A NEW SPECIES OF AN AUSTRALIAN BURROWING MAYFLY (LEPTOPHELIDAE, EPSHMEROPTERA)

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Abstract—A new species of Australian burrowing mayfly, Jappa campbelli sp. n. (Leptophlebiidae, Ephemeroptera) is described from reared adults, larval, 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 purplish-brown markings surrounding the bulla and base of MA 4 in the forewing. In the larva it can be characterized by double venation cephalic horns and a marginally ridged labrum in the head. Distributional and ecological notes are provided.

Key Words: Jappa campbelli, Leptophlebiidae, Ephemeroptera, taxonomy, Australia.

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 knobs in the burrowing mayfly family Potamanthidae from the northern hemisphere (Bae & McCafferty 1991, 1995; Edwards & 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. kathera 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 kathera Harker, J. emunadi Skedros & Polhemus, and J. serrata Skedros & Polhemus (Harker 1950, 1954; Skedros & Polhemus 1986, Campbell 1988, Fubbard & Campbell 1986, 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 1990). From our recent field investigations and rearing experiments, however, we recognize 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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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 (2003). Imagex 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 imagex 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 medio-lateral margin to end-length of the horn. The expansion rate of gig is defined by the ratio of vertical height of epimeroideal expansion of gig lobe (measured by direct line of height from base of apical filiment of gig to apex of expansion) against gig lobe length (measured by the direct line of length from base of gig to base of apical Filiment of gig). All specimens have been deposited in the National Museum of Victoria (NMV).

JAPAN CAMPBELL, BAE & FINLAY, NEW SPECIES

_Jappa sp._ AV4: Dean, 1999: 34.

(Figs. 1–12)

_Types._—Holotype (T-17939), male imagex (reared with larval exuvium), data: AUSTRALIA, Victoria, Locola, Wellington R., 3 km upstream from Alpine National-Pk entrance, 146°37' E, 37°34.5' 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, 1794) and 2 female (T-17942, 17943) imagex (reared with larval exuvium), 10 larvæ, 6 male (T-17944-17949) and 4 female (T-17950-17953) larvae (fully grown); deposited: AUSTRALIA, National Museum of Victoria, Melbourne.

_Description._—Male imagex. Body length 17.7 mm, caudal finlength length 13.6 mm. General body color dark purple-brown. Head. Dorsal compound eyes yellow-brown in alcohol, broadly connected posteriorly (ES = 6), dome-shaped, oval, laterally and somewhat internally 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, serrated anteriorly from lateral view. Antennæ dark brown, length 1.0 mm. Thora. Thorax dark purple-brown; pronotum and mesonotum with light yellow areas mediad; pleura with irregular white spots; mesonotum posteriormedian horn dark brown, moderately angled in lateral view (angle ca. 45º); sternum dark purple-brown with light yellow areas. Forewings (Fig. 1) transparent, length 10.7 mm, width 3.4 mm, with small dark brown-pattern markings at base of costal margin, near bulla, in stigmatic area and at base of MA fork; longitudinal veins light purple-brown; crossveins black-brown; numbers of crossveins C-S 21, Sc-R 17, and R 13, strongly infumated; crossveins in stigmatic area unusually innervated; MP, broadly connected to MP, and CuA (angle between MP, and crossvein MP, MP, larger than angle between MP, and crossvein MP, CuA); tibia I, II, III strongly constricted to CuA and CuP angle between MC 1 and CuP larger than angle between CuP and crossvein CuP, CuA); Hindwings (Fig. 2) transparent, without markings, length 2.3 mm, with 1.4 mm, veins hyaline; crossveins C-S 11 in number, apically constricted; costal area round with weakly developed costal projection at mid-length; vein Rs length 0.48 mm, Rs 0.75 mm, MP 0.25 mm, and MP 1.25 mm. Legs: light yellow with dark purple-brown markings at coxaal, middle, and subapical femora, apical tibia and tarsi 1, each tarsal joint and at claws; claws dissimilare forefemora length 2.10 mm, foretibia 2.90 mm, foretarsi
Figures 1-2. *Jesper campbell*, male imago. Figure 1. Browning. C = costa; Sc = subcosta; R = radius, MA = median anterior, MP = median posterior, CuA = cubitus anterior, ICu = intercalary cubitus, CuP = cubitus posterior. Figure 2. Hindwing. C = costa, Sc = subcosta, Rs = radial sector, R1 = radius, MA = median anterior, MP = median posterior.

