the genus was recently refined by Bae et al. (2003) and includes three species, *Jappa kutera* Harker, *J. edmundsi* Skedros & Polhemus, and *J. serrata* Skedros & Polhemus (Harker 1950, 1954; Skedros & Polhemus 1986, Campbell 1988, Hubbard & Campbell 1996, Bae et al. 2003). In addition to these nominal species, four species of larvae have also been informally classified as *Jappa* with drawings of their diagnostic key characters (Dean 1999).

The present distribution of the genus encompasses northern Australia and along the eastern seaboard primarily in tropical areas (Skedros & Polhemus 1986, Dean 1999). From our recent field investigations and rearing experiments, however, we recognized a new species of the genus from eastern temperate Australia. Therefore this is considered the first formally described species of *Jappa* to occur within a temperate climatic zone and also the first formally described species of *Jappa* from Victoria.

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## MATERIALS AND METHODS

Larvae were collected by kick sampling and were preserved in 80% ethanol or kept alive for rearing in which case they were placed in a container of water for transportation to the laboratory. Associations between the larvae and adults were made using a new rearing chamber and techniques described in Finlay (2001). Imagos emerged within seven days in a constant temperature room with the temperature initially set at 18° C and increased to 20° C after four days.

Material for the Scanning Electron Microscope (SEM) was prepared using the methods described by Finlay (2000).

Description terminology follows that of Bae & McCafferty (1991). Relative eye size of the male imagos was measured by the formula  $ES = B/D$  following Bae & McCafferty (1991) where  $ES$  = compound eye size,  $B$  = shortest distance between compound eyes, and  $D$  = longest dorsal diameter of a compound eye. The curvature of cephalic horns is measured by the angle between the direct line of length of horn and the direct line from base of medial margin to midlength of the horn. The expansion rate of gill is defined by the ratio of vertical height of apicomedial 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 (measured by the direct line of length from base of gill to base of apical filament of gill).

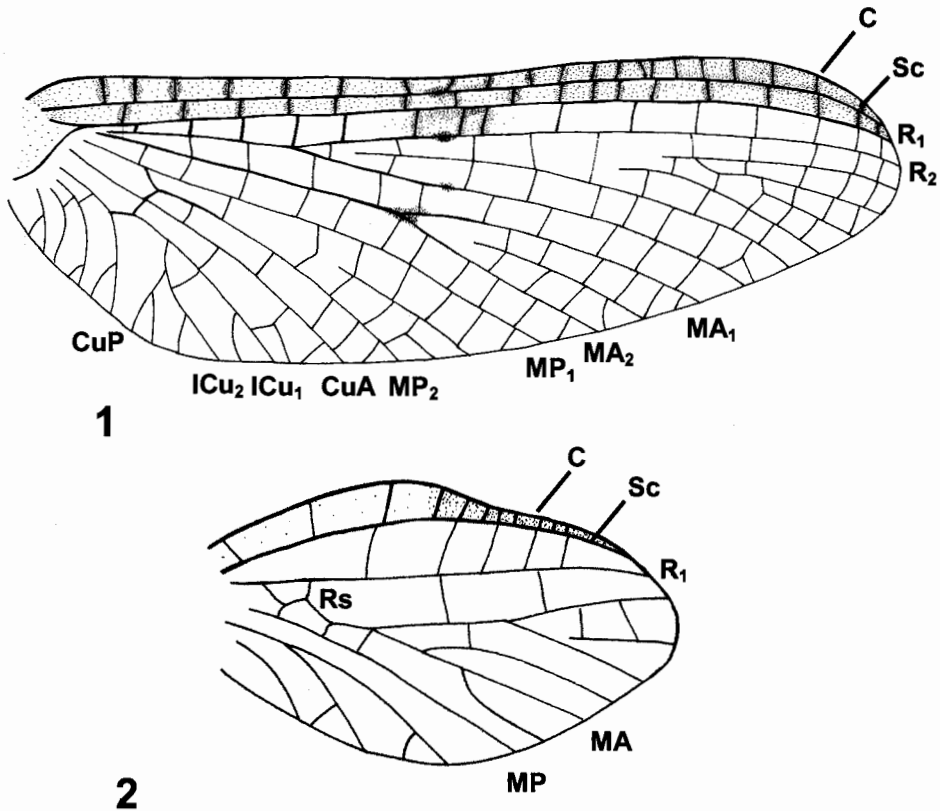
All specimens have been deposited in the National Museum of Victoria (NMV).

