



Molecular evidence for deeper diversity in Australian Tanypodinae (Chironomidae): *Yarrhpelopia* and related new taxa

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Abstract

The diversity and endemism of Australian Tanypodinae (Diptera: Chironomidae) has been unclear from morphological comparisons with well-grounded northern hemisphere taxonomy. As part of a comprehensive study, here we focus on one of the few described endemic genera, *Yarrhpelopia* Cranston. Extensive and intensive new sampling and newly-acquired molecular data provides clarity for the type species, *Yarrhpelopia norrisi* Cranston and allows recognition of congeners and potential sister group(s). We describe *Yarrhpelopia acorona* Cranston & Krosch **sp. n.**, and we recognise a third species from Western Australia, retaining an informal code ‘V20’ due to inadequate reared / associated material for formal description. We recognise a robust clade *Coronapelopia* Cranston & Krosch **gen. n.**, treated as a genus new to science for two new species, *Coronapelopia valedon* Cranston & Krosch **sp. n.** and *Coronapelopia quadridentata* Cranston & Krosch **sp. n.**, from eastern Australia, each described in their larval and pupal stages and partial imaginal stages. Interleaved between the independent new Australian clades *Yarrhpelopia* and *Coronapelopia* are New World *Pentaneura* and relatives, that allow a tentative inference of a dated gondwanan (austral) connection. Expanded sampling indicates that *Y. norrisi*, although near predictably present in mine-polluted waters, is not obligate but generally indicates acidic waters, including natural swamps and *Sphagnum* bogs. The inferred acidophily, including in drainages of mine adits, applies to many taxa under consideration here.

Key words: DNA-based taxonomy, *Coronapelopia* new genus, new species, new life histories, pollution indicators, acid waters

Introduction

The aquatic immature stages of the large and diverse family Chironomidae (non-biting midges; Diptera: the ‘true’ flies) are abundant and diverse in aquatic biomonitoring surveys (Cranston 1994; Ferrington 2007). In Australia, descriptions and keys to the immature stages associated to the adult allow identification often to morphospecies (e.g., Aphroteniinae: Cranston & Edward 1992; Podonominae: Cranston *et al.* 1987; 2002; Orthocladiinae: Boothroyd & Cranston 1995; Cranston 2000a, 2009; Cranston & Sæther 2010; Chironominae: Cranston & Hare 1995; Cranston 1996, 1997, 2000b, 2019a, 2019b). Keys to the immature stages include Cranston (1996, 2010, 2019c), Cranston & Dimitriadis (2004), Madden (2010) and Leung *et al.* (2011). More recent Australian studies integrate molecular data with morphology to enhance taxon discrimination, as advocated by Carew & Hoffman (2015) for *Procladius*, and implemented for *Austrochlus* (Cranston *et al.* 2002), *Cricotopus* (Krosch *et al.* 2015, Cranston & Krosch 2015) and *Riethia* (Cranston 2019b). The subfamily Tanypodinae is inadequately understood in its immature stages, and,

arguably, also in the conventionally name-bearing adult stage. The larvae are free-living, facultative predators at least in their 4th (final) instar. This habit, unusual outside the subfamily, is accompanied by unifying distinctive larval morphologies. Northern hemisphere (Holarctic) diagnoses for larvae (e.g., Fittkau 1962; Fittkau & Roback 1983; Cranston & Epler 2013), pupae (Fittkau & Murray 1986) and adult males (Murray & Fittkau 1989) are of limited help concerning putative endemic austral taxa. Thus far, two Australian genera incompatible with northern concepts have been described as monotypic, namely *Australopelopia* Cranston 2000c and *Yarrhpelopia* Cranston 2017. Further insights into the Australian Tanypodinae came from some antipodean taxa included in a morphological phylogenetic analysis (Silva & Ekrem 2016) and a molecular-based global study with representation of austral taxa (Krosch *et al.* 2017). The proposed higher classifications remain substantially congruent, but uncertainties continue concerning delimitation and relationships of some Australian clades.

In recent years we have sampled for Tanypodinae widely across Australia (including Lord Howe and Christmas Islands) and also in New Zealand. We have sought particularly endemic and species-rich genera for morphological and molecular studies, and extralimital taxa to place the fauna in a global context. This first contribution (of a series) concerns the Australian endemic *Yarrhpelopia* and relatives, recognised previously by informal codes.

Methods and materials

Kick sampling in appropriate standing waters and interception of drift in flowing waters used 250–300 µm mesh nets, seeking immature stages including parate adults. Specimens were field-sorted under a binocular microscope and those destined for DNA extraction and sequencing were isolated, preserved in 95–100% isopropanol and kept cold. Using non-destructive DNA extraction (Krosch & Cranston 2012), carcasses were then either vouchered permanently on microscope slides using Euparal mountant, or occasionally using Hoyer's which clears well and is readily remounted into Euparal. All molecular vouchers (MV) are coded as in Table 1, Fig. 1) and are on slides preserved in the Australian National Insect Collection, CSIRO, Canberra, Australia (ANIC). Some non-MV specimens are to be deposited in the Zoologische Staatssammlung München, Munich, Germany (ZSM).

Morphological terminology largely follows Sæther (1980). Minor additions and emendations for larvae are as implemented by Cranston (2012, 2013) incorporating Kowalyk's (1985) valuable insights into the taxonomic utility of the larval cephalic setation. In the pupa, we prefer the simpler terminology of Silva & Ferrington (2018) regarding the respiratory atrium of the thoracic horn, without differentiating horn sac, horn chamber or aeropyle, thus treating the atrium as everything internal between the connections to the spiracle and the plastron. If unstated, measurements are in µm, unless mm, as stated.

Following the rationale of Cranston *et al.* (2012), collections for greatest geographic and taxonomic diversity and recovery of DNA are often from larvae, vouchered by their head capsules and posterior abdomen. Identifications followed Cranston & Epler (2013) and Cranston (2010, 2019c), accepting that species-level identification keys to larvae are under-developed compared to those for the adult or (arguably) pupae. DNA extraction, PCR amplification, sequencing and analyses followed the existing protocols (Cranston *et al.* 2012, Krosch & Cranston 2012) using standard markers (*COI*, *28S*, *CAD* - Krosch & Cranston 2013; Krosch *et al.* 2011, 2015). Sequences have been lodged with GenBank: for accession numbers and additional details see Table 1.

Outgroups selected comprise the undescribed Genus B (Cranston 1996) a pentaneurine, outside of the *Yarrhpelopia* clade and under active study and description, and two specimens of *Alotanypus* Roback from tribe Macropelopiini.

Phylogenies were inferred for a concatenated partitioned dataset using maximum likelihood (RAxML Version 8.0.24 (Stamatakis 2006), 1000 bootstraps, GTRGAMMA model) and Bayesian inference (MrBayes Version 3.2.2 (Huelsenbeck & Ronquist 2001; Ronquist & Huelsenbeck 2003), GTR model, gamma distribution, 10 million generations sampled every 1000, 25% burn-in). All analyses were conducted on the CIPRES Science Gateway High Performance Computing platform (<http://www.phylo.org>; Miller *et al.* 2010). Estimated times of significant events followed the procedures of Krosch *et al.* (2017) and form part of a study of evolutionary tempo across the entire subfamily (Krosch *et al.*, in prep.). A complete time-scaled tree will be presented in this subsequent paper (and is available on request): here we report estimated divergence times only for relevant nodes.

Abbreviations. Morphological (semaphoront stated), geographic abbreviations and repositories used in the text: ANIC, Australian National Insect Collection; A.R., antennal ratio = length of ultimate flagellomere : combined

lengths of flagellomeres 1 to penultimate + ultimate (adult male) or ultimate (adult female), or length of basal segment : combined lengths of segments 2 to 4 (larva); asl, above sea level (in metres); Ck., creek; DP, dorsal pit of larval head; L, larva or Lake; Le, larval exuviae; Le/Pe/♂(♀), reared adult male (female) with associated larval and pupal exuviae; L.R., leg ratio: tarsomere1 length: tibia length; Mt(s), mountain(s); MV, molecular voucher; N.P., National Park; P(e), pupa (exuviae); P♂, (P♀), pharate male (female) within pupa (maybe dissected out as teneral adult); P₁₋₃, Legs (1–fore, 2–mid, 3–hind); R., river; R, R₁, R₄₊₅, radial wing veins; S5, S7, S8, S9, S10, setae of cephalic area (larva); SSm, seta submentum (larva); Ta₁₋₅, tarsomeres 1–5; VP, ventral pit of larval head.



FIG. 1. Phylogenetic tree from Bayesian inference for *Yarrhpelopia* Cranston and associated taxa (Table 1) based on concatenated gene fragments. Posterior probabilities (PP) and Bootstrap support (BS from Maximum Likelihood analysis) are indicated above branches only for nodes with PP > 0.95 or BS > 70. Maximal supported nodes are indicated with an asterisk. Likelihood bootstrap support (BS), located to the right of a PP value, are cited only if >~70%, considered as supporting that node. A dash (–) for either PP or BS indicates a value below the threshold for support; unlabeled nodes are unsupported under either criterion.

Results and discussion

Exclusion of introns and hyper-variable regions resulted in a final multilocus dataset of 2659 characters from 44 individuals including outgroups, with lengths per locus of: 642 bp (*FoI**COI*), 765 bp (*COI*), 510 bp (*28S*) and 742 bp (*CAD1*). No locus was complete for all taxa: 43 were represented in the *COI-5P* dataset, 21 for *COI-3P*, 23 for *28S* and only 4 for *CAD1* due to negligible representation within a wider subfamily-level molecular phylogenetic study. Nuclear sequence data was generated from taxa across the tree such that all major clades were represented. The result of phylogenetic analysis is presented in Fig. 1 with elaboration, discussion and with taxonomic implementation below. Bayesian support statistics for nodes are interpreted as Posterior Probability (PP) of 0.99–1.0 being robust and of 0.98–0.94 modestly supported. Likelihood bootstrap support (BS), located to the right of a PP value in Fig. 1, are cited only if >~70%, considered as supporting that node.

TABLE 1. List of taxa, codes, life-stages, locations and GenBank accessions. Life stages are larva (L), larva with pharate pupa (L(P)), male pupa (Pm), female pupa (Pf), pupal exuviae (Pe) where associated with adult: male (m) or female (f). Taxon with associated '?' is uncertain at species level. Genus B from Cranston 1996. Abbreviations: N.S.W. - New South Wales; Qld. - Queensland; Tas. - Tasmania; Vic. - Victoria; W.A. - Western Australia.