segments 1, 2, 3, 4, and 5 of 13 mm, 1.25 mm, 1.15 mm, 0.85 mm, and 1.38 mm respectively, forewings 0.15 mm; midfemora lengths 1.75 mm, midtibia 2.25 mm, midtarsi 0.75 mm, midtibiaes 0.15 mm; hindfemora lengths 2.00 mm, hindtibiae 2.10 mm, hindtarsi 0.70 mm, hindtibiaes 0.15 mm. Abdomen: Terga purple-brown to dark purple-brown with dark purple-brown subtergal biaquadrilateral stripes, longitudinal median white stripe and lateral and posterior lateral white areas; segment 9 with moderately developed posterior/lateral projections. Sternum dark purple-brown mediad and light brown laterally; each median dark purple-brown area with 2 pairs of tiny white spots (anterior open larger and wider), prox (Fig. 3) V-shaped, slender, length 0.33 mm, ca. half the length of forelegs segment 1; each lobe light yellow medianally and purple-brown laterally, apically round, without spine; forelegs (Fig. 5) segment 1, 2, and 3 lengths 0.52 mm, 0.12 mm, and 0.12 mm respectively; foreleg segment 1 dark purple-brown basally and light purple-brown apically, broadly basally and narrow apically abrupt constriction at three-fifths length, arched inward and upward at constriction, with inner expansion in apical fifth; forelegs 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), c.14.0 mm, ca. 1.36 mm 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 (dorsally located wings lighter in color), crossveins C-S1, S1-R1, and K1-R1 infuscated in basal half of wing. Hindwings hyaline, length 2.5 mm, width 1.5 mm, veins hyaline; venation similar to male. Forefemura
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 sense. 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 (SE = 1.15). Female compound eyes width 0.35 mm dorsally, distance between compound eyes 1.35 mm (SE = 0.79). 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. *Hypoce castanea*, SEMs of larva. Figure 4. Dorsal head and thorax, scale bar = 1.00 mm. Figure 5. Basal horn, scale bar = 86 μm. Figure 6. Terminal horn, scale bar = 100 μm. Figure 7. Basoventral setal field, scale bar = 30 μm. Figure 8. Foretibia, in part, scale bar = 120 μm. Figure 9. Setae on foretibia, scale bar = 8.6 μm.
yellow apically, inner length 1.00-1.25 mm, outer length 1.25-1.75 mm, capsule 23.67, with distinct dorsal and lateral ridges and prominent hooded summit (Fig. 9), with ca. 10.15 and 40 simple hairlike setal fields in basosculal, parascutal (Figs. 3 and 7) and apical dorsal areas, respectively (Fig. 6), with row of 4-6 dorsal and 10-13 strong spaces along ridges. Laternal distally subparallel to transverse length 0.36 mm; basal width 0.78 mm (ideal maximum width 0.84 mm), distinct marginal ridge dorsally. Intersegmental area between chyphosa and dorsal labium with row of ca. 40 large hairlike setae; dorsal surface of labrum heavily setose with basal and subapical hairlike setal rows, basal setae longer than subapical setae. Rounded subapical setae longer laterally, with ca. 15 setae densely arranged medially; lateral and anterior margins with hairlike setal rows; anterior margin concave with prominent median tubercle; ventral surface with dense hairlike setal field along anterior margin, with ca. 10–15 light purple-brown setae setae in row at each side of submedian margin, and field of ca. 50 light purple-brown hairlike setae broadly and centrally located on each side. Mandibles densely setose with very long hairlike setal row; ventral surface central area with ca. 20 light yellow setae mixed transversely. Postpeduncle metaturn, with well-developed fringes; right mandible outer incisor larger than inner incisor, 3 apical teeth, 2 denticulated; and 4 venterolateral tiny denticles; left mandible outer incisor larger than inner incisor, 3 apical teeth and 1 ventral denticle. Hypopharynx ventroapically laterally curved and apically protruded. Maxilla with dense hairlike setal field on coxal 1 of gonopodot, subapical to apical hairlike setal row on inner margin, maxillary palp segment lengths 1.2 and 3.03 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 apomictically, segment 3 distinctly demarcated from segment 2, opercule, with venterolateral portion, mouth setal field along inner and outer margins, labrale glossy sheathed and curved dorsally, with dense hairlike setae; paraglossae with dense hairlike setal field dorsally and ventrally; labial palp segment lengths 1.2, 3.045 mm, 0.36 mm, and 0.23 mm, respectively; segment 3 (females) demarcated from segment 2, opercule, with dense hairlike setal field along outer margin and stout setal row along inner margin. Thorax: Pronum light yellow with large C-shaped dark purple-brown markings laterally and medially at mid-length and centrally, as in adult forewing markings, also with tiny dark brown dots along lateral margins as in adult. Forewing C-Sc crossveins. Pleura and veins with irregular dark brown markings, mesovinum with transverse dark brown stripe anteriorly. Forefemur length 2.26 mm, femur 1.00 mm, trochanter 0.11 mm and foretarsi 0.35 mm respectively; forefootpods light yellow with dark brown transverse stripes at
