



## Article

# Three New Species of the Freshwater Shrimp Genus *Caridina* from Australia <sup>†</sup>

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**Abstract:** Three new species of the genus *Caridina* are described from the northernmost part of Australia. *Caridina darwin* n. sp. resembles *Caridina temasek* Choy and Ng, 1991 but differs in the armature of the rostrum, the development of epipods on the pereopods and the absence of an appendix interna on the male first pleopods. *Caridina magnovis* n. sp. resembles *Caridina serratiostris* de Man, 1892 but differs in the armature of the ventral margin of the rostrum, a shorter stylocerite, a stouter carpus of the first pereopod, the number and size of spiniform setae on the third and fifth pereopods, the shape of the preanal carina and the size of the embryos (referred to as “eggs” in most previous publications). *Caridina wilsoni* n. sp. resembles *Caridina gracilirostris* de Man, 1892 but differs in the size of the embryos and in some length to width ratios of the segments of the pereopods. Detailed morphological descriptions of all three new species are given. A molecular phylogeny (mt DNA 16S) supports the morphospecies hypothesis and illustrates the phylogenetic relationship with morphologically similar species from outside Australia.

**Keywords:** Crustacea; Decapoda; Atyidae; Australia

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## 1. Introduction

The species-rich freshwater shrimp family Atyidae De Haan, 1849 (Crustacea: Decapoda: Caridea) currently comprises 46 genera with 544 species and the number of taxa described is constantly increasing [1]. A significant number of species of the largest genus within the Atyidae, *Caridina* H. Milne Edwards, 1837 are known from Australia but are still awaiting formal species descriptions [2]. Some new species were recently described from the northern part of Australia like *Caridina malanda* Choy, Page, de Mazancourt and Mos, 2019, a species belonging to the *Caridina zebra* species complex [3], *Caridina biyiga* Short, Page and Humphrey, 2019, a member of the *C. thermophila* species group [4] or *Caridina pagei* Christodoulou and De Grave, 2023, a morphological cryptic species related to *Caridina sobrina* Riek, 1953 [5]. Christodoulou and De Grave [5] also provided an overview on the species of genus *Caridina* from Australia. Short et al. summarized the information on *Caridina* originating from the Northern Territory and gave a morphological key for their identification [4]. Page et al. [6] already suggested the existence of species complexes of problematic, cryptic Australian species within the genus *Caridina*. In 2007, Page et al. studied the phylogenetic and biogeographic relationships of Australian atyid freshwater shrimps, including *Caridina*, and identified potential species radiations. They found several genetically distinct and putatively new species of the genus *Caridina*. This material was subsequently included in a paper on the molecular and conservation biogeography of *Caridina* shrimps from northwestern Australia [7] and, with additional samples, to discuss the relationship within shrimp of the genus *Caridina* from the Northern Territory [4].

This study presents a detailed morphological examination of some of the material from Page et al. [7], supported by molecular data. It confirms that the genetically distinct

clades from Page et al. [7] are distinct species. Finally, we describe three new species from Australia.

## 2. Materials and Methods

All samples were obtained using dip and hand nets and preserved using 96% ethanol. Specimens were subsequently transferred into 70–80% ethanol for long-term preservation. A proportion of the preserved specimens were dissected and morphometric data were taken using a BMS 143 Trino Zoom dissecting microscope with an ocular grid. Details on setae and mouthparts were observed using a Reichert Biovar compound microscope. Rostral characters were taken from all examined specimens. Drawings were made from microphotographs using Adobe Illustrator following Coleman [8,9]. The setae terminology used mostly followed that of Short et al. [10].

All materials examined were deposited in museum wet collections at the Museum and Art Gallery of the Northern Territory, Darwin (NTM); the Western Australian Museum, Perth (WAM); Queensland Museum, Brisbane (QM); and the Museum für Naturkunde (Museum of Natural History), Berlin, Germany (ZMB). The abbreviations used were as follows: cl = carapace length (measured from the postorbital margin to the posterior margin of the carapace); ov. = ovigerous; and juv. = juveniles.

DNA was extracted from abdominal tissue using a Qiagen Blood and Tissue Kit (Qiagen N.V., Hilden, Germany) according to the manufacturer's instructions. A fragment of the mitochondrial 16S rRNA (16S, ~590 bp) gene was amplified by polymerase chain reaction (PCR) and sequenced using primers 16S-F-Car and 16S-R-Car1 [11]. Amplifications were conducted in 25 µL volumes containing 50–100 ng DNA, 1× PCR buffer, 200 µM of each dNTP, 0.5 µM of each primer, 2 mM MgCl<sub>2</sub> and 1 U of Taq polymerase. After an initial denaturation step of 3 min at 94 °C, 35 cycles of 30 s at 94 °C, 60 s at 50 °C and 60 s at 72 °C were performed, followed by a final extension step of 5 min at 72 °C. PCR products were sent to Macrogen Europe for purification and sequencing of both strands of the amplified gene fragments using the primers as given above. Contigs of forward and reverse strands were assembled using Geneious Prime (v. 2019.2.1) and corrected by eye. In addition, published sequences, notably twelve sequences of the three new species published by von Page et al. [7], Cook et al. [12], Short et al. [4] and de Mazancourt et al. [13], have been included in the analysis (Table 1). Sequences were aligned with MAFFT [14]. To determine the best substitution model for Bayesian inference analyses (see below), hierarchical likelihood ratio tests were carried out with jModelTest [15]. Based on the Akaike Inference Criterion (AIC), the GTR + I + G model was selected. The new sequences (n = 22) have been deposited in GenBank (for accession numbers and museum voucher numbers, see Table 1). Phylogenetic trees were reconstructed by Bayesian inference (BI) [16] using MrBayes 3.2.6 [17]. The MCMCMC algorithm was run with four independent chains for 10,000,000 generations, with samplefreq = 500 and burnin = 25%. Maximum likelihood analyses were run with IQ-TREE [18] and branch support was obtained through the implemented ultrafast bootstrap (1000 replicates) [19]. BI and ML analyses were run with the model specified above (for IQ-TREE, see [20]). In addition, maximum parsimony (MP) analyses were performed using the heuristic search algorithm as implemented in PAUP\* [21], with gaps treated as the fifth base. Support for nodes was estimated by bootstrap analysis (1000 bootstrap replicates with 10 random addition replicates each).

**Table 1.** List of sequenced specimens with geographic origin, voucher information and data source. “ZMB DNA” vouchers are DNA samples from specimens with an origin in the pet trade without any specimen remains.