Taxon name on tree	Code	Life stage	Location	Collector(s)	5P COI	3P COI	28S	Genbank Accession	CADI
<i>Yarrhpelopia norrisi</i>	FNQ16NIG3	P	Qld., Herberton Range NP, Wondecla Creek	Krosch, Bryant, Cranston	MW150329				
<i>Yarrhpelopia norrisi</i>	NSW13.5T4	m	New South Wales, Newnes, Coco Creek	Cranston	MW150331	MW150495	MW151658		
<i>Yarrhpelopia norrisi</i>	OTW4.6	L	Vic., Otway NP, Johanna River	Krosch, Bryant	MW150347	MW150500	MW151657		
<i>Yarrhpelopia norrisi</i>	TAS17.6.5	L	Tas., Goulds Country, Ransom River	Cranston	MW150350				
<i>Yarrhpelopia norrisi</i>	TAS17.7.1	P	Tas., Blue Tiers FR, Goblin's Trail, Full Moon Creek	Cranston	MW150352				
<i>Yarrhpelopia norrisi</i>	TAS17.6.7	P	Tas., Goulds Country, Ransom River	Cranston	MW150351	MW150502	MW151656		
<i>Yarrhpelopia norrisi</i>	TAS17.9.1	L(P)	Tas., Blue Tiers FR, Sun Flats Road, Quarry pool	Cranston	MW150356				
<i>Yarrhpelopia norrisi</i>	NSWCF2	L	New South Wales, Captain's Flat, Molonglo River	Cranston	MW150333	MW150496	MW151661		
<i>Yarrhpelopia norrisi</i>	NSWCF4	Pe/f	New South Wales, Captain's Flat, Molonglo River	Cranston	MW150334				
<i>Yarrhpelopia norrisi</i>	NSWCF5	Pe/m	New South Wales, Captain's Flat, Molonglo River	Cranston	MW150335				
<i>Yarrhpelopia norrisi</i>	TAS17.4.5	L	Tas., Charlie's Marsh	Cranston	MW150349	MW150501	MW151662		
<i>Yarrhpelopia norrisi</i>	NSWNE17.3.9	L	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150343				
<i>Yarrhpelopia norrisi</i>	TAS17.8.1	P	Tas., Blue Tiers FR, Sun Flats Road, Full Moon Creek	Cranston	MW150355	MW150504	MW151652		
<i>Yarrhpelopia norrisi</i>	TAS17.7.2	L	Tas., Blue Tiers FR, Goblin's Trail, Full Moon Creek	Cranston	MW150353	MW150503	MW151651		
<i>Yarrhpelopia norrisi</i>	TAS17.7.4	L	Tas., Blue Tiers FR, Goblin's Trail, Full Moon Creek	Cranston	MW150354				
<i>Yarrhpelopia norrisi</i>	V214	L	Vic., Toolangi SF, Mullindindi	Cranston	MW150358	HQ441020	HQ440858	HQ440398	
<i>Yarrhpelopia norrisi</i>	NSWCF1	L	New South Wales, Captain's Flat, Molonglo River	Cranston	MW150332			MW151660	
<i>Yarrhpelopia norrisi</i>	NSWCF7	Le/Pe/m	New South Wales, Captain's Flat, Molonglo River	Cranston	MW150336				
<i>Yarrhpelopia norrisi</i>	NSWCF8	Le/Pe/m	New South Wales, Captain's Flat, Molonglo River	Cranston	MW150337				
<i>Yarrhpelopia norrisi</i>	NSWG117.2.2	L(P)	New South Wales, Tibuc Road, Manning River	Cranston	MW150339				
<i>Yarrhpelopia norrisi</i>	NSWNE17.3.3	L(P)	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150341	MW150497	MW151654	MW173965	
<i>Yarrhpelopia norrisi</i>	NSWWC17.1	Pe/f	New South Wales, Northangera, Warrambucca Creek	Cranston	MW150344				

Continued on the next page

TABLE 1. (Continued)

Taxon name on tree	Code	Life stage	Location	Collector(s)	Genbank Accession
<i>Yarrhpelopia norrisi</i>	NSWNE17.2.8	L	New South Wales, Cathedral Rock NP, drain of swamp	Cranston	MW150340
<i>Yarrhpelopia norrisi</i>	NSWNE17.3.4	L(P)	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150342
<i>Yarrhpelopia norrisi</i>	OTW4.1	L	Vic., Otway NP, Johanna River	Krosch, Bryant	MW150345 MW150498 MW151650
<i>Yarrhpelopia norrisi</i>	OTW4.3	L	Vic., Otway NP, Johanna River	Krosch, Bryant	MW150346 MW150499 MW151659
<i>Yarrhpelopia norrisi</i>	TAS17.2.6	L	Tas., Little Pipers River	Cranston	MW150348
<i>Yarrhpelopia norrisi</i>	TAS17.9.4	L(P)	Tas., Blue Tiers FR, Sun Flats Road, Quarry pool	Cranston	MW150357 MW150505 MW151653
<i>Yarrhpelopia acorona</i>	NSWNE17.3.1	P(m)	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150360 MW151663
<i>Yarrhpelopia</i> 'V20'	WAB8R3.1	L(P)	W.A., Jarrahdale, Wungong Catchment	Carey	MW150359 MW150506 MW151649
<i>Pentaneura ?cinerea</i>	CH16Frias3	P(m)	Chile: Rio Negra, PN Nahuel Huapi, R. Frias	Cranston	MW197142 MW197143 MW198061
<i>Coronapeloplia valedon</i>	FNQ12CHT2	P	Qld., Mount Lewis NP, Churchill Creek	Cranston	MW150323 MW150491 MW151646
<i>Coronapeloplia quadridentata</i>	NSWNE17.3.11	P(f)	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150325
<i>Coronapeloplia quadridentata</i>	NSWNE17.3.7	L	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150327
<i>Coronapeloplia quadridentata</i>	NSWNE17.3.8	L	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150328 MW150493 MW151647
<i>Coronapeloplia quadridentata</i>	NSWNE17.3.6	L(P)	New South Wales, Cathedral Rock NP, Sphagnum swamp	Cranston	MW150326 MW150492 MW151648
Genus B	FNQ12CHT3	P(m)	Qld., Mount Lewis NP, Churchill Creek	Cranston	MW150322 MW150489 MW151645
Genus B	FNQ12.1T4	L	Qld., Herberston Range NP, Wondecla Creek	Cranston	MW150321
Genus B	CTC16.8	L	New South Wales, Cabbage Tree Creek	Cranston	MW150319
Genus B	CTC16.9	L	New South Wales, Cabbage Tree Creek	Cranston	MW150320
Genus B	NSWNew17.1.3	P	New South Wales, Newnes, Little Capertee Creek	Cranston	MW150323 MW150490 MW151644
<i>Alotanypus venustus</i>	CATP9.7.3	L	California, Santa Barbara Co., Cold Springs Ck.	McCluen	MW150361 KX684088 KX684175
<i>Alotanypus venustus</i>	APS2	L	USA: California, McCloughlin Reserve	Cranston	HQ440871 HQ440710 HQ440236

Divergence time estimates suggest that ‘Genus B’ last shared a common ancestor with *Yarrhpelopia* + *Coronapelopia* around 114Ma (100–129), while the latter two genera diverged around 95Ma (82–108). Divergence of North Queensland and southern Australian populations within *Coronapelopia* (representing the split of *C. valedon* and *C. quadridentata*) occurred approximately 42Ma (29–56). Within *Yarrhpelopia*, the divergence of Western Australian restricted ‘V20’ and Eastern Australian sister group occurred around 74Ma (58–89), with subsequent divergence amongst the eastern species at 57Ma (38–76). Tasmanian *Y. norrisi* are represented in several subclades, ranging in age from 3–17Ma (1–23).

Expanded sampling (Table 1) and analysis of molecular data (Fig. 1) clarifies the position of type species, *Y. norrisi* Cranston allowing recognition of putative conspecifics, potential congeners and postulated sister group(s). Below, we describe and illustrate a distinctive congener *Yarrhpelopia acorona* **sp. n.** Cranston & Krosch although with a sole molecular data point but with strong morphological evidence, and a third taxon ‘V20’, based on another singular molecular data point, but with morphological and biogeographic evidence yet unnamed for lack of reared material. A distinctive clade of two new species is treated as new genus *Coronapelopia* **gen. n.** Cranston & Krosch. A possible relationship suggested from DNA with a patagonian Andean taxon clearly assignable to *Pentaneura* Philippi, and likely the type-species *P. cinerea* Philippi as understood by Silva & Ferrington, 2018, will be discussed elsewhere.

Taxonomy

Yarrhpelopia Cranston 2017

Generic Diagnoses as for *Yarrhpelopia* (Cranston 2017) amended as follows: **Adult male.**

Antennal ratio 1.7–2.0, plume may be dark or pale; pedicel with 2–4 setae; terminal antennal seta may be short and apical, or as long as the terminal flagellomere and inserted subapically (Fig. 3A). Wing veins with only typical setae (~100µ long) or may have a continuous row of 40µ long, near hyaline, blunt-ended setae (Fig. 3B) from base of vein R to apex of R₁. Tergite IX with sparse to many setae (Fig. 3D).

Adult female. Antenna with 11 flagellomeres, terminal setae shorter than to subequal to slightly longer than terminal flagellomere; Antennal ratio 0.22 (*norrisi*) or 0.29–0.31; scape with 4–6 setae, pedicel with 6–9 setae. Range of setal counts and measurable mensural characters as in male, or 15% greater. Gonocoxapodeme VIII gently curved. Gonapophysis VIII triangular, with single rounded microtrichiose lobe. Notum thin, 3x seminal capsule length. Gonotergite IX bare. Tergite IX thin, non-setose. Postgenital plate large bearing small globular cerci. Three ovoid / globular seminal capsules; spermathecal ducts bare, ending separately.

Pupa. Thoracic horn (Fig. 2A, B, 3E, F) ratios of length / width of horn, and plastron plate to total length of the thoracic horn vary considerably; respiratory atrium may have internal structuring (Fig. 2B); corona surrounding plastron plate broad (Fig. 2A, B) or completely lacking (Fig. 3E, F), horn variably spinose externally (Figs 2A, B, 3E, F); thoracic comb may comprise several digitiform tubercles (Fig. 2A), fewer short blunt tubercles (Fig. 3F) or, possibly, be absent. Anal lobes tapering (Fig. 2D, E), or squat (Fig. 3G).

Larva. Head shape slightly (Fig. 2L) to more obviously tapering. Antenna varies in lengths and proportions of terminal segments and Lauterborn organ (Fig. 2M, 3J). Inner teeth of ligula slightly to strongly recessed, directed near anteriorly or slightly curved outward (Figs 2N, 3L). Submentum with weak to strong transverse striae (Figs. 2F, G, 3O); arrangements of ventral cephalic setae (S9, S10, SSm) and ventral pit (VP) vary (Figs. 2F–H, 3O). Mandible varies in strength and intensity of pigment of apical tooth and tooth-like molar extension (Figs. 2I–J, 3K); some posterior parapods may have hyaline outer margin, with or without ‘flattened hook’ claw(s).

Remarks. Molecular data shows a monophyletic cluster (Fig. 1) including specimens from the type locality (‘NSWCF, Captains Flat’). Intermingled are variants formerly termed ‘ST1’ (from streams polluted by sewage treatment (‘ST’) or ‘genus D’ (Cranston 1996), from acidified, polluted or less obviously impacted sites in central Tasmania. Features that suggested their differentiation had included the pupal thoracic horn (Fig. 2A, B), and in the larva include the dimensions of the molar and inner teeth of the mandible (Fig. 2I–K), and the arrangement of setae and pits on the head capsule (Fig. 2F, G). From the relationships inferred in Figure 1, we now attribute all these to intra-specific variation including some ‘variation’ caused by poor slide mounts.

The distribution previously reported as covering eastern Australia from 30°S to 42°S, with apparent absence from inland, northern and western Australia, is confirmed after increased nation-wide sampling for our molecular

studies. For molecular voucher (MV) material for *Y. norrisi* Cranston, see Table 1. Additional material expanding original data ('non-MV') include as follows: New South Wales: New England, Cathedral Rock N.P., P♂, Sphagnum swamp drain, 30°26'42"S 152°16'E 13.iii.2017; P♀, same, except Sphagnum bog pool, 30°26'18"S 152°17'9"E; Pe, Northangera, Warrambucca Ck., 34°34'S 142°55'E, 4.i.2017; Tasmania, L, Quarry pool, 41°11'36"S 148°0'25"E, 22.ii.2017.