yellow scapally, inner margin 1.80-1.45 mm, outer length 1.25-1.75 mm, curvature 23.0°, with distinct dorsal and lateral ridges and a prominent basal dorsal tubercle (Fig. 5), with ca. 10, 15 and 40 simple-batike setal fields in baccalomal, baccalomalateral (Figs. 5 and 7) and apodosomal areas respectively (Fig. 6), with row of 4-4 dorsal and 10-13 lateral spines along ridges. Labiath distally widened (maximum length 0.36 mm; basal width 0.78 mm; distal maximum width 0.94 mm), distinct marginal ridge dorally; intersegmental area between clypeus and dorsal labrum with row of ca. 40 long batike setae; dorsal surface of labrum heavily setose with basal and subapical batike setal rows (basal spine longer than subapical spines); row of subapical setae laterally longer, with ca. 15 setae densely arranged medially; lateral and interior margins with batike setal row; anterior margin concave with prominent median tubercle; ventral surface with dense batike setal field along anterior margin; with ca. 10-15 light purple-brown stout setae in row at each side of subanterior margin, and 6-8 of ca. 50 light purple-brown batike setae broadly and centrally located on each side. Mandibles dorsolateral margins with many long hair-like setae rows; ventral surface central area with ca. 20 light yellow setae roved transversely; prostheca pedunculate, with well developed fringe, with many minute spines. Head: inner margin concave with 2 apical teeth, 2 doral teeth and 1 ventrolateral tiny denticle; left mandible outer incisor with 3 apical teeth and 1 ventrolateral tiny denticle. Hypopharynx superciliatum laterally curved and spiculately pointed. Maxillae with dense batike setal field in median 3/4 of abscissa tooth crown, with subapical coarse batike setal row in mesial half of galacomatic crown, with 1 protocoxal comb-like seta mesoxiphiopodally and dense batike setal row on inner margin; maxillary palp segments 1.2 and 3.01 mm, 0.48 mm, and 0.33 mm respectively; segments 1 and 2 with spiculate batike setae along outer margin, segment 2 with dense batike setal field apicomically; segment 3 distinctly demarcated from segment 2, spiculately pointed with protocoxal outer margin and densely developed batike setal field along inner and outer margins. Labial glossa stalked and curved doralward, with dense batike setae, paraglossae with dense batike setal field dorsocapally and ventralward; labial palp segments lengths 1.2 and 3.45 mm, 0.39 mm, and 0.03 mm respectively; segment 3 distinctly demarcated from segment 2, spiculately pointed, with dense batike setal field along outer margin and most setal row along inner margin. Thorax: Pronotum light yellow with large C-shaped dead purple-brown markings paler submedially; anterolateral margin rounded, lateral margin light yellow with row of sparse batike setae. Mesosternum with submedian dark purple-brown stripes, sparse batike setae laterally; forewing pads with small dark brown markings broadly and laterally at rad-edge and centrally as in adult forewing markings, also with tiny dark brown dots along lateral margin as in adult forewing C-Sc crossveins. Fl ima and stemma with spiculate dark brown markings; mesosternum with transverse dark brown stripes 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...
Figure 2. Known geographical distribution of Lappa campbelli.
mid-length and apically long, barbulate seed sials along anterior and posterior margins and long barbulate seed sials on barbed-ridged thread; furfuraceous light yellow basally and purple-brown apically, with light yellow dense zigzaggy barbulate setae (filtering sias) (Fig. 9), 3 rows along inner and outer margins (sias of filtering sias) (Fig. 9), with stout setae (sliding sias) along inner margin sparsely; crenate dark purple-brown, dense barbulate setae on dorsal and lateral surface; foremost dark purple-brown mostly and black-brown sparsely with tiny teeth on basal three-quarters. Mid and hindbody lighter in color; marking- and situation similar to forebody. Abdomen: Torga 1-9 light yellow with paired large brown melanosome with purple-brown markings and submarginal long dark brown stripes, very long barbulate setae surrounding. Half of dorsal area along median line and barbulate sias along lateral margins; tegmen 10 dark purplish-brown; abdominal segments 8 and 9 with moderately developed posterioral projections. Sinna bare, sternum 1 dark-purple brown, vent 1-9 with dark purple-brown longitudinal stripe along median line containing 2 pairs of white spots (anterior spots larger and wider); Gillia on abdominal segments 1-7, double; both lanates somewhat light purple-brown stained in inner part and white in outer part and marginally, dark purple-brown median ranges without lateral tuft and with single apical diameter; gilllobe inner part strongly expanded apicocaudally, fine setae on 16 apical margins; gilllobe outer part with fine setae on entire margin; apical diameter attenuating with marginal fine setae; Gill 4 length 1.73 mm, width 0.95 mm. Element length 1.61 mm, weakly developed apical expansion ca 0.294. Caudal filaments light yellow, ca 0.9 × length of body, each segment with row of barbulate setae.