**JAPPA CAMPBELLI, BAE & FINLAY, NEW SPECIES*****Jappa* sp. AV4: Dean, 1999: 34.**

(Figs. 1–12)

*Types*.—Holotype (T-17939), male imago (reared, with larval exuvium), data: AUSTRALIA, Victoria, Licola, Wellington R., 3 km upstream from Alpine National Pk entrance, 146°37' E, 37°34' S, 6 Jan 2002 (emerged 13 Jan 2002), K. J. Finlay, Y. J. Bae & N. Ainsworth; deposited: AUSTRALIA, National Museum of Victoria, Melbourne. Paratypes: same data as holotype, 2 male (T-17940, 17941) and 2 female (T-17942, 17943) imagos (reared, with larval exuviae), 10 larvae, 6 male (T-17944–17949) and 4 female (T-17950–17953) larvae (fully grown); deposited: AUSTRALIA, National Museum of Victoria, Melbourne.

*Description*.—Male imago. Body length 10.7 mm; caudal filament length 15.0 mm. General body color dark purple-brown. Head: Dorsal compound eyes yellow-brown in alcohol, broadly connected posteriorly ( $ES = 0$ ), dome-shaped, oval dorsally and somewhat laterally angled, length 1.20 mm, width 1.08 mm, height 0.68 mm; basal compound eyes yellow-brown, dome-shaped, invisible in dorsal view, length 0.67 mm, height 0.58 mm, oriented anteriorly from lateral view. Antennae dark brown, length 1.0 mm. Thorax: Thorax dark purple-brown; pronotum and mesonotum with light yellow areas medially; pleura with irregular white areas; mesonotum posteromedial hump dark brown, moderately angled in lateral view (angle ca. 45°); sterna dark purple-brown with light yellow areas. Forewings (Fig. 1) transparent, length 10.7 mm, width 3.4 mm, with small dark purple-brown markings at base of costal margin, near bulla, in stigmatic area and at base of MA fork; longitudinal veins light purple-brown; crossveins blackish brown; numbers of crossveins C-Sc 21, Sc-R<sub>1</sub> 17, and R<sub>1</sub>-R<sub>2</sub> 15, strongly infuscated; 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). Hindwings (Fig. 2) transparent, without markings, length 2.3 mm, width 1.4 mm, veins hyaline; crossveins C-Sc 11 in number, apically concentrated; costal area round with weakly developed costal projection at mid-length; vein Rs length 0.48 mm, R<sub>1</sub> 0.75 mm, MPs 0.25 mm, and MP<sub>1</sub> 1.25 mm. Legs light yellow with dark purple-brown markings at subbasal, middle, and subapical femora, apical tibiae and tarsi 1, each tarsal joint and at claws; claws dissimilar; forefemora lengths 2.10 mm, foretibiae 2.90 mm, foretarsi



Figures 1-2. *Jappa campbelli*, male imago. Figure 1. forewing. C = costa, Sc = subcosta, R = radius, MA = medius anterior, MP = medius posterior, CuA = cubitus anterior, ICu = intercalary cubitus, CuP = cubitus posterior. Figure 2. hindwing. C = costa, Sc = subcosta, Rs = radial sector, R<sub>1</sub> = radius<sub>1</sub>, MA = medius anterior, MP = medius posterior.

segments 1, 2, 3, 4, and 5 0.13 mm, 1.25 mm, 1.15 mm, 0.85 mm, and 0.38 mm respectively, foreclaws 0.15 mm; midfemora lengths 1.75 mm, midtibiae 2.25 mm, midtarsi 0.75 mm, midclaws 0.15 mm; hindfemora lengths 2.00 mm, hindtibiae 2.10 mm, hindtarsi 0.70 mm, hindclaws 0.15 mm. Abdomen: Terga purple-brown to dark purple-brown with dark purple-brown sublateral longitudinal stripes, longitudinal median white stripe and lateral and posterosublateral white areas; segment 9 with moderately developed posterolateral projections. Sterna dark purple-brown medially and light brown laterally; each median dark purple-brown area with 2 pairs of tiny white spots (anterior spots larger and wider). Penes (Fig. 3) V-shaped, slender, length 0.33 mm, ca. half the length of forceps segment 1; each lobe light yellow medially and purple-brown laterally, apically round, without setae; forceps (Fig. 3) segment 1, 2, and 3 lengths 0.92 mm, 0.12 mm, and 0.12 mm respectively; forceps segment 1 dark purple-brown basally and light purple-brown apically, broad basally and narrow apically with abrupt constriction at three-fifths length, arched inward and upward at constriction, with inner expansion in apical fifth; forceps segments 2 and 3 indistinctly demarcated, mesial side light brown and dark brown laterally, brown with black hue at joints. Caudal filaments light yellow with dark purple-brown markings at joints (markings at every second segment pronounced); cerci 14.0 mm, ca. 1.3× length of body; terminal filament 15.0 mm.