***Yarrhpelopia acorona* Cranston & Krosch sp. n.**

(Fig. 3)

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[‘?Telmatopelopia’ (part) Cranston 1996]

Type material. **Holotype** P♂, slide-mounted in Euparal, AUSTRALIA: New South Wales, New England, Cathedral Rock N.P., Sphagnum pool, 30°26'18"S 152°17'9"E, 13.iii.2017 (Cranston) ANIC, MV: NSWNE17.3.1. **Paratypes** (collected Cranston unless stated otherwise, deposited ANIC). 3Pe, Queensland, Mt. Lewis N.P., Churchill Ck., 420 m. asl, 16°34'S 145°20'E, 6–7.iv.1997; P♂, P♀, 9Pe, Herberton, Carrington Falls, 17°34'S 145°20'E, 9–10.iv.1997; P♂, 3Pe, Cardwell, 5 Mile Ck., 18°20'S 146°03'E, 1–4.iv.1997 [P♂ to ZSM]; Pe, Fitch Hatton Gorge, 21°05'S 148°37'E, 200 m. asl, 22.iii.1998.

Northern Territory, Pe, Arnhem Land, ‘Podocarpus canyon’, 12°39'S 133°26'E, 18–19.v.1992; Kakadu N.P., Pe, U. Magela Ck., below Bowerbird Billabong, 12°47'S 133°03'E, 28.v.1988; Rockhole Mine Ck., 13°30'S 132°30'E (*M. Smith*); 2Pe, 22.iv.1993, Pe, P(♀), 29.iv.1993 [Pe to ZSM], Pe, P(♀), 6.v.1993, Pe, P(♀) 20.v.1993, 3P(♀), 27.v.1993 (all *M. Smith*) [P♀ to ZSM]; Pe, same location, 25.iv.1992, 2Pe, 3.vi.1992 (*Hardwick*).

Unassociated larvae: 3L, as above, Rockhole Mine Ck., 13°30'S 132°30'E, .v.1993 (*M. Smith*). L, New South Wales: nr Tallong, Barber’s Ck. (*Sydney Water*), viewed previously, now unavailable.

Description. Adult male (n=4, pharate/dissected).

Teneral body length ~3 mm, abdomen 2 mm, wing length ~2 mm. Thorax yellow-brown, scutal vittae mid-brown, scutellum darker brown; antennal plume and legs pale yellow.

Head. Antenna with terminal flagellomere 50 long, with tapered or rounded apex, 2.5–3 × as long as broad, with terminal seta 50–60 long (Fig. 3A); penultimate flagellomere 4.5–6 × terminal flagellomere; A.R. 3.4–3.5. Eye bare, with dorsomedial extension of 6 ommatidia. Temporal setae 11–14 aligned continuous with inner verticals, none dorso–laterally. Clypeal setae 13–16. Palp (2–4) 30, 64, 85, 116. Pedicel with 4 aligned setae.

Thorax. Anteprenotal setae 1–3; acrostichals ~15–24, unevenly uni-biserial between vittae ending in anterior prescutellar field; dorsocentrals ~24–42, arising with cluster in anterior humeral field, multiserial in humeral area, =/- uni-biserial between vittae, expanded nearer to scutellum; supraalars 0; prealars 14–15 bi/multiserial, extending anteriorly more than usual; scutellars 12–14, scattered.

Wing. Membrane unpatterned, densely setose in all cells and all veins. Continuous row of near hyaline, blunt-ended 40 long setae (Fig. 3B) running from base of vein R to apex of R₁ observed in 1 intact wing, not in other abraded wings. Venation and VR not determinable on teneral uninflated wing. Anal lobe not determined. Squamal setae 18.

Legs. All teneral/pharate, only P₁ lengths and ratios calculated: 350, 360, 330, 210, 160, 120, 100; LR₁ 0.91, BV₁ 2.06, SV₁ 2.15. Tibial spurs sinuous, each with 2–5 short lateral teeth and 0–several denticles (Fig. 3C): lengths; P₁ 35–40; P₂ 28–30, 28–30; P₃ 52–63, 35. Without tibial comb. Claws very slender, sinuous curved, distally pointed, simple. Pulvilli absent.

Hypopygium (Fig. 3D). Tergite IX setose, dorsally with paired clusters, ventrally with median and lateral clusters; “anal point” present, hyaline, not illustrated. Gonocoxite 75–85 long, cylindrical, beset with dense setae on dorsal and lateral surface, extending only slightly beyond base of gonostylus; proximal dorso-medial surface with demarcated oval area of dense, mid-lengthed, medially-directed setae; posterior and lateral to this area, dense long setae are directed postero-laterally/medially. Gonostylus 60–70 long, with swollen base, strongly tapering, microtrichiose without longer setae, megaseta 8–12 long. Phallapodeme slender 50 long, sternapodeme slender, inverted V-shaped.

Adult female (n=6, all pharate/dissected). Body length ~2.5 mm, abdomen ~1.5 mm, wing length ~1.6 mm. Yellow-brown, scutal vittae and scutellum mid-brown. Antennal plume and legs pale yellow.

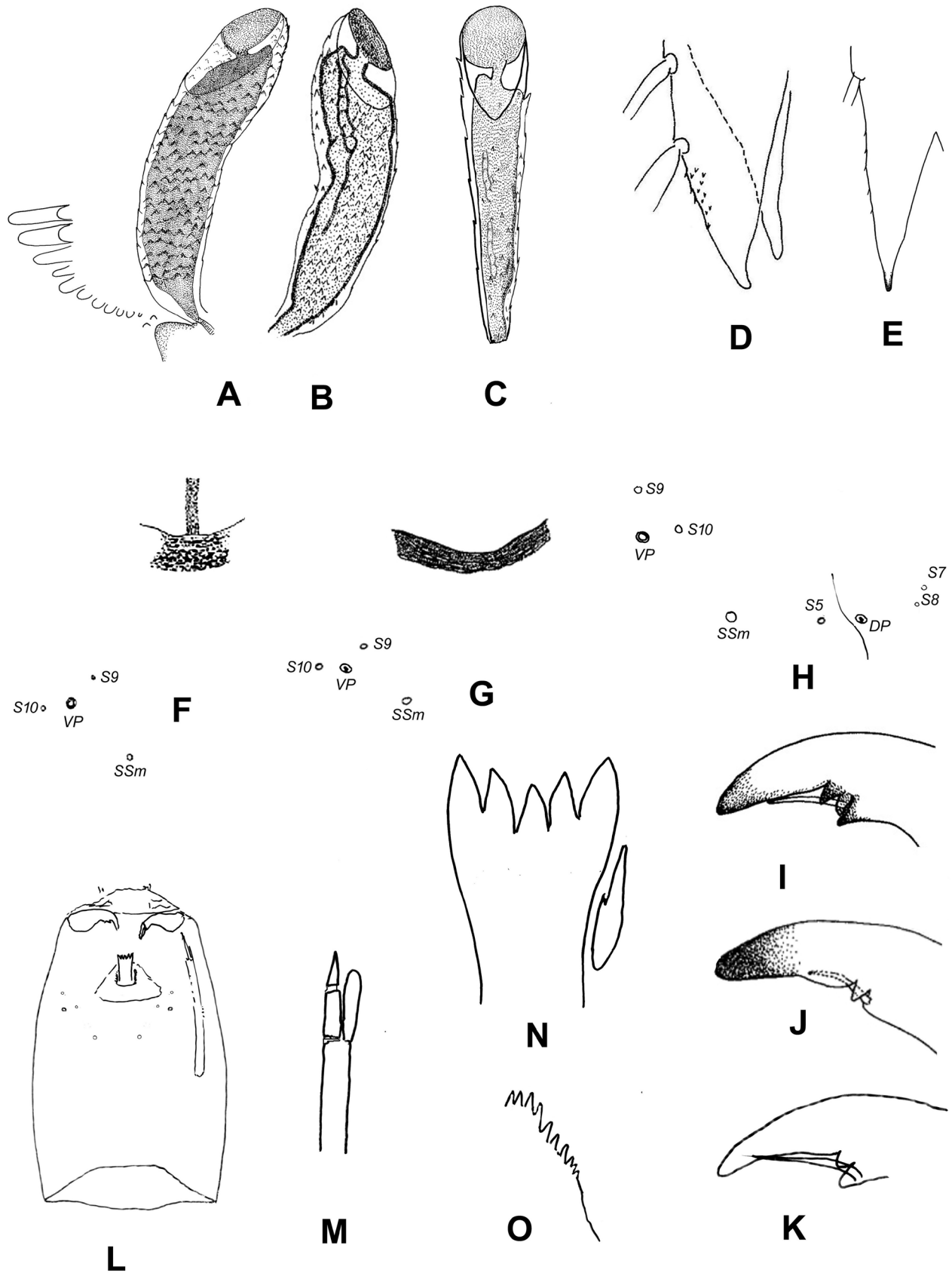


FIG. 2. *Yarrhpelopia* Cranston, Pupa, Larva. A–C, Thoracic horns; D, E, Anal lobes (left side only); F–H, Submenta; I–K, Mandibles; L, ventral head; M, antennal apex; N, Ligula, paraligula; O, Pecten hypopharyngis. A, E, F, *Y. norrisi*, type locality; B, I, *Y. norrisi* var ‘ST1’; D, G, *Y. norrisi* var. ‘genus D’; C, K–O, *Y. ‘V20’*. Abbreviations: S5–S10 cephalic setae, DP – dorsal pit, VP – ventral pit.