Species	Origin	Museum Voucher	GenBank Accession	Sequence Source
<i>Atya scabra</i>	Panama	ZMB DNA 510	PP471291	This study
<i>Atyoida pilipes</i>	Indonesia: Sulawesi	MZB Cru 5451	PP471292	This study
<i>Atyopsis moluccensis</i>	Indo-Pacific	ZMB DNA 222	DQ681281	This study
<i>Caridina appendiculata</i>	Indonesia: Sulawesi	ZMB 29000	PP471299	This study
<i>Caridina brachydactyla</i>	Indonesia: Sulawesi	ZMB 30397	PP471302	This study
<i>Caridina brevicarpalis</i>	Indonesia: Sulawesi	ZMB 30741	PP471304	This study
<i>Caridina brevidactyla</i>	Indonesia: Sulawesi	ZMB 29007	PP471300	This study
<i>Caridina celebensis</i>	Philippines: Mindoro	ZMB 29619	PP471310	This study
<i>Caridina darwin</i> n.sp.	Australia: NT	ZMB 29211	PP471291	This study
		GU1252	KJ801322	Short et al., 2019 [4]
<i>Caridina endehensis</i>	Indonesia: Sulawesi	ZMB 29420	PP471303	This study
<i>Caridina excavatoides</i>	Thailand	ZMB 30195	PP471308	This study
<i>Caridina gracilipes</i>	Indonesia: Sulawesi	ZMB 30733	OQ185493	Klotz et al., 2023 [22]
<i>Caridina gracilirostris</i>	Indonesia: Bali	ZMB 29345	PP471297	This study
		ZMB 29099	PP471298	This study
<i>Caridina gracillima</i>	Malaysia (peninsular)	ZMB 29578	PP471294	This study
	Australia: WA	GU333/334/337	DQ478554	Page et al., 2007 [7]
		GU537	DQ478555	
<i>Caridina magnovis</i> n. sp.	Australia: NT	GU1257	KJ801324	Short et al., 2019 [4]
		CA1744	JN167243	
			MK189913	De Mazancourt et al., 2019 [13]
<i>Caridina malayensis</i>	Malaysia (peninsular)	ZMB 29777	PP471306	This study
<i>Caridina neglecta</i>	Indonesia: Sulawesi	ZMB 29004	PP471293	This study
<i>Caridina peninsularis</i>	Malaysia (peninsular)	ZMB 29500	PP471301	This study
<i>Caridina serratirostris</i>	Indonesia: Sulawesi	ZMB 29006	PP471311	This study
<i>Caridina temasek</i>	Singapore	ZMB 29664	PP471307	This study
<i>Caridina typus</i>	Reunion	ZMB 32380	PP471305	This study
	Australia: NT	ZMB 29180	PP471295	This study
		ZMB 29240	PP471296	This study
			DQ478533	Page et al., 2007 [7]
<i>Caridina wilsoni</i> n. sp.	Australia: QLD	GU567	DQ478530	Page et al., 2007 [7]
		GU584	DQ478531	Page et al., 2007 [7]
		GU996	DQ478532	Page et al., 2007 [7]
	Australia: NT/QLD	GUB68	JN167234	Cook et al., 2011 [12]
		GUB103	JN167233	Cook et al., 2011 [12]

### 3. Results

#### Family ATYIDAE De Haan, 1849;

#### Genus *Caridina* H. Milne Edwards, 1837;

#### *Caridina darwin* n. sp.;

*Caridina* sp. ‘NT2’ Wilson, 2008;

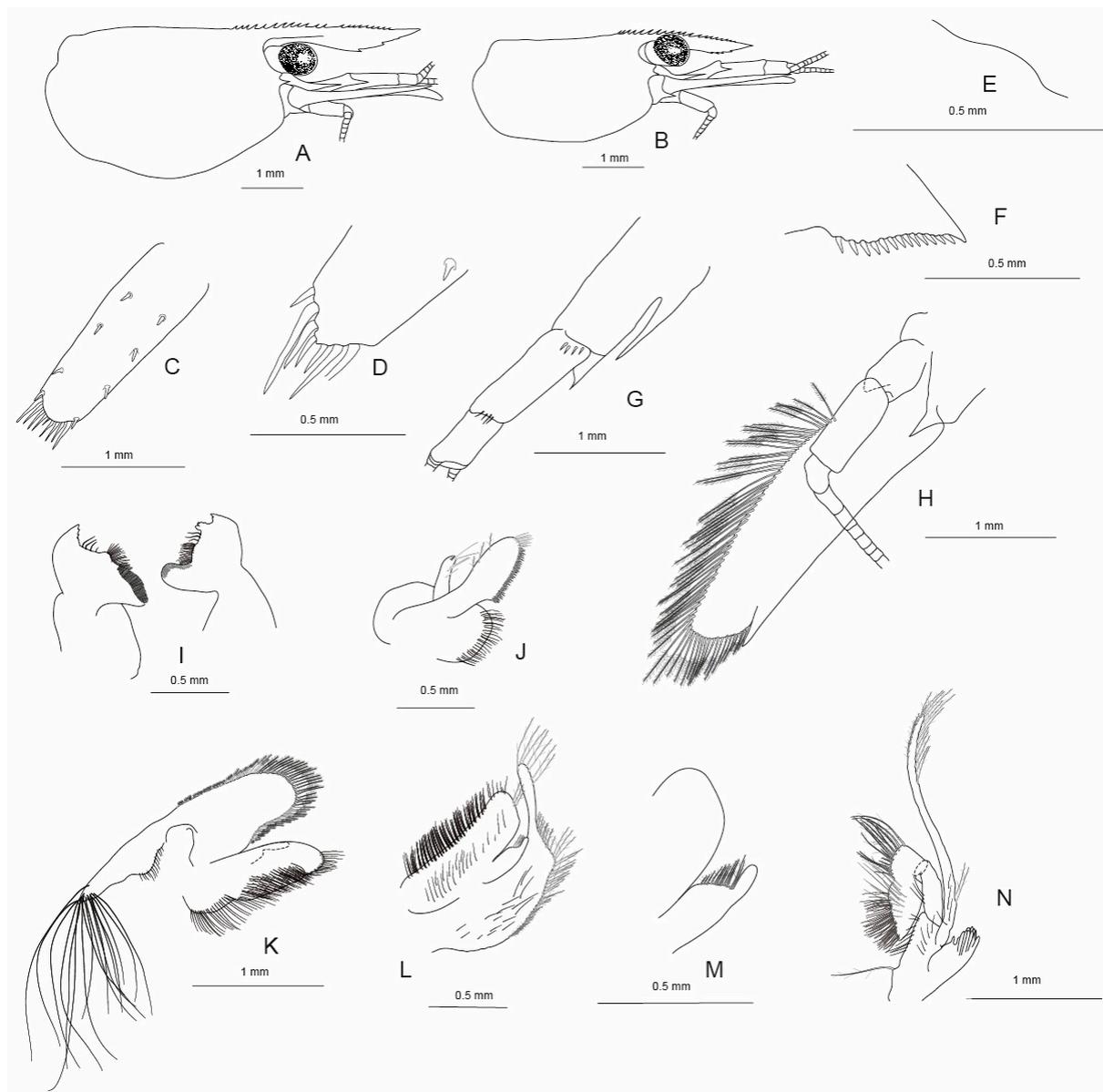
*Caridina* ‘sp. NT2’ Short, Page and Humphrey, 2019;  
(Figures 1 and 2).