Female imago. Body length 12.0 mm. General body color and markings similar to male. Head: Compound eyes width 0.33 mm; distance between compound eyes 1.53 mm (ES = 4.7). Thorax: Forewings length 11.3 mm, width 3.6 mm, venation similar to male; veins dark purple-brown (distally located veins lighter in color); crossveins C-Sc, Sc-R<sub>1</sub>, and R<sub>1</sub>-R<sub>2</sub> infuscated in basal half of wing. Hindwings hyaline, length 2.5 mm, width 1.2 mm, veins hyaline; venation similar to male. Forefemora

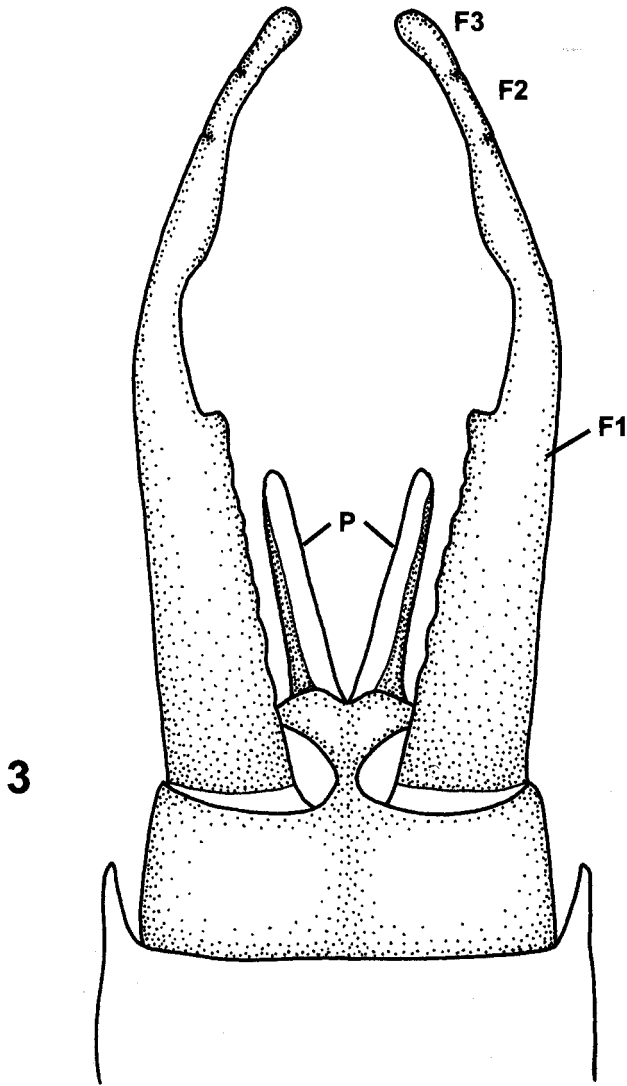
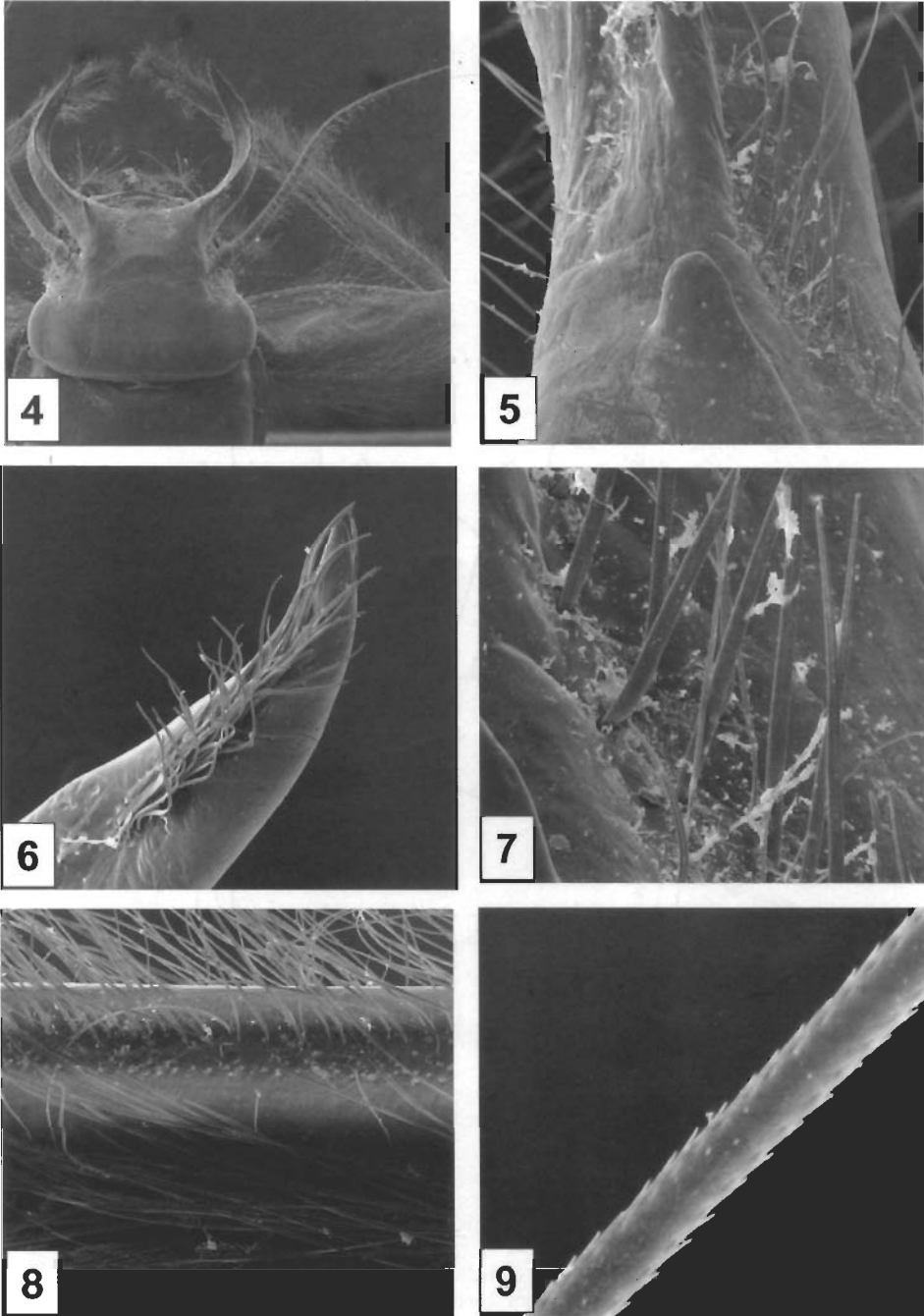


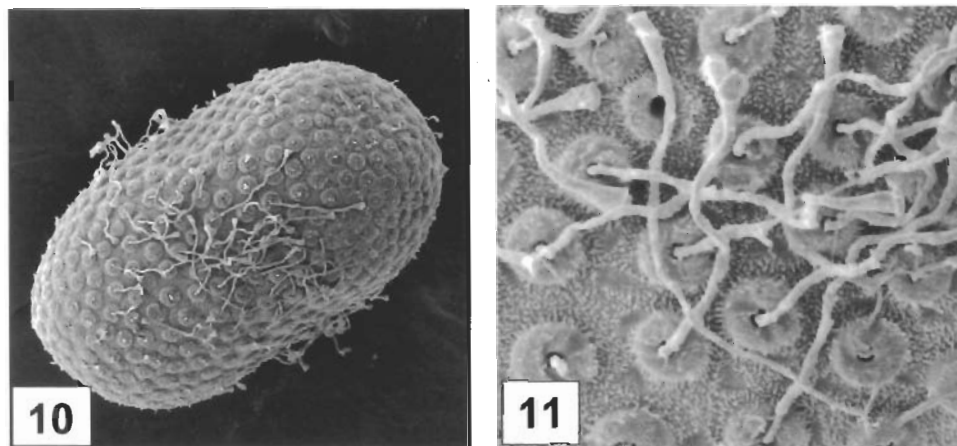
Figure 3. *Jappa campbelli*, ventral view of male imago genitalia: P = penes, F1, F2 & F3 = forcep segments 1, 2 & 3 respectively.

lengths 3.0 mm, foretibiae 3.7 mm, foretarsi 1.7 mm. Abdomen: Color and markings similar to male. (Caudal filaments broken.)