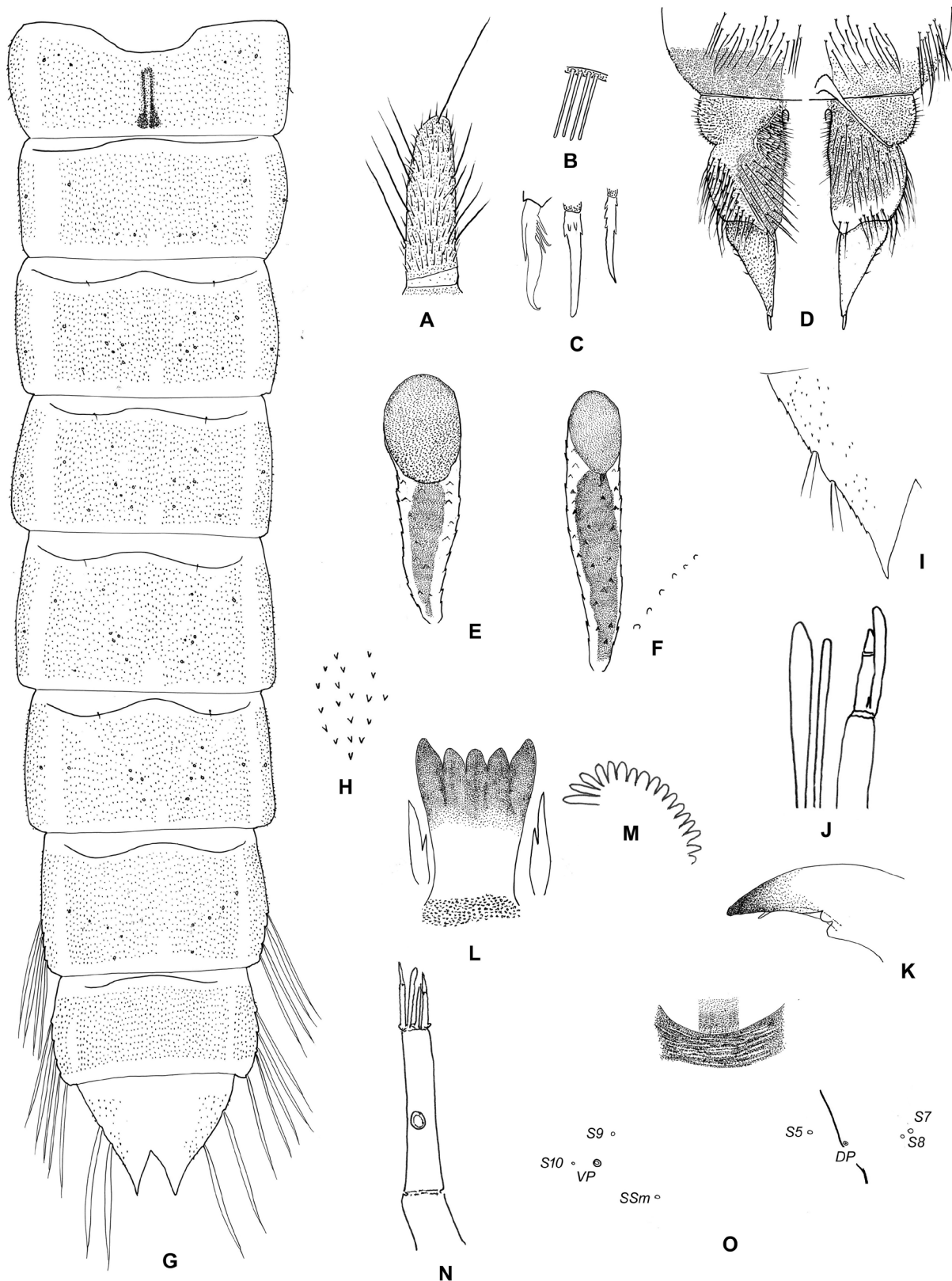


FIG. 3. *Yarrhpelopia acorona* sp. n. Adult male. A, Antennal apex; B, Setae of wing veins R, R₁; C, Spurs on tibial apex, (Left) P₁ (♀), (Right) inner and outer P₃ (♂); D, Hypopygium, left, dorsal (overlying ‘anal point’ omitted), right, stylised semi-ventral. Pupa. E, Thoracic horn (holotype); F, Thoracic horn, comb (Rockhole Mine Ck.); G, Dorsal abdomen; H, Tergite IV spinulation (‘shagreen’), detail; I, Anal lobe. Larva. J, Antenna, blade, apex; K, Mandible, L, Ligula, paraligulae; M, Pecten hypopharyngis; N, Maxillary palp; O, Mentum, submentum, ventral, right side dorsal. Abbreviations: S5–S10 cephalic setae, DP – dorsal pit, VP – ventral pit.

Head. Antenna with 4 setae on scape, 6–8 on pedicel; with 11 flagellomeres, terminal flagellomere 90–115 long, abruptly tapered to narrow blunt apex, with terminal seta 0–30% longer than terminal flagellomere; A.R. 0.29–0.31; eyes bare, separated medially by 2–3 ommatidia. Temporal setae 10–12 continuous with uniserial 5–7 inner verticals. Clypeal setae 9–13. Palp segment lengths (2–5): 30–37, 60–75, 85–105, 125–160.

Thorax. Some thoracic setae (esp. scutellars) stout and long, up to ~200. Antepronotal setae 3; acrostichals 29–34, uni-biserial between the vittae ending in anterior prescutellar field; dorsocentrals 32–42, anteriorly commencing with cluster in anteriormost humeral field, multiserial from humeral area, =/- uni-biserial in broader area towards scutellum; supraalars 0; prealars bi/multiserial 9–15; scutellars 22–26 multiserial.

Wing. Membrane unpatterned, densely setose with long setae in all cells and all veins (without distinctive setae on R veins). Anal lobe not determined. Squamal setae 16–18.

Legs. All teneral/pharate, lengths and ratios incalculable. Tibial spurs sinuous, each with 2–5 lateral fine teeth exemplified on P₁ (Fig 3, left) and few small fine hairs, lengths; P₁ 45–50; P₂ 29–43, 25–27; P₃ 43–47, 25–27. Without tibial comb. Claws fine, slender, curved, distally pointed, simple; pulvilli absent.

Genitalia. Gonocoxapodeme VIII pale-brown, gently curved. Gonapophysis VIII triangular with a tapering distally rounded microtrichiose lobe. Gonotergite IX without setae. Notum thin, 110–132 long, 3x seminal capsule length, free part of rami pale. Tergite IX thin, non-setose. Postgenital plate large bearing small globular cerci, 30 x 30. Three ovoid / globular seminal capsules, 40 long, 30 wide; spermathecal ducts bare, ending separately.

Pupa (n=10, including some pharate). Length 5.2–6.8 mm, colour varying from mid yellow to darker golden yellow, transverse apophyses distinct, mid-yellow to darker.

Thoracic horn (Fig. 3E, F) tubular, of variable shape: holotype 360 long, 100 wide, near parallel-sided to slightly broadening distally, plastron plate ovoid 160 long, 45% length of horn, respiratory atrium 50–60% width of stem (Fig. 3E); Rockhole Mine Ck shorter, 250–270 long, less broadened distally, 45 wide at base, 55 at widest (subapex); plastron plate ovoid, 75–88 x 55–60, ~30% length of horn (Fig. 3F); corona absent, externally with dense well developed spines, separated or with fused bases in tropical specimens; respiratory atrium lacking internal structuring, occupying ~70–80% of horn width, tubular until constricted at connection to plastron plate. Thoracic comb of ~12 small blunt tubercles varying in size, in single uneven row.

Abdomen (Fig. 3G) with somewhat squat segments, with strong scar on I, distinct apophyses, and prominent dense, strong, simple spinules (Fig. 3H), with posterior transverse band of stronger darker spinules on a darkened background in tropical specimens, fainter in temperate specimens. Anal lobe triangular 245–280 long, 140–160 wide at base, distally a slightly but distinctly offset triangular point; setae of anal lobe rather narrow, inserted at ~40 and 55% of length respectively; mediolaterally with simple spinules, some extending to margin (Fig. 3I). Genital sacs triangular in male, 75–80% length of anal lobe, in female rounded and very small, ~30–40% of lobe length.

Larva (n=1). Head length 600; tapering, cephalic ratio (l:w) 77%, pale yellow with occipital margin deeper yellow. Cephalic setation (Fig. 3O) dorsally conventional for *Yarrhpelopia* with S7, S8, and DP near aligned at ~90° to A–P axis, S5 slightly anterior to alignment; ventrally with S9, S10 and VP proximate in triangular arrangement, SSm posteriormost, significantly distant from remainder.

Antenna (Fig. 3J). ~50% head length, 3x mandible length, segment lengths: 260: 55: 6: 4; A.R. 3.8, ring organ at mid-point; basal segment ~10x as long as basal width; blade bifid, inner narrow branch 60, outer dilate branch 64. Style very small 2–3; Lauterborn organ slender extending beyond antennal apex.

Mandible (Fig. 3K) gently curved, 110 long, with bluntly tapering apical tooth, short, barely projecting inner tooth, and weakly protruding rounded mola from which seta subdentalis arises.

Ligula (Fig. 3L) with 5 teeth in concave row, apices of middle teeth directed slightly laterally; ligula gently broadened from midpoint; darkened apical teeth to 33% of ligula, area of muscle attachment occupying basal 20–25%. Paraligula bifid, with outer branch 50% length of ligula, inner shorter. Pecten hypopharyngis (Fig. 3M) with 16 distinct teeth, transversely orientated in gentle arc with innermost tooth longest and directed medially.

Maxillary palp (Fig. 3N) with distinct basal section, 25 long, flexible membranous at connection to main segment 50 long; ring organ at c 50–55% from base; crown 20 long with short setae and sensilla including 2-segmented b-seta with unequal sections.

Submentum (Fig. 3O) anteriorly with ‘creases’ of lighter sclerotisation. Dorsomentum, M appendage and vesicles very reduced or indistinguishable. Pseudoradula very broad, 50 wide, densely micro-granulose non-aligned posteriorly without contact to ventral hypopharyngeal apodemes.

Abdomen. Body without fringe of swim setae. Anterior parapod claws simple, pale. Anal tubules not distin-

guishable. Procercus pale, unicoloured, $\sim 4.5\times$ as long as wide ($140 \times 25\text{--}28$), with 8 mostly broken anal setae, max length 400. Subbasal seta of posterior parapod simple, ~ 270 long. Posterior parapods yellow, all conventionally simple, except the shortest that is a strong flattened hook.

Etymology (Derivatio nominis). The specific epithet *acorona* refers to the diagnostic lack of any corona in the pupal thoracic horn. To be treated as a noun in apposition.

Remarks. The first specimens found were coded as ‘nr *Telmatopelopia*’, and came from an acidic mine-affected creek in Kakadu N.P., Northern Territory. The taxon was keyed in larval and pupal stages by Cranston (1996). Tentative identification as ‘nr *Telmatopelopia*’ was based on a pupal resemblance to this so-far monotypic northern hemisphere genus, notably the large ovate plastron plate lacking any surrounding corona on a tubular, spinose thoracic horn. Placement of this taxon within an expanded *Yarrhpelopia* derives from robust molecular evidence that it is sister to *Y. norrisi* (Fig. 1). The adults resemble the type species *Y. norrisi*, as does the larva (below) although the pupa differs in the thoracic horn, spinosity of the abdomen and the terminal segment.

This taxon, listed in Smith & Cranston (1995, Appendix) as ‘nr *Telmatopelopia*’, was one of 5 species based on pupal exuvial evidence that increased in abundance at the entry of the polluted Rockhole Mine adit into the creek (Cranston *et al.* 1997).

Larval association has been problematic, with only one definite association from Rockhole Mine Creek and none from elsewhere. No potential larva was found amongst the sympatric specimens at the holotype location of NSWNE17.3, where larvae sampled for molecular study from that site (17.3.6,7,8 & 11) belong to *Coronapelopia quadridentata* (described below) and others (17.3, 4 & 9) to *Yarrhpelopia norrisi*. Larval specimens 17.3.2 and 10 provisionally allocated to ‘ST1’, now fall within the variation of *Y. norrisi*.

Initial identification as ‘near to’ *Telmatopelopia* is refuted by a different larval morphology including S9-S10, VP and SSm forming a curved line, with the DP absent (Rieradevall & Brooks 2001), plus the serrate anterior parapod claws (Cranston & Epler 2013). Although the pupa and adult male resemble *Telmatopelopia*, and although we lack molecular material, it is unlikely on the evidence at hand that this western European genus occurs in Australia.

Yarrhpelopia acorona is eastern Australian, apparently abundant only in the acidic polluted sections of Rockhole Mine Creek in Kakadu National Park; otherwise several locations in north Queensland (from 16°S) and a drain from a Sphagnum bog in Cathedral Rock N. P., New England (N.S.W.). Many sites are, or are surmised to be, acidified from mine wastes, with ferric flocculence, or in naturally acidic seeps or faster flowing waters.

‘*Yarrhpelopia*’ species ‘V20’

(Fig. 2C, K–M)

[Pentaneurini ‘V20’. Leung, Pinder & Edward, 2011]

Material examined. AUSTRALIA: L(P), Western Australia, Jarrahdale, Wungong catchment, Seldom Seen Brook, $32^{\circ}15'07''\text{S } 116^{\circ}05'47''\text{E}$, 25.x.2016 (*Carey*) MV B8R3.1.