#### 3.1. Material Examined

Holotype: ♂ cl 2.1 mm, Australia, New Territory «Provinz», Finnis River catchment, Howard Springs, leg. S. Choy, 29.06.1992, NTM Cr019569.

Paratypes: One ♂ cl 2.4 mm, same data as holotype, NTM Cr019570; two ♀ cl 3.2 and 3.7 mm, one specimen lacking the pleon cl 1.8 mm, Australia, New Territory «Provinz», Darwin area, Blackmore River, cultured specimens provided by D. Wilson NTM Cr019571;

two ov. ♀♀cl 2.1 and 2.3 mm, Australia, Northern Territory, Howard Springs, S 12°27.345' E 131°3.146', leg. M. Glaubrecht, N. Brinkmann, T. von Rintelen 27.06.2004, ZMB 29211.



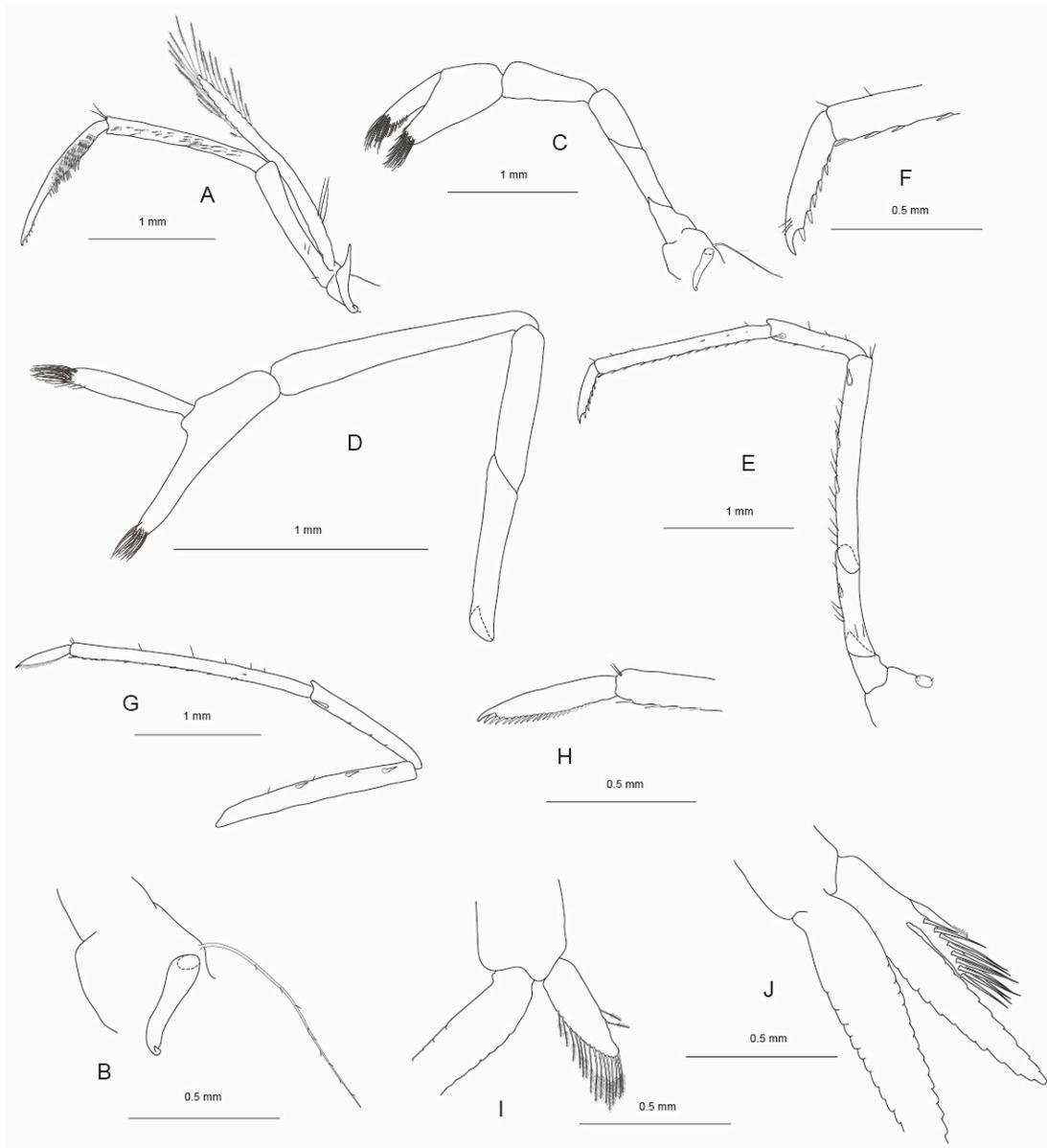
**Figure 1.** (A,C,E–N) *Caridina darwin* n. sp. paratype ♀cl 3.2 mm, NTM Cr019571; (B,D) *Caridina darwin* n. sp. paratype ♂cl 2.4 mm, NTM Cr019570. (A,B) Carapace; (C) telson; (D) distal margin of telson; (E) preanal carina; (F) uropodal diaeresis; (G) antennular peduncle; (H) scaphocerite; (I) mandibles; (J) maxillulae; (K) maxillae; (L) first maxilliped; (M) palp of first maxilliped; (N) second maxilliped.

### 3.2. Comparative Material Examined

Paratypes. *Caridina temasek* Choy and Ng, 1991. Five specimens, Singapore, freshwater stream near Sime road, MacRitchie catchment area, ca. N 1°20.233' E 103°48.783' leg. P.K.L. Ng and K.K.P. Lim Aug. 1990.

Other material. *Caridina temasek* Choy and Ng, 1991. Two ♂♂cl 2.1 and 2.3 mm, two ♀♀cl 2.8 and 3.7 mm Singapore, Central catchment, N 1°21.32' E 103°48.279', leg. W. Klotz 08.12.2011, ZMB 29681.

*Caridina excavatoides* Johnson, 1961. Three ♀♀cl 2.3–3.2 mm, Indonesia, Sumatra, Jambi, Tributary of Batang Hari River, Danau Lamo Village, S 1°28.003' E 103°38.262', leg. M. de Bruyn 01.01.2009 ZMB 29583.



**Figure 2.** (A–C,E–H) *Caridina darwin* n. sp. paratype ♀cl 3.2 mm, NTM Cr019571; (D,I,J) *Caridina darwin* n. sp. paratype ♂cl 2.4 mm, NTM Cr019570. (A) Third maxilliped, (B) well-developed epipod and seto-branch on first pereiopod, (C) first pereiopod, (D) second pereiopod, (E) third pereiopod, (F) dactylus of third pereiopod, (G) fifth pereiopod, (H) dactylus of fifth pereiopod, (I) first pleopod, (J) second pleopod.