Mature larva. Male body length 10.3 mm; cephalic horns 1.0 mm; caudal filaments 7.0 mm. Female body length 10.4–12.7 mm; horns 1.0–1.4 mm; caudal filaments 7.2–9.2 mm. Body surface shiny and highly setose. General body color light yellow with dark brown markings. Head (Fig. 4) light brown with dark brown markings, length 1.55 mm, width 2.20 mm, dark brown transverse stripes at vertex, dark brown areas near compound eyes and between lateral ocelli, light yellow areas around basal horns and along clypeal margins. Male compound eyes width 0.75 mm dorsally, distance between compound eyes 0.65 mm (ES = 1.15). Female compound eyes width 0.35 mm dorsally, distance between compound eyes 1.33 mm (ES = 3.79). Antennae length 5.3 mm with whorls of hairlike setae at each segment. Cephalic horns (Fig. 4) attenuating, apically convergent and directed upward, light purple-brown basally and light

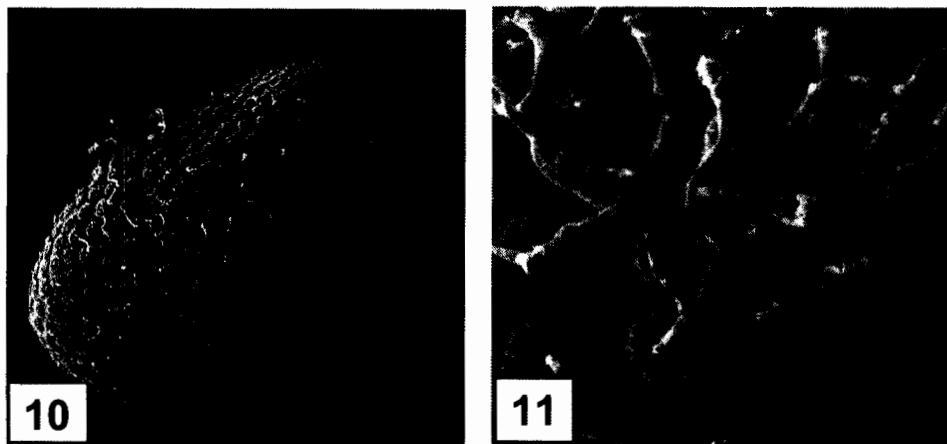


Figures 4–9. *Jappa campbelli*, SEMs of larva. Figure 4, dorsal head and thorax, scale bar = 1.00 mm. Figure 5, basal horn, scale bar = 86  $\mu$ m. Figure 6, terminal horn, scale bar = 100  $\mu$ m. Figure 7, basosublateral setal field, scale bar = 30  $\mu$ m. Figure 8, foretibia, in part, scale bar = 120  $\mu$ m. Figure 9, seta on foretibia, scale bar = 8.6  $\mu$ m.



Figures 10–11. *Jappa campbelli*. SEMs of egg. Figure 10, whole egg, scale bar = 38 µm. Figure 11, egg surface, scale bar = 8.6 µm.