Description. Pupa ($n=1$ pharate, inadequately visible). Thoracic horn (Fig. 2C) 230 long, tubular, dilate distally, 25 wide at narrowest (base), 57 at widest (apex); plastron plate near circular, diameter 40–42; corona tapered oval, 87 long, 42 wide, $\sim 40\%$ length of horn. Respiratory atrium occupying $\sim 90\%$ of horn, weakly bilobed at connection to plastron plate at $\sim 80\%$ length, with internal structuring that may be struts and / or vacuoles.

Abdomen. Lateral apophyses dark yellow; armament of sparse isolated spinules. Anal lobe with, at most, very fine marginal spinules.

Larva ($n=1$). Head (Fig. 2L) length 650; cephalic ratio (l:w) 55%, subrectangular, pale yellow with occipital margin no darker. Cephalic setation (Fig. 2H) dorsally as in *Yarrhpelopia* with S7, S8, and DP near aligned at $\sim 60^{\circ}$ to A–P axis, and S5 slightly anterior to alignment; ventrally with S9, S10 and SSm aligned at near 45° to A–P axis, and VP lateral to S10.

Antenna (Fig. 2L, M) $\sim 60\%$ head length, $3\times$ mandible length, segment lengths: 260: 75: 7: 6; A.R.: 2.95, ring organ at $\sim 55\text{--}60\%$; basal segment $\sim 12\times$ as long as basal width, blade indeterminable. Style very short, 2; Lauterborn organ elongate subovoid 10, extending to mid-segment 4 (Fig. 2M).

Mandible (Fig. 2K) strongly curved, 112 long, with bluntly tapering apical tooth, short, slightly projecting inner tooth, and a very strong, tooth-like, extended mola from which seta subdentalis arises.

Ligula (Fig. 2N) with 5 teeth in concave row, apices of middle teeth directed slightly laterally; ligula gently broadened from midpoint; narrow area of muscle attachment occupying basal 8–10%. Paraligula bifid, with outer branch 50% length of ligula, inner shorter. Pecten hypopharyngis (Fig. 2O) with 9–10 straight teeth increasing in length to most anterior tooth.

Maxillary palp length 80, basal segment 35 long; ring organ at c 55% from base; crown with well-developed setae and sensilla including long 2-segmented b-seta with unequal sections.

Submentum (Fig. 2H) anteriorly with faint ‘creases’ of lighter sclerotisation. Dorsomentum, M appendage and vesicles not distinguishable. Pseudoradula 18 wide, essentially parallel-sided, densely micro-granulose slightly aligned linearly, posteriorly without contact to ventral hypopharyngeal apodemes.

Abdomen. Body without fringe of swim setae. Anterior parapod claws simple, pale. Anal tubules short (60). Procercus yellow, unicoloured, ~3.5× as long as wide (95 × 28), with 8 anal setae of length 410–420. Subbasal seta of posterior parapod simple, ~200 long. Posterior parapods yellow, contracted, seemingly all simple.

Remarks. Leung *et al.* (2011) differentiated this taxon from ‘sp. A’ (= *Yarrhpelopia norrisi* Cranston) as ‘V20’ and recognised this as unique to Western Australia (WA). Although it had been reported by Bunn *et al.* (1986), it was not included in Cranston (1996). The sole sequence was obtained from a mature larva with pharate pupa within / amongst a batch of larvae from south-western Western Australia. Molecular placement as sister to all sampled eastern *Y. norrisi* (Fig. 1) is credible and thus in ‘V20’ we have a morphologically distinct larva / pupa as sister to ‘core’ *Yarrhpelopia*. However, lacking adult material, formal description as a new species is premature and we retain Edward’s and Leung *et al.* ‘s code for description of the larva and partial pupa. Thus, we lack a successful DNA extraction from any ‘core’ *Yarrhpelopia* in Western Australia that was recognised by Leung *et al.* (2011) as resembling *Y. norrisi*.

This species is a Western Australian endemic, likely limited to the moist south-west of the state, in creeks in jarrah forest (D.H. Edward pers. comm. to Cranston 1990).

***Coronapelopia* Cranston & Krosch gen. nov.**

(Figs. 4–6)

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Type species: *Coronapelopia valedon* **sp.n.**, here designated.

Other included species: *Coronapelopia quadridentata* **sp.n.**

Diagnosis

Adult male (Fig. 4A–D). Scape bare, pedicel with 1 seta, terminal segment short, with apical fine seta; A.R. ~2. Scutum smooth without tubercle. Wings (teneral, uninflated) with membrane and veins including crossveins pale, densely setose; R_{4+5} meets non-extended costa (C) well proximal to wing apex, seemingly proximal to end of M_{3+4} . Squama setose. Tibial spurs present or apparently absent on P_1 , on P_2 and P_3 single short, sinuous without side teeth or setae, without tibial comb. Pulvilli absent; claws very slender, all pointed. Tergite IX microtrichiose, without setae including on gently rounded margin, without anal point. Gonocoxite with mediobasal depression containing dense setae, medially orientated, shorter than dense long setae on dorsal, ventral and outer lateral gonocoxite. Gonostylus slender with long terminal spine.

Adult female (Fig. 4E–G). Scape ventrally with linear setae, extending half circumference, ventral pedicel likewise (Fig. 4E). Antenna 10-segmented, apical segment tapered, without strong seta; A.R. ~0.25. Wing pale with densely setose veins and membrane, R_1 meets R_{4+5} proximal to wing apex, R_{2+3} faint with indeterminate apex and ending. Squama setose. Single tibial spur in each leg, short, sinuous, bare or with few fine lateral hairs.

Genitalia with pale (teneral) gonocoxapodeme VIII gently curved. Gonapophysis VIII forming single distally rounded microtrichiose lobe. Gonotergite IX protruding with 5–7 strong setae. Notum thin, pale (teneral). Tergite IX thin, non-setose. Postgenital plate narrow, bearing small cerci. Three small globular seminal capsules, ducts bare, ending separately.

Pupa (Fig. 5) with elongate broadened, flat thoracic horn less than 3× as long as broad; horn sac narrow

proximally, broadening distally and divided proximal to plastron plate to form narrow-necked connection to plastron plate and extended digitiform lobe; plastron plate laterally orientated, ovoid, filling ~60–75% of surrounding corona; corona well defined, almost circular, occupying ~35–60% of apical horn. Horn (except corona) densely covered with pointed scales. Thoracic comb 6–9 short, apically rounded tubercles in uniserial row. Basal lobe dome-shaped, thorax smooth. Tergite I with pigmented scar; all tergites covered evenly with sparse, unaligned, small flat spinules. L(ateral) setae fine and very short, taeniate on posterior of VII (4) and VIII (5). Anal lobe elongate, near rectangular, with both margins smooth, sometimes with few small spinules posterior to distal anal seta; anal setae adhesive. Genital sacs of female very short, of male tapering, extending to apex of anal lobe.

Larva (Fig. 6) with head index ~0.7. Ligula 5-toothed, weakly concave, inner teeth directed anteriorly and mid-tooth slightly recessed, or 4-toothed. Antenna shorter than head, A.R. ~2.7–3.2, ring organ either at ~20 or 50% of segment 1, segment 2 smooth; Lauterborn organ conventional either subequal to segment 3 or dilate and extending to antennal apex. Basal palp segment undivided, ring organ 40% from base. Mandible conventional, seta subdentalis arising on molar area, proximal to slightly or distinctly protruding inner tooth, molar area low or tooth-like. Gula slightly to more strongly creased (visible in phase contrast or Nomarski interference). SSm slightly more posterior than VP, V9, V10 which are +/- equidistant in triangle; dorsal pit (DP) present or absent, S7 near S8, DP (when present) close to S5. Body without swim hairs. Procercus bi-coloured, 2.5–3 × width. All parapod claws simple, pale.

Etymology (Derivatio nominis). The hyaline area surrounding the plastron plate of the pupal thoracic horn, the *corona*, is notably large, and *-pelopia* is a common suffix in Tanypodinae (from the suppressed *Pelopia* Meigen 1800).

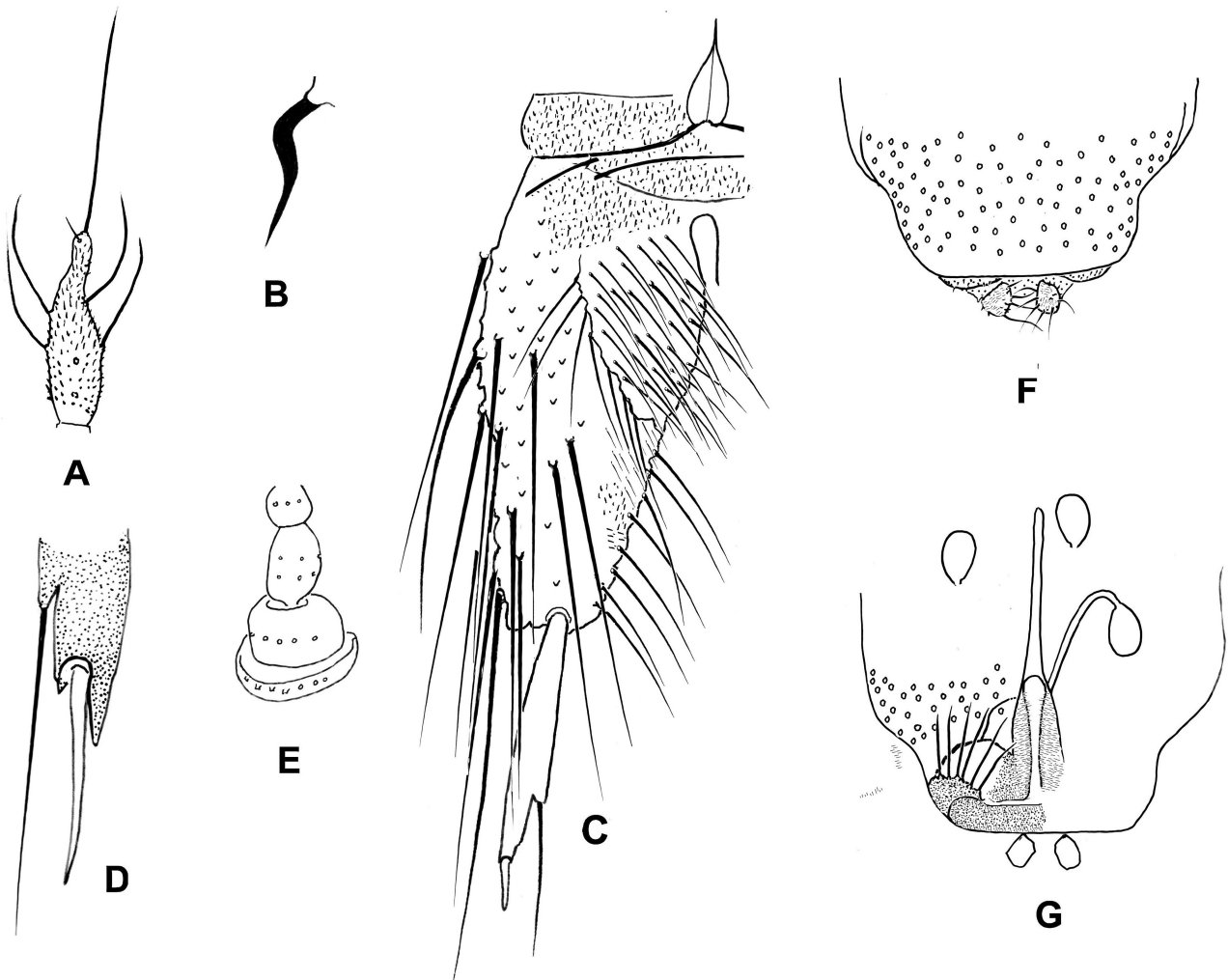


FIG. 4. *Coronapelopia* gen. n. Adults. Male. A, Antennal apex; B, Tibial spur, C, Hypopygium, left side, dorsal, right side stylised ventral/internal, D, Detail, gonostylus apex. Female. E, Antennal scape, pedicel, basal flagellomere. F, Genitalia dorsal; G, Ventral, left side detail. A–D, *C. valedon* sp. n., E–G, *C. quadridentata* sp. n.