### 3.3. Description

**Cephalothorax and cephalic appendages:** Small shrimp with carapace lengths of 1.8–3.7 mm (median 2.3 mm,  $n = 7$ ) in apparently adult specimens. Carapace (Figure 1A,B) smooth, antennal spine clearly separated from suborbital lobe, pterygostomial angle broadly rounded. Rostrum (Figure 1A,B) extending from midlength of second article of antennular peduncle to distal end of it, 0.70–0.85 (median 0.71,  $n = 5$ ) times as long as carapace, nearly straight or slightly sinuous, terminating in acute tip; dorsal margin armed with 15–21 basally articulated teeth over entire length, including 4–5 postorbital, teeth above orbit larger than anterior and proximal teeth; ventral margin with 2–4 moderately large teeth located in distal half of the rostrum. Rostrum formula based on six specimens 4–5(4)+11–17/2–4. Eyes (Figure 1A,B) well developed with pigmented globular cornea. Antennular peduncle (Figure 1A,B,G), 0.86–0.93 (median 0.92,  $n = 4$ ) times as long as carapace in females, 1.0 times as long as carapace in males, first segment 1.69–1.92 (median 1.81,  $n = 5$ ) times

as long as second segment, second segment 1.86–2.67 (median 1.88,  $n = 5$ ) times longer as third segment; distolateral tooth on first segment well developed, acute, 0.15–0.38 (median 0.20,  $n = 5$ ) times as long as second segments; second and third segments unarmed, with few spiniform setae near distal margin. Stylocerite acuminate, reaching to 0.72–0.93 (median 0.80,  $n = 5$ ) times the length of the basal segment of antennular peduncle. Antennal scaphocerite (Figure 1H) with well-developed distolateral tooth, 3.86–4.0 (median 3.80,  $n = 3$ ) times as long as wide.

Pleon, telson and uropods: The sixth pleomere 0.60–0.67 (median 0.63,  $n = 4$ ) times the carapace length, 1.63–1.83 (median 1.72,  $n = 4$ ) times as long as the fifth pleomere, and 0.87–1.0 (median 0.92,  $n = 4$ ) times as long as the telson. Telson (Figure 1C,D) slightly tapering distally, distal margin strongly convex to triangular, lacking median apex, with 3–4 ( $n = 3$ ) pairs of dorsal short spiniform setae and one pair of short spiniform setae dorsolaterally; distal margin with 6–8 ( $n = 5$ ) strong spiniform setae, where the lateral pair was the longest. Preanal carina (Figure 1E) rounded, low. Uropodal diaeresis (Figure 1F) with 10–13 movable spiniform setae, outermost one shorter than lateral angle.

Mouthparts and branchiae: Mandibles (Figure 1I) without palp, incisor process ending in irregular teeth, molar process truncated. Lower endite of maxillula (Figure 1J) broadly rounded with long pappose setae and few rows of serrate setae near margin and scattered cuspidate setae proximal, upper endite elongate, with numerous distinct cuspidate setae flanked by a row of serrate setae on inner margin and few pappose setae subterminal, palp slender with few simple setae and one conical spiniform seta near tip. Upper endites of maxilla (Figure 1K) subdivided, furnished with numerous pappose, simple and papposerrate setae arranged in rows, palp slender, scaphognathite tapering posteriorly, fringed with long, curved serrulate setae on truncate posterior margin and plumose setae inferiorly. Palp of first maxilliped (Figure 1L,M) terminating in finger-like extension, caridean lobe and flagellum with plumose setae, base with numerous pappose, papposerrate and serrate setae arranged in rows and tufts. Podobranch on second maxilliped (Figure 1N) well developed; exopod slender, protruding propodal segment, with long plumose setae distally; basis and merus with rows of pappose setae, distolateral margin of penultimate segment with numerous pappose and serrate setae; dactylus with numerous serrate setae flanked by a row of pappose setae. Third maxilliped (Figure 2A) slender, with two arthrobranches; exopod slender, exceeding distal margin of antepenultimate segment, with few long plumose setae distally; antepenultimate segment of endopod slender, with few simple setae basally; penultimate segment slender, with straight lateral margins, with few simple setae distally, inner margin with rows of short serrate setae; ultimate segment slightly shorter than penultimate segment, tapering distally, ending in a claw-like curved spiniform seta (nail), proximal to nail with few cuspidate setae; inner margin densely covered with rows of serrate setae; epipod well developed, with distal hook. Branchial apparatus as shown in Table 2; well-developed (with distal hooks) epipods present on third maxilliped and first pereopod (Figure 2B). Vestigial epipods (visible only after cleaning and staining of appendages) on second and third pereopods.

**Table 2.** Branchial formula of *Caridina darvin* n. sp. 1, 2: present, well developed; (1): reduced; -: absent.

	Maxillipeds			Pereopods				
	1	2	3	1	2	3	4	5
Pleurobranchs	-	-	-	1	1	1	1	1
Arthrobranchs	-	-	2	1	-	-	-	-
Podobranchs	-	1	-	-	-	-	-	-
Epipods	-	-	1	1	(1)	(1)	-	-
Setobranchs	-	-	-	1	1	1	1	1
Exopods	1	1	1	-	-	-	-	-

Pereiopods: Chela of the first pereiopod (Figure 2C) was caridinoid in shape, slender, with well-developed palm, 2.44–2.90 ( $n = 2$ ) times as long as wide, 1.30–1.32 ( $n = 2$ ) times as long as carpus; fingertips rounded, without hooks but each with tuft of setae; dactylus 3.67–4.00 ( $n = 2$ ) times as long as wide, 1.22–1.44 ( $n = 2$ ) times as long as palm. Carpus slender, hardly excavated distally, 2.73–2.75 ( $n = 2$ ) times as long as wide, 1.29–1.36 ( $n = 2$ ) times as long as merus. Merus not inflated, 2.44–2.62 ( $n = 2$ ) times as long as wide, shorter than ischium. Chela of second pereiopod (Figure 2D) very slender, caridinoid in shape, with well-developed palm, 3.65–3.75 ( $n = 2$ ) times as long as wide, 0.73–0.84 ( $n = 2$ ) times as long as carpus; fingertips rounded, without hooks but each with tuft of seta, dactylus 6.17–6.67 ( $n = 2$ ) times as long as wide, 1.42–1.67 ( $n = 2$ ) times as long as palm. Carpus slender, 6.17–6.63 ( $n = 2$ ) times as long as wide, 1.64–1.67 ( $n = 2$ ) times as long as merus. Merus not inflated, 3.82–4.55 ( $n = 2$ ) times as long as wide, shorter than ischium. Third pereiopod (Figure 2E,F) with dactylus (Figure 2F) 5.00–5.33 ( $n = 2$ ) times as long as wide (including terminal claw and spiniform setae on flexor margin), terminating in one claw, with five or six accessory spiniform setae on flexor margin; propodus not dilated or distally curved, 12.0 ( $n = 2$ ) times as long as wide, 3.0 ( $n = 2$ ) times as long as dactylus; carpus 4.33–4.71 ( $n = 2$ ) times as long as wide, 0.54–0.55 ( $n = 2$ ) times as long as propodus, 0.45–0.49 ( $n = 2$ ) times as long as merus, with one large spiniform seta near distal margin and three small spiniform setae proximal; merus 7.07–9.73 ( $n = 2$ ) times as long as wide, 2.04–2.21 ( $n = 2$ ) times as long as carpus, with three or four strong movable spiniform setae on externo-inferior margin; ischium with one spiniform seta. Fourth pereiopod was similar to third but slightly smaller. Fifth pereiopod (Figure 2G,H) slender; dactylus (Figure 2H) 4.0–5.50 ( $n = 2$ ) times as long as wide (including terminal claw and spiniform setae on flexor margin), terminating in one large claw, with 21–49 spiniform setae on flexor margin; propodus with small spiniform setae on ventral margin, distal pair of spiniform setae not enlarged, propodus 12.50–16.40 ( $n = 2$ ) times as long as wide, 2.27–4.10 ( $n = 2$ ) times as long as dactylus; carpus 5.0–7.83 ( $n = 2$ ) times as long as wide, 0.50–0.57 ( $n = 2$ ) times as long as propodus, 0.61–0.67 ( $n = 2$ ) times as long as merus, with one strong spiniform seta near distal margin and 2–5 small spiniform setae proximal; merus 9.11–9.33 ( $n = 2$ ) times as long as wide, 1.49–1.64 ( $n = 2$ ) times as long as carpus, bearing three strong appressed movable spiniform setae on externo-inferior margin. Ischium with or without one spiniform seta.