yellow apically, inner length 1.00–1.45 mm, outer length 1.25–1.75 mm, curvature 23.6°, with distinct dorsal and lateral ridges and prominent basodorsal tubercle (Fig. 5), with ca. 10, 15 and 40 simple hairlike setal fields in basomesial, basosublateral (Figs. 5 and 7) and apicodorsal areas respectively (Fig. 6), with row of 4–6 dorsal and 10–13 lateral spines along ridges. Labrum distally wider (maximum length 0.36 mm; basal width 0.78 mm; distal maximum width 0.94 mm), distinct marginal ridge dorsally; intersegmental area between clypeus and dorsal labrum with row of ca. 40 long hairlike setae; dorsal surface of labrum heavily setose with basal and subapical hairlike setal rows (basal setae longer than subapical setae); rowed subapical setae laterally longer, with ca. 15 setae densely arranged medially; lateral and anterior margins with hairlike setal row; anterior margin concave with prominent median tubercle; ventral surface with dense hairlike setal field along anterior margin, with ca. 10–15 light purple-brown stout setae in row at each side of subanterior margin, and field of ca. 50 light purple-brown hairlike setae broadly and centrally located on each side. Mandibles dorsolateral margins with very long hairlike setal row; ventral surface central area with ca. 20 light yellow setae rowed transversely; protheca rudimentary, with well developed fringe; right mandible outer incisor larger than inner incisor, 3 apical teeth, 2 dorsolateral and 4 ventrolateral tiny denticles; right mandible inner incisor with 2 apical teeth, 2 dorsolateral and 1 ventrolateral tiny denticle; left mandible outer incisor larger than inner incisor, 3 apical teeth and 2 ventrolateral tiny denticles; left mandible inner incisor with 3 apical teeth and 1 ventrolateral tiny denticle. Hypopharynx superlinguae laterally curved and apically pointed. Maxillae with dense hairlike setal field in medial 3/4 of galealacinal crown, with subapical comblike setal row in mesial half of galealacinal crown, with 1 pronounced comb-like seta mesioapically and dense hairlike setal row on inner margin; maxillary palp segment lengths 1, 2 and 3 0.31 mm, 0.48 mm, and 0.31 mm respectively; segments 1 and 2 with sparse hairlike setae along outer margin; segment 2 with dense hairlike setal field apicomediaally; segment 3 indistinctly demarcated from segment 2, apically pointed with pronounced outer margin and strongly developed hairlike setal field along inner and outer margins. Labium glossae stalked and curved downward, with dense hairlike setae; paraglossae with dense hairlike setal field dorsoapically and ventroapically; labial palp segment lengths 1, 2, and 3 0.45 mm, 0.39 mm, and 0.23 mm respectively; segment 3 indistinctly demarcated from segment 2, apically pointed, with dense hairlike setal field along outer margin and stout setal row along inner margin. Thorax: Pronotum light yellow with large C-shaped dark purple-brown markings paired submedially; anterolateral margin round; lateral margin light yellow with row of sparse hairlike setae. Mesonotum with submedian dark purple-brown stripes, sparse hairlike setae laterally; forewing pads with small dark brown markings basally and laterally at mid-length and centrally as in adult forewing markings, also with tiny dark brown dots along lateral margin as in adult forewing C-Sc crossveins. Pleura and sterna with irregular dark brown markings; mesosternum with transverse dark brown stripe anteriorly. Forefemora lengths 2.50 mm, foretibiae 3.00 mm, foretarsi 1.00 mm and foreclaws 0.35 mm respectively; forefemora light yellow with dark brown transverse stripes at