Discussion (of genus)

This new taxon was recognised as potentially novel and of supra-species rank by Cranston (1996) based on the immature stages. Given the code of Pentaneurini genus D, it was stated to resemble *Nilotanypus* Kieffer, although differing in its ecology. The larva, from a polluted creek in the Blue Mountains (courtesy of Sydney Water, as Australian Water Technologies), bore little resemblance to *Nilotanypus*. Revisited, the pupa shared only superficial similarity in thoracic horn and the elongate genital sacs that accommodate the very long gonocoxal setae, whereas most other features refute any relationship. Ecologically, the taxon is restricted to low-order montane and submontane creeks of the south-east of Australia, whereas *Nilotanypus* in Australia is tropical, eurythermic, and found in sandy-bedded streams. Distinctiveness of the immature stages remains apparent (Cranston 1996, 2010, 2019c) and distant to *Nilotanypus*.

In keys to larva of Holarctic Tanypodinae (Cranston & Epler, 2013), *Coronapelopia* belongs to the subfamily Pentaneurini, and lies outside the Thienemannimyia-complex, keying to couplet 35 where the procercal height-width ratio (~ 3.0) implying *Trissopelopia* but which fails on the simple parapod claws, ligula and mandible shape and organisation of cephalic setae and pits. In the key to pupae of Holarctic Tanypodinae (Fittkau & Murray 1986), *Coronapelopia* is a pentaneurine, clearly not a member of the Thienemannimyia-complex, but it cannot be taken further in lacking distinct anal lobe spinules. The adult male uniquely has strongly reduced number and morphology of the tarsal spurs with an extended gonostylar spine, both evidently autapomorphies that do not assist in keying or assessing relationships.

Coronapelopia has not been included previously in any molecular analyses but has been sampled (as MV FNQ12 CH2) from a pupa / pharate male from the north-east of the distribution. Its position as sister group with strong support to the previously coded 'genus E' of Cranston (1996), which is treated here as new and distinct second species *Coronapelopia quadridentata*, is described below. This pair is sister to the expanded *Yarrhpelopia* (previously 'genus A', now including 'ST1' and at least specimens under '?*Telmatopelopia*' of Cranston (1996)). The expanded endemic Australian genus *Yarrhpelopia* is considered above.

Coronapelopia valedon Cranston & Krosch sp. n.

(Figs. 4–6)

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[Pentaneurini genus D Cranston 1996, 2010, 2019c]

Material examined (collected Cranston unless stated otherwise, deposited ANIC).

Holotype, slide-mounted in Euparal: P♂, AUSTRALIA: New South Wales, Brown Mt., Rutherford Ck., 36°36'S 149°47'E, 16.x.1990 (Cranston & Edward).

Paratypes: AUSTRALIA: Queensland, 4Pe, Cape Tribulation, Oliver Ck., 16°08'37"S 145°26'21"E, 22–23.iv.1999; P♂, Mt. Lewis N.P., Churchill Ck., 16°34'S 149°47'E, 1.xi.2012 MV FNQ12 CHT2; 4Pe, Kenilworth State Forest, Bundaroo Ck., 26°41'S 152°36'E, 26.ix.1989 (Cranston & Edward); Pe, same except 27.xi.1989 (Cranston).

New South Wales: 2L, L(P), Blue Mts, Grose Valley, Fairy Dell Ck., 33°35'S 150°15'E, site E0101, 18.xi.1992 (AWT); Pe, Brindabella, Goodradigbee R., 35°23'54"S 148°44'51"E, 4.i.2001; ♂, P♂, 7Pe, as holotype [Pe to ZSM].

Australian Capital Territory: Pe, Brindabella [Ranges], Blundell's Ck., 35°22'S 148°50'E, 6–9.iv.1988; Pe, Corin, Gibraltar Falls, 30.i.2001, 35°28'S 148°55'E.

Description. Adult male (n=4–5, all teneral) body length ~2.3–2.5 mm, wing length undetermined. Colour apparently yellow-brown, scutal vittae mid-brown, scutellum darker brown. Antennal plume and legs pale.

Head. A.R. ~2.0–2.1, terminal flagellomere tapering, 3–4× as long as broad, with terminal strong seta 50 long (Fig. 4A); penultimate flagellomere 3.5× terminal flagellomere; eye bare, with 6 ommatidia long dorsomedial extension. Temporal setae 8–9 closely aligned as inner verticals, none dorso-laterally. Clypeal setae 16. Palp (n=1) clearly 5 segmented; 1 bare, 2–4 with long setae, 5 much less setose; lengths of 2–5: 23, 42, 74, 110, seemingly lacking sensilla clavata. Scape bare, pedicel with 1 lateral seta.

Thorax. Scutal tubercle absent. Antepnotal setae 1, fine; acrostichals ~15, uni-biserial between the vittae

ending in anterior prescutellar field; dorsocentrals ~20, arising anteriorly in humeral field, multiserial in humeral area, uniserial between vittae, expanded posteriorly; supraalars 0; prealars biserial 8–9; scutellars 9–10 uniserial. Preepisternum bare.

Wing. Costa ending at apex of R_{4+5} , distant from wing apex, ending above midpoint between ends of M_{1+2} ; and M_{3+4} ; R_2 , R_{2+3} and VR not determinable on teneral wing. Membrane unpatterned, densely setose in all cells and all veins. Anal lobe rounded. Squamal setae 7–9.

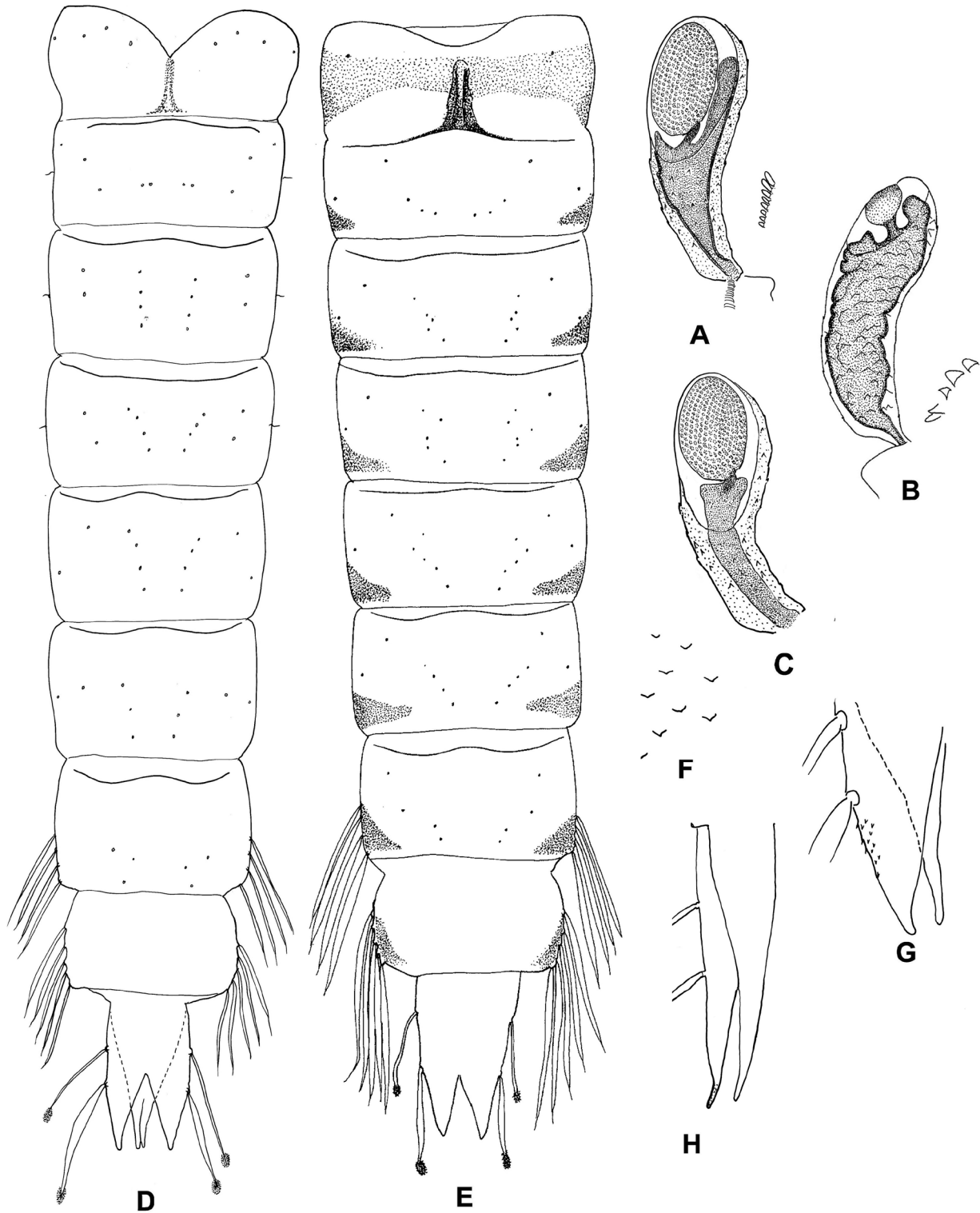


FIG. 5. *Coronapelopia* gen. n. Pupa. A–C. Thoracic horn and comb; D, E, Dorsal abdomen; F, Tergite IV spinulation (‘sha-green’), detail; G–H. Male anal lobe. A, D, F, G. *C. valedon* sp. n., B, E, H, *C. quadridentata* sp. n., C, *Pentaneura ? cinerea* Philippi.