Pleopods: Endopod of male first pleopod (Figure 2I) elongated subtriangular, lacking appendix interna, 3.2 times as long as proximal width, 0.38 times as long as exopod, with long plumose setae on outer and distal margins, with few pappose setae on inner margin. Male second pleopod with appendix masculina rod-shaped (Figure 2J), 8.3 ( $n = 1$ ) times as long as wide, 0.63 ( $n = 1$ ) times as long as endopod, armed with strong spiniform setae on inner margin and distal margin; appendix interna originating from about 0.4 times the length of appendix masculina, reaching to about 0.75 times the length of appendix masculina.

Reproductive biology: Ovigerous females with medium-sized embryos; size of undeveloped embryos (without eyes)  $0.59\text{--}0.64 \times 0.37\text{--}0.39$  mm.

Size: Postorbital carapace length of apparently adult specimens 1.8–3.7 mm.

Colouration: Transparent to brownish with cream-colored transversal stripes on the pleon (Wilson 2008; Short, Page and Humphrey 2019).

Distribution: The species occurs in rivers around Darwin, Northern Territory, Australia.

Etymology: The species name *darwin* is derived from the Darwin river catchment, the natural habitat of the proposed new species, and is used as a noun in apposition.

Common name. Blackmore River Caridina.

Remarks: Based on morphology, *Caridina darwin* n. sp. is related to a group of species that includes *Caridina propinqua* de Man, 1908 and *Caridina laevis* Heller, 1862 as the best known members. Within this group of species related to *C. laevis*, two species with large embryos—*Caridina temasek* Choy and Ng, 1991 and *Caridina excavatoides* Johnson, 1961, both occurring in freshwaters of the Malayan peninsula—are most closely related to the proposed new species. *Caridina darwin* n. sp. differs from *C. temasek* by a higher number of teeth on the dorsal margin of the rostrum (15–21 vs. 14–16 in *C. temasek*), the development

of epipods (vestigial epipods (only visible after clearing and staining of the appendages) on the second and third pereopods, the lack of an epipod on the fourth pereopod vs. a well-developed (with distal hooks) epipod on the second pereopod, a reduced epipod on the third and a vestigial epipod on the fourth pereopod in *C. temasek*). Furthermore, the proposed new species differs from *C. temasek* by lacking an appendix interna on the first pleopod of males (vs. with well-developed appendix interna in *C. temasek*) and smaller embryo size ( $0.59\text{--}0.64 \times 0.37\text{--}0.39$  mm vs.  $0.70\text{--}0.80 \times 0.44\text{--}0.54$  mm in *C. temasek* according to the original description). There is still some confusion about the shape of the preanal carina in *C. temasek*. Choy and Ng [23] did not give a drawing of this part, but in the verbal description, they wrote “Pre-anal carina with about 10 setae”, suggesting that they did not observe a distinct hook-like spine. In their paper on Atyidae from peninsular Malaysia and Singapore [24], Cai et al. wrote that the preanal carina in *C. temasek* is “triangular, no spine or with a very tiny spine”. Four of five paratypes of *C. temasek* observed for the present study show a prominent hook-like spine on the preanal carina, as do all four topotypical specimens from Singapore listed above. The holotype of *C. temasek* lacks a spine on the preanal carina (Y. Cai, pers. comm.). It seems likely that specimens assigned to *C. temasek* with and without a hook-like spine on the preanal carina might belong to different species. All specimens of *Caridina darwin* n. sp. lack a spine on the preanal carina.

*Caridina darwin* n. sp. is also similar to *Caridina excavatooides* Johnson, 1961. Both species lack an appendix interna on the endopod of the first pleopod in males. The proposed new species differs from *C. excavatooides* by a longer sixth pleomere (0.60–0.67 times the length of the carapace vs. less than 0.6 times the length of the carapace in *C. excavatooides*). Furthermore, *Caridina darwin* n. sp. differs from this species in the shape of the palp of the first maxilliped (with a distinct finger-like extension vs. ending in a triangular extension in *C. excavatooides*). *Caridina darwin* n. sp. differs from *C. excavatooides* in the development of the epipods on the third maxilliped and pereopods in the same way as *C. temasek*. The dactylus of the fifth pereopod has a smaller number of spiniform setae on the flexor margin (21–49 vs. 50–60 in *C. excavatooides*).

*Caridina magnovis* n. sp.

*Caridina* sp. WA 4 Page, von Rintelen and Hughes 2007;

*Caridina* sp. ‘WA 4’ Wilson, 2008;

*Caridina* sp. WA 4 Cook, Page and Hughes 2011;