Egg. (Fig. 10) shape oval, long axis 134 μm; short axis 90 μm. Color pale yellow in nature, white in alcohol. Egg surface. (Fig. 11) with ca 590 relatively evenly distributed sub-terminal coiled threads; diameter of knob-terminated coiled threads 4.6 μm; polar caps absent.

Diagnosis.—J. campbelli can be distinguished from all other known species of Jappa by the following combination of characteristics. In the imago forewings with dark purple-brown markings surrounding bulbs 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 beva 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 River, 150736 E, 34°41' S, 22 July 1973, J. Dear, 4 larvae (NSW); Tarragindi, 5 miles S of Nerindagundah, 149°55' E, 36°58' S, 1 Feb 1975, J. Dom. 1 larva (NMV); Rosewood Cl, 152°46' E, 39°24' S, 1981-82, G.J. Meran, 1 larva (NMV). VIC: Yarkonias, 18 May 2001, Y. Bar, 3 females; B. Ram, 5 May 2001, Y. Bar & K.J. Lim, 50 larvae (NMV); Wellington R., ca 10 km upstream from Alpine National Forest at second bridge, 14°57' E, 37°51' S, 12 May 2001, Y. Bar, K.J. Farsky & N. Auswirth, 30 larvae (NMV); Freestone Cl, Cudbrooke, 25°30' S of Mathins, 14°70' E, 37°43' S, 5 Sep 1977, A. Nebbett, 1 larva (NMV); Avon R., Lesby Park, 147°01' E, 37°52' S, 5 Sep 1977, A. Nebbett, 1 larva (NMV).

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

LARVAL Key to KNOWN Species of Jappa

1a Cephalic horns without lateral spines; NT, Qld. NSW. .......... 1b
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 Shekves & Polhemus 1986; Qld. .......... 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 Shekves & Polhemus 1986; Qld. .......... 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 stone 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 some 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 and substrate (Bay TJ & Campbell RC, 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 Juppa, 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 (12.6–25.5°C) than later in the season (15.1–18.8°C) indicating that J. campbelli may tolerate a wider range of water temperatures for emergence.

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