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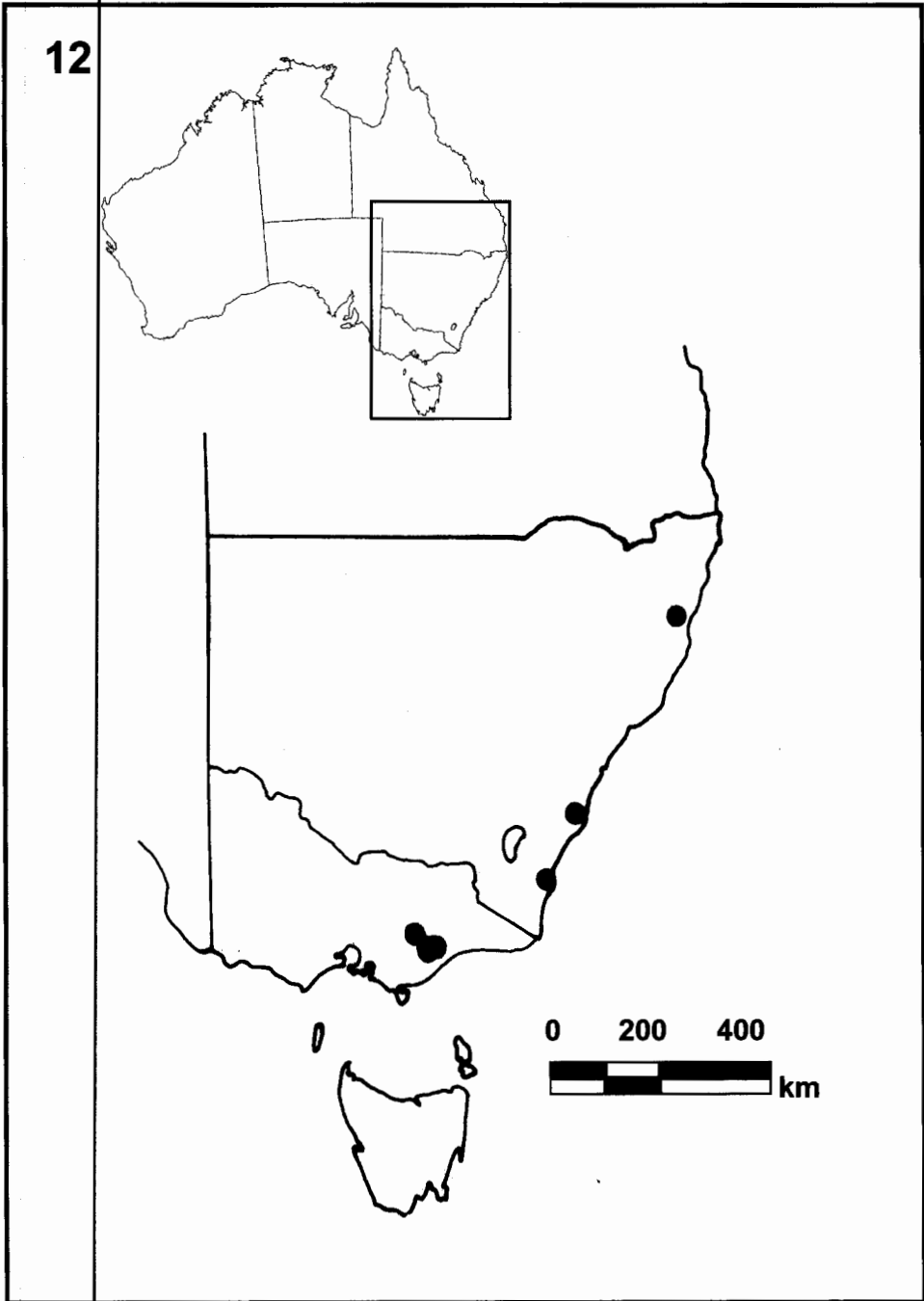


Figure 2. Known geographical distribution of *Jappa campbelli*.



mid-length and apically, long hairlike setal fields along anterior and posterior margins and long hairlike setal field on basomedial third; foretibiae light yellow basally and purple-brown apically, with light yellow dense bipectinate hairlike setae (filtering setae) (Fig. 8), 3-rows along inner and outer margins (setules of filtering setae rudimentary: Fig. 9), with stout setae (raking setae) along inner margin apical 2/3; foretarsi dark purple-brown, dense hairlike setae on dorsal and lateral surface; foreclaw dark purple-brown basally and black-brown apically with tiny teeth on basal three-quarters. Mid and hindleg lighter in color; markings and setation similar to forelegs. Abdomen: Terga 1–9 light yellow with paired large anteromedian dark purple-brown markings and sublateral longitudinal dark brown stripes, very long hairlike setae covering ca. half of dorsal area along median line and hairlike setal row along lateral margins; tergum 10 dark purple-brown; abdominal segments 8 and 9 with moderately developed posterolateral projections. Sterna bare; sternum 1 dark purple-brown, sterna 1–9 with dark purple-brown longitudinal stripe along median line containing 2 pairs of white spots (anterior spots larger and wider). Gills on abdominal segment 1–7, double; both lamellae somewhat light purple-brown stained in inner part and white in outer part and marginally, dark purple-brown median trachea without lateral tracheae and with single apical filament; gill lobe inner part strongly expanded apicomediaally, fine setae on 1/6 apical margin; gill lobe outer part with fine setae on entire margin; apical filament attenuating with marginal fine setae; gill 4, length 1.75 mm, width 0.95 mm, filament length 1.63 mm, weakly developed apical expansion (expansion rate 0.029). Caudal filaments light yellow, ca.  $0.9 \times$  length of body; each segment with whorl of hairlike setae.