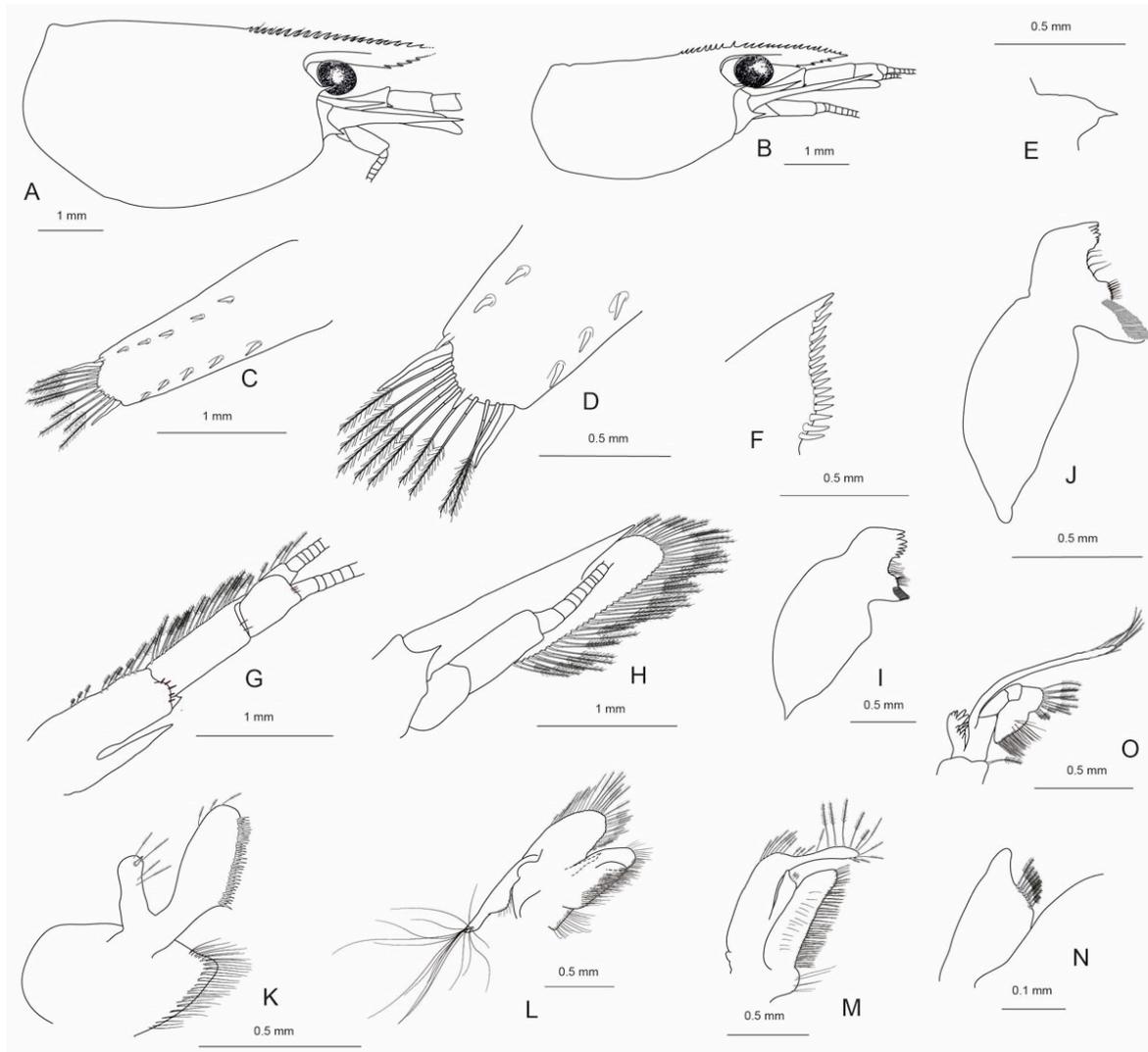
*Caridina* ‘sp. WA4’ Short, Page and Humphrey, 2019;

(Figures 3 and 4).

### 3.4. Material Examined

Holotype: ♂cl 2.9 mm, Australia, Western Australia, Fitzroy River catchment, Calder Yard, FIT12-6, leg. M. Scanlon 29.04.1998, WAM C81392.

Paratypes: One ♂cl 2.6 mm, one ♀cl 3.7 mm, same data as holotype WAM C81393; one ♂cl 2.7 mm, Australia, Western Australia, Ord River catchment, Mantinea Flats, leg. M. Scanlon 18.09.1998, WAM C81394; two ov. ♀♀cl 4.0 and 4.3 mm, one ♀cl 3.7 mm, Darwin Area, Howard River, Gunn Pt. Rd Xing, cultured specimens provided by D. Wilson NTM Cr019573; three ♀♀cl 1.8–2.2 mm, two ♂♂cl 2.3 and 2.4 mm, Fitzroy River catchment, Dimond Gorge, leg. M. Scanlon 14.04.1998 ZMB 33101; one ♂cl 3.0 mm, Darwin Area, Blackmore River, cultured specimens provided by D. Wilson ZMB 33112; one ♀cl 2.1 mm, one ov. ♀cl. 3.1 mm, four juv. cl 1.6–1.8 mm, Australia, Northern Territory, Top End, Coomalie Creek, S 13°0.884', E 131°7.371', 85-04, leg. N. Brinkmann und T. von Rintelen 28.06.2004, ZMB 29152; two ♀♀cl 2.5 und 2.7 mm, two ov. ♀♀cl 2.8 und 2.9 mm, Australia, Northern Territory, Howard Springs, S 12°27.345' E 131°3.146', 79-04, leg. M. Glaubrecht, N. Brinkmann, T. von Rintelen 27.06.2004, ZMB 32120.



**Figure 3.** (A,C–F,I) *Caridina magnovis* n. sp. paratype ov. ♀cl 4.0 mm, NTM Cr019573; (B,G,H,J–O) *Caridina magnovis* n. sp. paratype ♂cl 2.7 mm, WAM C81394. (A,B) Carapace; (C) telson; (D) distal margin of telson; (E) preanal carina; (F) uropodal diaeresis; (G) antennular peduncle; (H) scaphocerite; (I,J) mandibles; (K) maxillulae; (L) maxillae; (M) first maxilliped; (N) palp of first maxilliped; (O) second maxilliped.