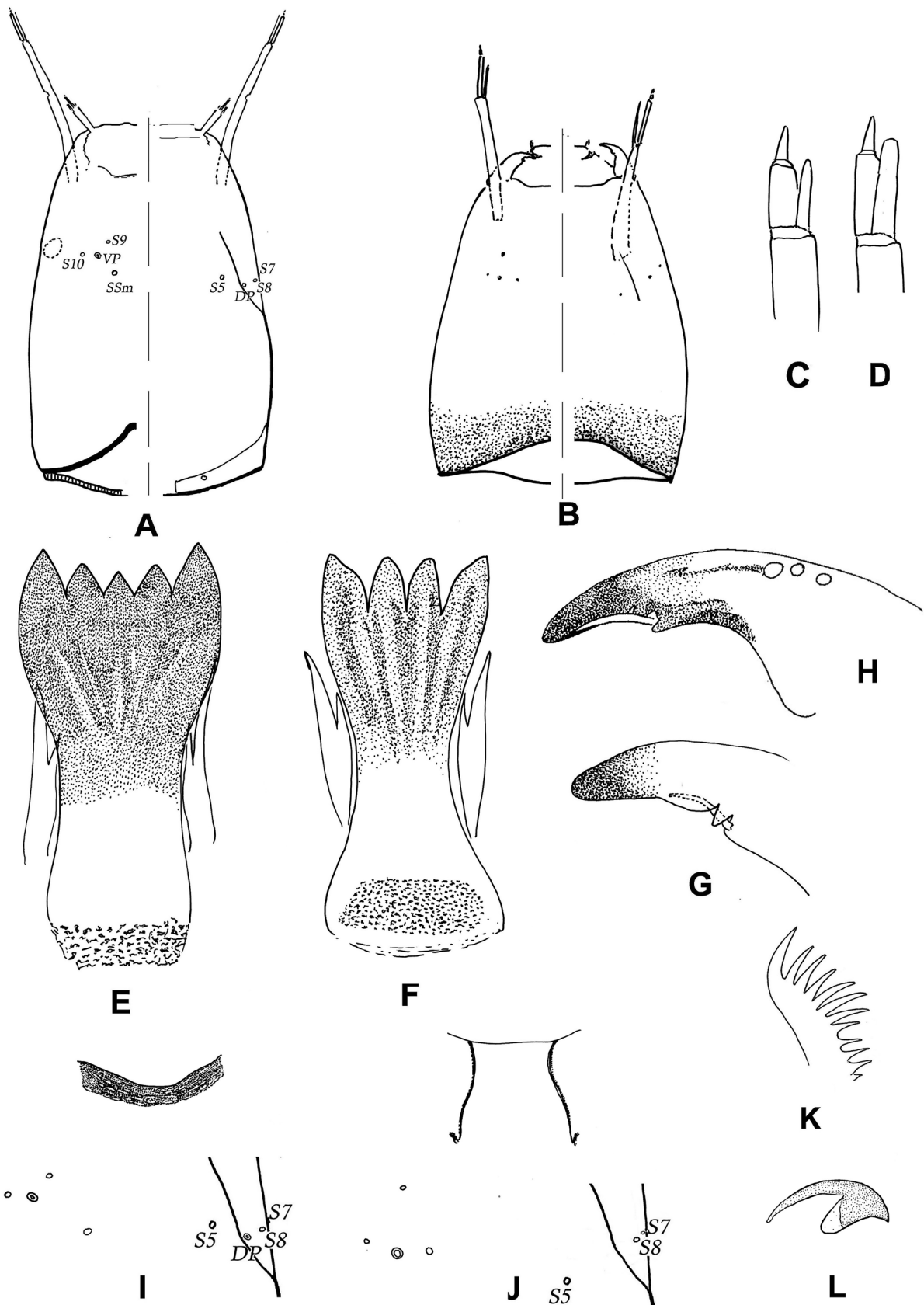


FIG. 6. *Coronapelopia* gen. n. Larva. A, B, Head, left ventral, right dorsal; C, D, Segments 2–4 of antenna; E, F, Ligula, paracymbia; G, H, Mandible apex; I, J, Submentum, ventral, right side insert dorsal; K, Pecten hypopharyngis; L, Flattened claw of posterior parapod. A, C, E, G, I, K. *C. valedon* sp. n., B, D, F, H, L. *C. quadridentata* sp. n. Abbreviations: S5–S10 cephalic setae, DP – dorsal pit, VP – ventral pit.

Legs. LR₁ 0.6–0.64, BV₁ 1.9–2.2, SV₁ 3.0–3.2; LR₂ 0.7–0.72, BV₂ 2.5, SV₂ 3.2 LR₃ 0.72–0.73, BV₁ 2.2, SV₁ 2.8. Tibial spur (Fig. 4B) lengths; P₂ 15; P₃ 15; without tibial comb. Claws very slender, slightly curved, distally pointed, simple. Pulvilli absent.

Hypopygium (Fig. 4C, D). Tergite IX microtrichiose without setae; “anal point” not evident. Gonocoxite 95 long, cylindrical, beset with very long (>125 long) setae on dorsal and lateral surface, extending well beyond flexed gonostylus; proximal dorso-medial surface with oval patch of mid-lengthed, dense, medially-directed setae. Gonostylus 78–80 long, very narrow but scarcely tapering, terminal spur 23 long, subapical seta inserted on inner margin 35 from apex (Fig. 4D). Phallapodeme not visible, sternapodeme inverted V-shaped.

Adult female unknown.

Pupa (n=10). Length 2.5–2.9 mm. Cephalothorax pale yellow including wing sheaths; abdomen TI with strong yellow-brown scar, remainder pale to yellow, with golden transverse apophyses.

Cephalothorax. Thoracic horn (Fig. 5A, flattened elongate ovoid; Corona large, occupying ~40–50, exceptionally 60% of length of thoracic horn, plastron plate subovoid, angled to long axis. Thoracic comb comprising 10–13 short tubules tending to fine spinules, longest 10 long (Fig. 5A), or seemingly absent. Basal lobe elongate lobe, 30 long. Thorax bare or micro-spinulose; without scutal or postnotal tubercle. Single anteprenotal seta retracted from margin, only 1 weak precorneal seta; other thoracic setae indistinct.

Abdomen (Fig. 5D). Tergite I with scar, lateral muscle marks not visible. Abdominal microspinulation (shagreen) (Fig. 5H) of sparse, fine spinules not aggregated or linear. L setae taeniate on segments VII (4, clustered in posterior half) and VIII (all 5, evenly spaced). D setae: 3 on I, 4 on II, 5 on III–VII, absent on VIII; O-setae: 1 pair dorsal, 1 ventral, situated close to apophyses. Anal lobe (Fig. 2D) near rectangular ~2× as long as broad (270–300 × 26–32), with ultra-fine scattered spinules; borders smooth. Anterior macroseta thin (~5–6) after initial dilation compared to broader (10–12) posterior macroseta; macrosetae adhesive. Genital sheaths smooth, of male ~220, extending ~90–100% length of anal lobe, containing very long gonostylar setae. of female short (~70).

Larva (n=2). Body length 4.0–4.8 mm, head capsule (Fig. 6A) length 550–590 μm, golden-yellow with narrow cephalic margin only slightly darker golden-brown; mandible golden yellow, ligula golden, grading darker in distal half, anterior parapod claws fine and pale, posterior claws broader, golden-yellow, simple (but all contracted), Capsule longish-oval, cephalic index ~0.75 (compressed). Cephalic setation (Fig. 6A, I): SSm slightly retracted on mola, VP with V9, V10 unaligned, equidistant in a triangle; dorsal pit (DP) close to S5, S7 close to S8.

Antenna (Fig. 6A, C) ~60% head length, 2.5× mandible length, segment lengths: 250–300: 100–105: 5: 3; A.R.: 2.7–3.2, ring organ at ~50%; basal segment ~8× as long as basal width, Blade bifid, broad outer branch 65, slightly shorter than or subequal to narrow accessory blade, extending to or slightly beyond antennal apex. Lauterborn organ thin, short, 4–5, subequal to segment 3 (Fig. 6C).

Mandible (Fig. 6G) gently curved, with bluntly tapering apical tooth, 90–105 long; short, rounded, non-projecting inner tooth, seta subdentalis arises from rounded non-extended mola.

Ligula (Fig. 6E) with 5 teeth in concave row, all teeth directed anteriorly; ligula broadened from midpoint; narrow area of muscle attachment occupying basal 8–10%. Paraligula bifid, with outer branch 50% length of ligula, inner shorter. Pecten hypopharyngis (Fig. 6J) with 10–12 upcurved lobe/teeth, increasing in length anteriorly (nearest to ligula).

Maxillary palp length 80, basal segment 52 long; ring organ at < 20% from base; crown with well-developed setae and sensilla including 2-segmented b-seta with subequal sections.

Submentum (Fig. 6I) anteriorly with transverse ‘creases’ of light sclerotisation, more evident laterally than medially. Dorsomentum with darker sclerotised patch 10 long, bearing 3–4 small teeth; M appendage uncertain, vesicles not distinguishable. Pseudoradula 8–10 wide, essentially parallel-sided, densely micro-granulose without alignment, posteriorly without contact to ventral hypopharyngeal apodemes.

Abdomen. Anterior parapod claws simple, pale. Anal tubules not determined. Procercus yellow, bicoloured, paler posteriorly, ~3× as long as wide (85 × 30), with 8 anal setae of length 350. Subbasal seta of posterior parapod simple, ~200 long. Posterior parapods yellow. seemingly all simple (but contracted) subtended on parapod by subapical area of few fine spinules.

Etymology (Derivatio nominis). The species epithet *valedon*, derives from farewell (*vale*) to our late colleague ‘Don’ Edward who was associated with the first collection made, in eastern Australia although somewhat ‘out of range’ of this proud western Australian. To be treated as a noun in apposition.

Remarks. *Coronapelopia valedon* is an Australian endemic distributed along the eastern margin of Australia, from 18°S to 36°S, and apparently absent from Tasmania.

***Coronapelopia quadridentata* Cranston & Krosch sp. n.**

(Figs 4–6)

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[Pentaneurini genus E Cranston 1996, 2000, 2010, 2019c]

Material examined. Holotype, slide-mounted in Euparal, Le/Pe/♀, AUSTRALIA: Western Australia, Shannon River N.P., mid-Shannon River, 34°39'E 116°22'E, 23–24.xi.1994 (Cranston) ANIC.

Paratypes (collector Cranston, deposited ANIC, unless indicated otherwise). As holotype, Le/Pe/♀, P♀, 20Pe; south-western Western Australia, Shannon River N.P., Shannon R., 34°39'E 116°22'E, 23–24.xi.1994 [P♀, 6Pe to ZSM]; 2L, Fish Ck., 34°40'E 116°23'E, 24.xi.1994.

New South Wales, P♀, 3L, New England, Cathedral Rock N.P., Sphagnum bog pool, ~1360 m. asl, 30°26'18"S 152°17'9"E, 13.iii.2017, MV: NSWNE17.3.6, 7, 8, 11.

Other material. Tasmania: 4 Pe, Walls of Jerusalem N.P., Solomon's Jewels, pond #2, 41°47'8"S 146°16'5"E, 1185 m. asl, 17.iii.1997 (Wright).

Description. Male unknown.

Female (n=2, +/- pharate). Total length c. 2.0 mm, wing length 2.1 mm. Antenna: scape and pedicel each with 5–7 setae ventrally in semicircle on each (Fig. 4E); with 10 flagellomeres, A.R. 0.26, terminal flagellomere 80 µm long, tapering, apex without seta. Dorsomedial extension of eye 5–6 ommatidia wide. Temporal setae 13, linear uniserial. Clypeal setae 27. Palp lengths 2–5: 35, 75, 108, 175, lacking any sensilla. Thoracic setation: anteprenotal seta 1; acrostichals (ac) 29–32, multiserial, starting far anterior ending just short of scutellum; dorsocentrals (dc) 38, broadly scattered in humeral area, then biserial to just anterior to scutellum (ac and dc setae bimodal in size); supraalars 0; prealars irregularly biserial, 18–20; scutellars biserial, 15–16. Squama 5. Leg ratios (n=1) LR₁ 0.64, BV₁ 2.50, SV₁ 2.93; LR₂ 0.58, BV₂ 2.77, SV₂ 3.55; LR₃ 0.64, BV₃ 2.62, SV₃ 2.82. Single tibial spur similar on all legs, slightly sinuous, 7–8 long, bare or with few very fine, hair-like side teeth.