Egg. (Fig. 10) shape oval; long axis 124  $\mu$ m; short axis 70  $\mu$ m. Color pale yellow in nature, white in alcohol. Egg surface (Fig. 11) with ca. 568 relatively evenly distributed knob-terminated coiled threads; diameter of knob-terminated coiled threads 4.6  $\mu$ m. Polar caps absent.

*Diagnosis.*—*J. campbelli* can be distinguished from all other known species of *Jappa* by the following combination of characters. In the imago forewings with dark purple-brown markings surrounding bulla and at base of MA fork (Fig. 1) and the V-shaped and slender penes with each penis lobe tapering apically (Fig. 3). In the larva cephalic horns with rowed small spines along the dorsal and lateral ridges and distinct marginal ridge on the labrum (Figs. 4–7).

*Distribution.*—New South Wales and Victoria (Fig. 12).

*Material examined.*—See types. AUSTRALIA. NEW SOUTH WALES: Upper Kangaroo R., 150°36' E, 34°41' S, 22 Jul 1972, J. Dean, 4 larvae (NMV); Tuross R., 5 miles S of Nerringundah, 149°55' E, 36°08' S, 1 Feb 1977, J. Dean, 1 larva (NMV); Rosewood Ck, 152°46' E, 30°24' S, 1981–82, G.J. Morgan, 1 larva (NMV). VICTORIA: same loc. as Holotype, 18 Mar 2001, Y.J. Bae, F. Govedich & B. Bain, 16 IV 2001, Y.J. Bae & K.J. Lim, 50 larvae (NMV); Wellington R., ca. 10 km upstream from Alpine National Pk entrance at second bridge, 146°37' E, 37°31' S, 12 May 2001, Y.J. Bae, K.J. Finlay & N. Ainsworth, 30 larvae (NMV); Freestone Ck, Culloden, 20 km NE of Maffra, 147°06' E, 37°47' S, 5 Sep 1977, A. Neboiss, 1 larva (NMV); Avon R., Bushy Park, 147°01' E, 37°52' S, 5 Sep 1977, A. Neboiss, 1 larva (NMV).

*Etymology.*—The specific epithet is in honour of Dr. I. C. Campbell of Monash University in Melbourne.

#### LARVAL KEY TO KNOWN SPECIES OF *JAPPA*

- 1a Cephalic horns without lateral spines; NT, QLD, NSW. . . . . *J. kutera*  
 1b Cephalic horns with lateral spines . . . . . 2  
 2a (1b) Cephalic horns with prominent lateral single spine at 2/3 apically appearing bifurcate horns (Fig. 1 in Skedros & Polhemus 1986); QLD. . . . . *J. edmundsi*  
 2b (1b) Cephalic horns without prominent lateral single spine (with row of spines).  
 . . . . . 3  
 3a (2b) Cephalic horns with single row of greatly developed spines appearing serrate horns (Fig. 3 in Skedros & Polhemus 1986); QLD. . . . . *J. serrata*  
 3b (2b) Cephalic horns with two rows of small spines (Fig. 4); NSW, VIC . . . . .  
 . . . . . *J. campbelli* NEW SPECIES

## BIOLOGY

The preferred habitat for *J. campbelli* are relatively pristine watercourses heavily shaded by native riparian vegetation. Larvae were collected from a stony substrate overlying mixed gravel, sand, and silt in fast flowing water between 0.2 and 0.6 metres deep. Larvae are commonly found burrowing in the finer substrates, especially in pools or near bank edges where the water flow is slightly slower. Laboratory investigations have revealed that the larvae can actively burrow and maintain U-shaped tube burrows through the surface of stone substrate (diameter of tube burrow 3–5 mm, distance between burrow openings 10–33 mm, depth of burrow from substrate surface 5–9 mm) when the stone is embedded in sand-silt substrate (Bae YJ & Campbell IC, unpublished data).

Monthly samples taken from the type locality (Wellington River, Victoria) over one year (April 2001–April 2002) indicate a univoltine life cycle for *J. campbelli* with one main emergence period per year in late Summer (January). A second informal species of *Jappa*, known as sp. "AV3" (Dean 1999), was found co-habiting the same stretch of river but was found to emerge later (generally mid February to mid March). Average water temperatures of the two emergence periods were very similar (18.0° C, 18.5° C respectively). However, there were greater temperature fluctuations in early summer (12.6–23.7° C) than later in the season (15.1–21.8° C) indicating that *J. campbelli* may tolerate a wider range of water temperatures for emergence.

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