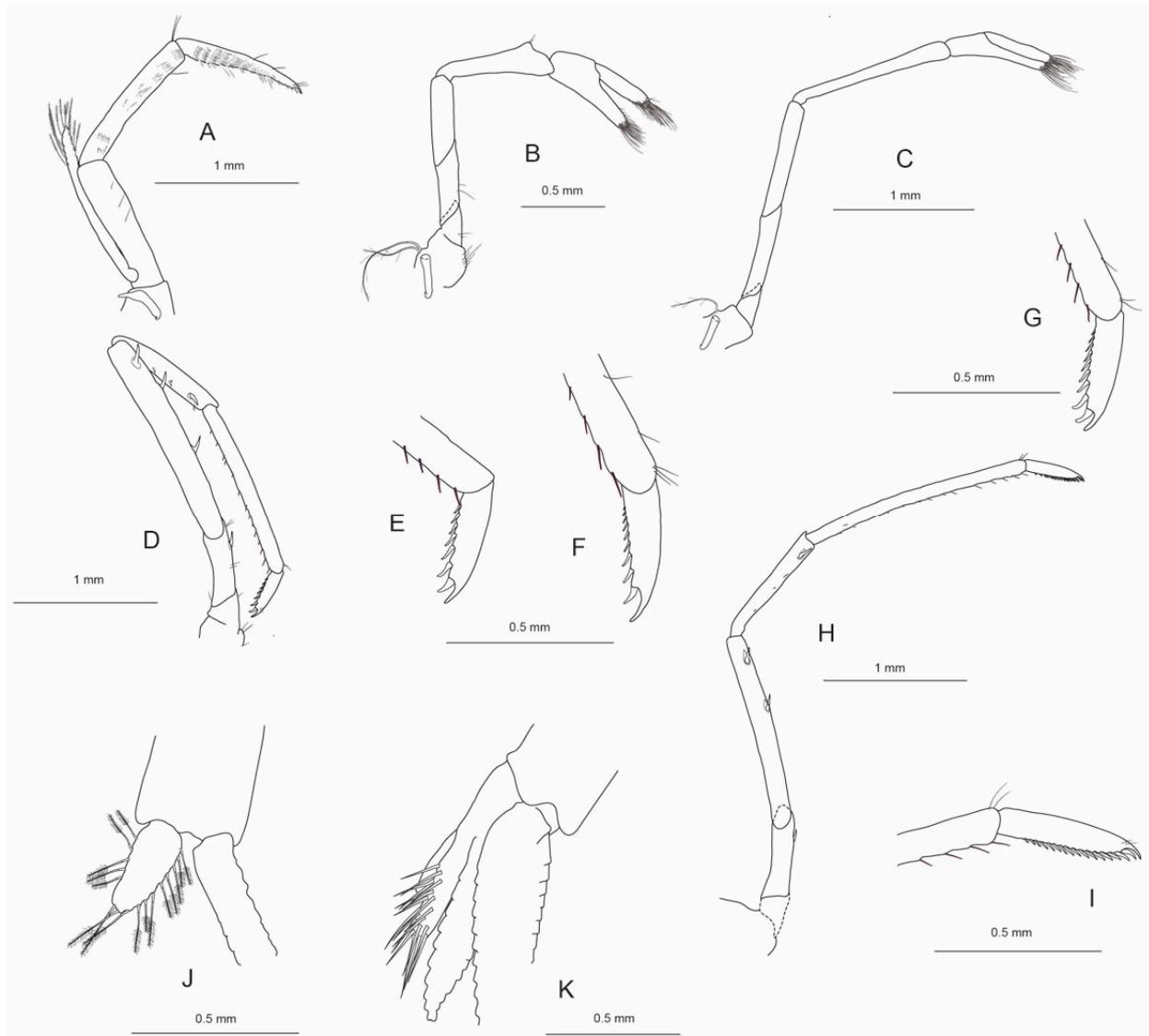
### 3.5. Comparative Material Examined

Lectotype. *Caridina serratiostris* de Man, 1892. Ov. ♀cl 5.0 mm, Bangkalanvir River, Saleyer, RMNH.CRUS.D.57023. Syntypes. *Caridina serratiostris* de Man, 1892. Two ov. ♀♀cl 4.4 and 4.6 mm, two ♂♂cl 3.1 and 3.3 mm, Bangkalanvir River, Saleyer, ZMA.CRUS.D.102625. Four ov. ♀♀cl 3.3–4.4 mm, two ♀♀cl 2.4 and 3.5 mm, two ♂♂cl 2.4 and 2.6 mm, Indonesia, Rivier bij Reo, Flores eil. coll. 1888.

### 3.6. Description

Cephalothorax and cephalic appendages: Small shrimp with carapace lengths of 2.1–4.3 mm (median 2.9 mm,  $n = 16$ ) in apparently adult specimens. Carapace (Figure 3A,B) smooth, antennal spine almost fused with suborbital lobe, pterygostomial angle rounded. Rostrum (Figure 3A,B) extending to end of second segment of antennular peduncle or to distal end of antennular peduncle, 0.53–0.76 (median 0.64,  $n = 8$ ) times as long as carapace, nearly straight or slightly convex, ending in acute tip; dorsal margin armed with 17–29 teeth over entire length, including 5–8 postorbital; teeth above orbit larger than anterior and posterior teeth, ventral margin with 3–6 teeth located in distal half of rostrum.

Rostrum formula based on 12 specimens  $5 - 8 + 12 - 24/3 - 6$ . Eyes (Figure 3A,B) well developed with pigmented globular cornea. Antennular peduncle (Figure 3A,B,G) 0.60–0.71 (median 0.67,  $n = 9$ ) times as long as carapace in females, 0.91 times as long as carapace in males, first segment 1.69–2.10 (median 2.0,  $n = 9$ ) times as long as second segment, second segment 2.20–2.75 (median 2.31,  $n = 8$ ) times as long as third segment; distolateral tooth on first segment short (0.14–0.23 times as long as second segment), well developed; second and third segments unarmed, with few spiniform setae near distal margin. Stylocerite acuminate, reaching to 0.89–1.05 (median 1.00,  $n = 9$ ) times the length of basal segment of antennular peduncle. Antennal scaphocerite (Figure 3H) with well-developed distolateral tooth, 2.92–3.7 (median 3.14,  $n = 5$ ) times as long as wide.



**Figure 4.** (A–E,G–K) *Caridina magnovis* n. sp. paratype ♂ cl 2.7 mm, WAM C81394. (F) *Caridina magnovis* n. sp. paratype ov. ♀ cl 4.0 mm, NTM Cr019573. (A) Third maxilliped, (B) first pereopod, (C) second pereopod, (D) third pereopod, (E,F) dactylus of third pereopod, (G) dactylus of fourth pereopod, (H) fifth pereopod, (I) dactylus of fifth pereopod, (J) first pleopod, (K) second pleopod.

Pleon, telson and uropods: Sixth pleomere was 0.44–0.54 (median 0.46,  $n = 7$ ) times the carapace length, 1.23–1.69 (median 1.55,  $n = 6$ ) times as long as fifth somite, 0.80–0.89 (median 0.87,  $n = 5$ ) times as long as telson. Telson (Figure 3C,D) slightly tapering distally, distal margin convex, with a prominent median point, with 4–5 ( $n = 7$ ) pairs of dorsal short spiniform setae and one pair of short spiniform setae dorsolaterally; distal margin

with one pair of strong spiniform setae and 7–9 plumose setae clearly exceeding lateral pair of spiniform setae. Preanal carina (Figure 3E) rounded, high, with a small tooth in 2 of 7 specimens. Uropodal diaeresis (Figure 3F) with 12–15 movable spiniform setae, the outermost shorter than the lateral angle.

Mouthparts and branchiae: Shown in Figure 3I–O and Figure 4A. Similar to *Caridina darwin* n. sp. except for the incisor process of mandible (Figure 3I,J), comparably well-developed and numerous irregular teeth and palp of first maxilliped (Figure 3M,N) terminates in a triangular extension. Third maxilliped (Figure 4A) was slender, with the last segment of maxilliped slightly shorter than penultimate segment. Branchial apparatus as shown in Table 3, with one well developed and one reduced arthrobranch on third maxilliped and one arthrobranch on first pereopod.