Genitalia (Fig. 4E, F). Gonocoxapodeme VIII pale (teneral) gently curved. Gonapophysis VIII a single distally rounded lobe. Gonotergite IX protruding with 5–7 strong setae. Notum thin, pale. Tergite IX thin, non-setose. Post-genital plate narrow, with small pediform cerci. Three small globular seminal capsules of diameter 70–75, spermathecal ducts bare, ending separately.

Pupa (n=10). Body length 5.2–6.0 mm. Cephalothorax and abdomen golden-brown; wing sheaths, scar, posterolateral areas of each segment and apophyses contrastingly darker.

Cephalothorax. Thoracic horn (Fig. 5B) cylindrical, flattened in antero-ventral plane, curved in lateral view, dilate and rounded apically, 275 long, maximum length 2.5× maximum width, external membrane with spines nearly united into irregular mesh. Horn sac tubular, occupying c. 90% of horn, bilobed each side of connection to plastron at 80% length. Corona wide, occupying c. 30–40% length of thoracic horn, plastron plate ovoid, 50% width of corona, angled to long axis. Basal lobe tubercular, c 35 long. Thoracic comb comprising 7–8 squat, near contiguous tubercles, 10 long. Thorax smooth; without scutal or postnotal tubercle. Thoracic setae difficult to discern: only 1 weak precorneal seta; dorsal setae 1 and 2 present, simple, 2 displaced laterally close to anterior wing sheath base, dcs4 in supraalar position.

Abdomen (Fig. 5E). Tergite I with scar, lateral muscle marks very weak. Abdominal spinulation (shagreen) (Fig. 5F) aggregated into short rows, larger and denser and in triplets medially or aligned laterally especially on more posterior segments. L setae taeniate only on segments VII (4, clustered in posterior half) and segment VIII (all 5, evenly spaced). D setae: 3 on I, 4 on II, 5 on III–VII, absent on VIII; O-setae: 1 pair dorsal, 1 ventral, situated mid-curve of apophyses. Anal lobe ~1.5× as long as broad, bare, neither border with strong spinules (Fig. 5E,H), terminating in sclerotised point (Fig. 5H). Anterior seta of anal lobe half width at base (c. 8 µm) of the posterior (distal) (~15 µm). (Anal macrosetae adhesive. Genital sheath of female very short; of male smooth, extending c. 95% length of anal lobe,

Larva (n=2–3). Body length 4.1–4.2 mm, head capsule length 400–430, width 300–315, golden-yellow, darkened posteriorly (Fig. 6B), mandible golden, apical tooth variably darkened ligula golden brown grading to darker brown distal 1/3 (Fig. 6H), anterior parapod claws fine and pale, posterior claws broader, simple, pale yellow. Capsule elongate-oval, cephalic index 0.7–0.75. Cephalic setation (Fig. 6B, J): S10, S9 and SSm forming a triangle with VP between S10 and SSm, dorsal pit absent, S7 close to S8, S5 strongly retracted, aligned with extension of S7 and S8.

Antenna (Fig. 6B, D) ~50% head length, segment lengths: 137–142: 44–45: 6, 3, A.R. 2.1–2.2; basal segment ~8× as long as basal width, ring organ distal to mid-point (66%); blade bifid, broad outer branch 48, inner branch thin, both ending at apex of antenna. Lauterborn organs swollen, 10, reaching apex of antenna (Fig. 6D).

Mandible (Fig. 6H) gently curved, with tapering apical tooth, 54–57 long; short, rounded inner tooth not projecting, long seta subdentalis arises from projecting tooth-like distal mola.

Ligula (Fig. 6F) 48–50 long, with 4 teeth in level row, with all teeth directed anteriorly, ligula constricted medially; narrow rectangular area of muscle attachment occupying basal 8–10%. Paraligula bifid, with outer branch ~50% length of ligula, inner much shorter. Pecten hypopharyngis (Fig. 6K) with 6–8 teeth, homogenous in size or diminishing slightly laterad.

Maxillary palp with basal segment 30 long; ring organ situated at 10% length from base; crown with well-developed setae and sensilla including 2-segmented b-seta with sections subequal in length.

Submentum (Fig. 6J) anteriorly with only very weak transverse ‘creases’ of lighter sclerotisation. Dorsomen-tum and pseudoradula indistinct, faint.

Abdomen. Anterior parapods short, claws simple, pale. Anal tubules slender, pointed, 60 long. Procercus slightly darkened posteriorly, ~2.5× as long as wide (50–52 × 20–22), with 7–8 anal setae, 250–280. Subbasal seta of posterior parapod long, simple. Posterior parapods 300 long, claws subtended on parapod by few fine spinules. Two mid-sized claws are ‘folded’ (Fig. 6L) as noted for WA specimens by Leung *et al.* (2011), confirmed here also for eastern Australia in individuals with distinct claws visible.

Etymology (Derivatio nominis). The species epithet *quadridentata* refers to the four-toothed larval ligula, unusual and diagnostic in Australian pentaneurine tanypods.

Remarks. As with other taxa treated using codes in Cranston (1996), ‘Pentaneurini genus E’ was segregated based on immature stage characters (larvae and usually also pupae) of which corresponded to no northern hemisphere taxa. Formal taxonomy with diagnoses and species descriptions awaited full life stage associations and especially insights anticipated from molecular data. Although disappointingly few additional life histories have been made, pharate adults are now available from collections made in the appropriate habitats seeking material (successfully) for molecular studies. However, for ‘genus E’ all adults are pharate females and generally description of novel taxa without the adult male is to be avoided. Molecular analyses (Fig. 1) reveal the taxon as sister to, and thus indicated as congeneric, with the taxon treated here as *Coronapelopia valedon*. The morphology of the immature stages can be reconciled with this, although the female adult is unknown for the genotype *C. valedon*, and the male is unknown for *C. quadridentata*.

The larva of *C. quadridentata* was segregated (as ‘Pentaneurini genus E’ Cranston 1996) by the narrow, elongate four-toothed ligula (Fig. 6F). Although a tooth number of the conventional five can occur due to developmental abnormality, in this species it is unlikely given a ventral setal arrangement with S10, ventral pit and SSm transversely aligned in a pattern unknown in any previously recognised larva with an aberrant four-toothed ligula. All larvae from several localities in south-western Western Australia possessed this characteristic ligula, although some material from eastern Australia rarely may have a 5-toothed ligula, but be otherwise identical in every detail.

The species appears acidophilic in Western Australia where the Shannon River and the tributary Fish Creek naturally are acidic with low conductivity and nutrient levels, in a catchment entirely within the Shannon River National Park. The species is reported as both lotic and lentic in the south west of Western Australia by Leung *et al* (2011).

Several eastern Australian localities where this taxon had previously been recorded are named as swamps (e.g., Basket Swamp and Tin Swamp Creek) amongst Sydney Water monitoring sites. However, further locality details were not provided nor are specimens available for morphological study. The location from which molecular material was obtained was at elevation (~1360 m. asl) in a large sphagnum swamp amongst snow gums, including in a small stream draining the bog.

The sole site in Tasmania is a small pond (Jewels Pond #2) also at elevation (1185 m. asl) in cushion plant heathland.

Conclusions

The genesis of this study arose from attempts to understand the biodiversity and systematics of the little-studied Chironomidae of seasonally wet tropical systems in northern Australia in relation to monitoring historic, ongoing and contemplated expansion of uranium mining in an area of outstanding natural beauty, Kakadu National Park. Monitoring required species-level understanding of the aquatic immature stages, although associated adults are needed for refined taxonomy. Associations were sought for the Tanypodinae, but reliance was largely upon pupae, and less so, larvae. Comparisons with the northern hemisphere fauna were unclear, and therefore, many taxa were identified by codes that were maintained as surveys extended covering the whole continent.

Conversion of codes to formal taxonomy is time-consuming, yet all semaphoronts should be described in taxonomic and biodiversity studies, as is well argued by Faria *et al.* (2020). With the advent of molecular systematics and funding to compare the phylogeny of all Tanypodinae, progress came from ‘reciprocal illumination’ in synthesising molecular data and morphology of all stages.

Morphological segregates of immature stages found some support as species or higher (‘Pentaneurini genus X’) but differentiation of others failed due to unrecognised high variation in some morphology. Despite molecular guidance, naive interpretation of, for example, barcode DNA, could imply high cryptic diversity. However, even our continent-wide sampling does not approach the data density needed for population genetics analysis. We take a conservative approach to this issue in the phylogenetic context.

Regarding the value of morphology in this study, some observations can be made. Adult structures show much less informative variability in Pentaneurini than in most other chironomids. The male hypopygium that is often species-specific elsewhere is very generalised, with volsellae only in the monophyletic Thienemannimyia group, and here it provides at best only subtle details of the gonostylar apex including the megaseta. The female genitalia are typical for ‘core’ Pentaneurini (Sæther 1977) apparently lacking any idiosyncratic (diagnostic) or differentiating features. Mensural features and counts do show variation but without any obvious association with differentiation of taxa. All wings examined are from pharates, unexpanded, and are densely setose precluding examination of venational differences and costal extension and wing vein R_{2+3} are not discernible. In tribe Pentaneurini (*sensu* Fittkau 1962, Silva & Ekrem 2016; Krosch *et al.* 2017), wing features are few and may be ambivalent (Murray & Fittkau, 1989). The number, size and shape of the tibial spurs are potentially valuable: in *Yarrhpelopia*, the 1,2,2 pattern of sinuous spurs with few distinct lateral teeth is typical, whereas in *Coronapelopia* a reduced number of simplified spurs is distinctive.

The pupal stage that initially provided informative variation actually is less distinctive (and sometimes misleading) than was expected. For example, thoracic horns with a large plastron plate in a large corona are seen in additional taxa, namely the Australian endemic *Australopelopia* Cranston, some members of the Thienemannimyia-group (the Australian representatives are distinguished on other group-specific features), and certain western hemisphere species of *Pentaneura* (Fig. 5C), some North American *Zavrelimyia* Fittkau (e.g. *Z. wartinbei* Roback and many species formerly in *Paramerina* Fittkau) and in *Trissopelopia* Kieffer. Although the enlarged corona is not uniquely diagnostic, it is unusual in Pentaneurini and shared between certain sister taxa on molecular evidence. However, a large corona alone cannot be taken as evidence of close relationships – for example, *Yarrhpelopia acorona* lacks a corona and is the sister taxon to *Y. norrisi* in the group in which otherwise the large corona is characteristic. Unexpected distinctions are found in the terminal pupal segments, concerning the shape and relative lengths of the anal lobes and male genital sacs.

The larval ventral cephalic setal / pit pattern may be distinctive amongst Australian pentaneurines, but the dorsal is not. Unexpected variation in this within the widespread species *Y. norrisi* led to earlier segregation of larval types, and patterns are not genus-specific for *Coronapelopia* (see Fig. 6 I, J). However, the distinction between the two species of *Coronapelopia* notably in the number of teeth of the ligula and other features is clear, as is their sister group relationship based on the molecular data (Fig. 1).

The discussion is predicated on the molecular information accurately representing species distinction and phylogenetic relationships. We have confidence in well-sampled nodes with robust support. Unsupported nodes relate to shallow internal relationships with one exception, some interdigitated *Pentaneura* and relatives.

A major outcome of this study is a better understanding of the ecology of a wider clade that is extended from an association with aquatic mine waste of *Y. norrisi* to a propensity to acidophily, potentially across the clade. Habitats include acid mine drainages, but extend to nature acid waters from bogs and swamps, both lotic and lentic.

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