**Table 3.** Branchial formula of *Caridina magnovis* n. sp. 1, 2: present, well developed; (1): reduced; -: absent.

	Maxillipeds			Pereiopods				
	1	2	3	1	2	3	4	5
Pleurobranchs	-	-	-	1	1	1	1	1
Arthrobranchs	-	-	1, (1)	1	-	-	-	-
Podobranchs	-	1	-	-	-	-	-	-
Epipods	-	-	1	1	1	1	1	-
Setobranchs	-	-	-	2	1	1	1	1
Exopods	1	1	1	-	-	-	-	-

Pereiopods: Chela of first pereopod (Figure 4B) was caridinoid in shape, slender, with well-developed palm, 1.75–2.84 (median 2.21, n = 5) times as long as wide, 0.93–1.17 (median 1.12, n = 5) times as long as carpus; fingertips rounded, without hooks but each with a tuft of setae; dactylus 2.73–4.25 (median 3.57, n = 5) times as long as wide, 1.00–1.64 (median 1.25, n = 5) times as long as palm. Carpus slender, hardly excavated distally, 2.12–3.22 (median 2.78, n = 5) times as long as wide, 1.09–1.25 (median 1.17, n = 5) times as long as merus. Merus not inflated, 2.75–4.33 (median 3.00, n = 0) times as long as wide, 0.95–1.18 (median 1.0, n = 5) times as long as ischium. Chela of second pereopod (Figure 4C) very slender, caridinoid in shape, with well-developed palm, 2.75–4.40 (median 3.30, n = 5) times as long as wide, 0.66–0.71 (median 0.69, n = 5) times as long as carpus; fingertips rounded, without hooks; dactylus 4.44–5.45 (median 5.00, n = 5) times as long as wide, 1.25–1.36 (median 1.33, n = 5) times as long as palm, with tufts of setae distally; carpus slender, 6.36–8.17 (median 7.14, n = 5) times as long as wide, 1.04–1.40 (median 1.35, n = 5) times as long as merus. Merus not inflated, 5.83–7.83 (median 6.24, n = 5) times as long as wide, 1.06–1.17 (median 1.13, n = 4) times as long as ischium. Third pereopod (Figure 4D–G) with dactylus (Figure 4E–G) slightly sexually dimorphic, spiniform setae on flexor margin more curved, 3.78 times as long as wide (including terminal claw and spiniform setae on flexor margin) in males (n = 1), 4.00–5.00 (median 4.56, n = 4) times as long as wide in females, terminating in one claw, with 6–8 accessory spiniform setae on flexor margin, first spiniform seta on flexor margin strong and curved in some specimens; propodus not enlarged or curved distally, distal spiniform seta not enlarged, 10.6–14.29 (median 12.50, n = 5) times as long as wide, 3.24–3.73 (median 3.33, n = 5) times as long as dactylus; carpus 5.67–6.80 (median 5.86, n = 4) times as long as wide, 0.63–0.70 (median 0.66, n = 4) times as long as propodus, 0.50–0.59 (median 0.57, n = 4) times as long as merus, with one large spiniform seta near distal margin and 3–6 small spiniform setae proximally; merus 6.84–9.08 (median 8.47, n = 4) times as long as wide, 1.69–2.00 (median 1.74, n = 4) times as long as carpus, with 3–5 strong movable spiniform setae on externo-inferior margin; ischium without or with one spiniform seta. Fourth pereopod similar to third but slightly smaller. Fifth pereopod (Figure 4H,I) was slender; dactylus (Figure 4I) 3.6–5.00 (n = 2) times as long as wide (including terminal claw and spiniform setae on flexor margin), terminating in one large claw, with 16–18 spiniform setae on flexor margin; propodus

with small spiniform setae on ventral margin, distal pair of spiniform setae not enlarged, propodus 12.40–13.80 (median 12.50,  $n = 3$ ) times as long as wide, 3.44–3.75 ( $n = 2$ ) times as long as dactylus; carpus 5.83–7.09 (median 6.62,  $n = 3$ ) times as long as wide, 0.56–0.57 (median 0.57,  $n = 3$ ) times as long as propodus, 0.66–0.68 (median 0.67,  $n = 3$ ) times as long as merus, with one strong spiniform seta near distal margin and five small spiniform setae proximally; merus 7.43–8.43 (median 8.40,  $n = 3$ ) times as long as wide, 1.47–1.51 (median 1.49,  $n = 3$ ) times as long as carpus, with 2–4 strong appressed movable spiniform setae on externo-inferior margin. Ischium with one or without spiniform seta.

Pleopods: Endopod of male first pleopod (Figure 4J) elongated triangular, lacking appendix interna, 2.0 ( $n = 1$ ) times as long as proximal width, 0.40 times as long as exopod, with long plumose setae on distal margin, and few shorter plumose setae on inner and outer margins. Male second pleopod with appendix masculina rod-shaped (Figure 4K), 10.0 ( $n = 1$ ) times as long as wide, 0.83 ( $n = 1$ ) times as long as endopod, armed with strong spiniform setae on inner margin and distal margin; appendix interna originating from about 0.4 times the length of appendix masculina, reaching to about 0.65 times the length of appendix masculina.

Reproductive biology: Ovigerous females with medium-sized embryos; embryo size 0.66–0.76 × 0.39–0.49 mm ( $n = 6$ ). Twenty-five and thirty embryos counted in two ovigerous females.

Size: Postorbital carapace length of apparently adult specimens 2.1–4.3 mm.

Colouration: Variable. Some specimens reddish with a pale median dorsal line extending from the rostrum to the sixth pleomere, some specimens mottled with reddish and creamy chromatophores, smaller specimens mostly transparent [4,25].

Distribution: The species is known from rivers draining into the Timor Sea. From the Fitzroy River in Western Australia eastwards to the Howard River in the Northern Territory.

Etymology: The species name *magnovis* is derived from the rather large size of the embryos of the proposed new species compared to *C. serratiostris*.

Common name: North Australian Chameleon Shrimp.

Remarks: The general morphology of *Caridina magnovis* n. sp., with a straight rostrum, armed throughout close to the tip and a high number of postorbital teeth (5–8), a long stylocerite, slender chelipeds and distal margin of the telson armed with long plumose setae clearly exceeding a lateral pair of strong spiniform setae and the variable coloration of living specimens resembles that of *Caridina serratiostris* de Man, 1892. The proposed new species differs from *C. serratiostris* in the armature of the rostrum, i.e., ventral teeth located in the distal half of the rostrum vs. ventral teeth placed at midlength of the rostrum in *C. serratiostris*. The stylocerite of *Caridina magnovis* n. sp. is shorter, reaching to 0.89–1.05 of the first segment of antennular peduncle vs. clearly exceeding this segment (1.09–1.47 times the length of the first segment). Carpus of first pereopod is 2.12–3.22 times as long as wide in *Caridina magnovis* n. sp. vs. 2.63–4.67 times in *C. serratiostris*. Dactylus of third pereopod with 6–8 spiniform setae vs. with 4–5 in *C. serratiostris*. Dactylus of fifth pereopod with 16–18 spiniform setae on flexor margin, first seta not markedly enlarged vs. with 11–17 spiniform setae, first seta enlarged in *C. serratiostris*. Uropodal diaeresis with 12–15 movable spiniform setae vs. with 16–21 movable spiniform setae in *C. serratiostris*. Preanal carina rounded, without prominent tooth in most specimens (vs. preanal carina with a prominent hook-like tooth in all specimens of *C. serratiostris*). Embryos 0.66–0.76 × 0.39–0.49 mm vs. 0.37–0.44 × 0.20–0.26 mm in *C. serratiostris*.

*Caridina wilsoni* n. sp.

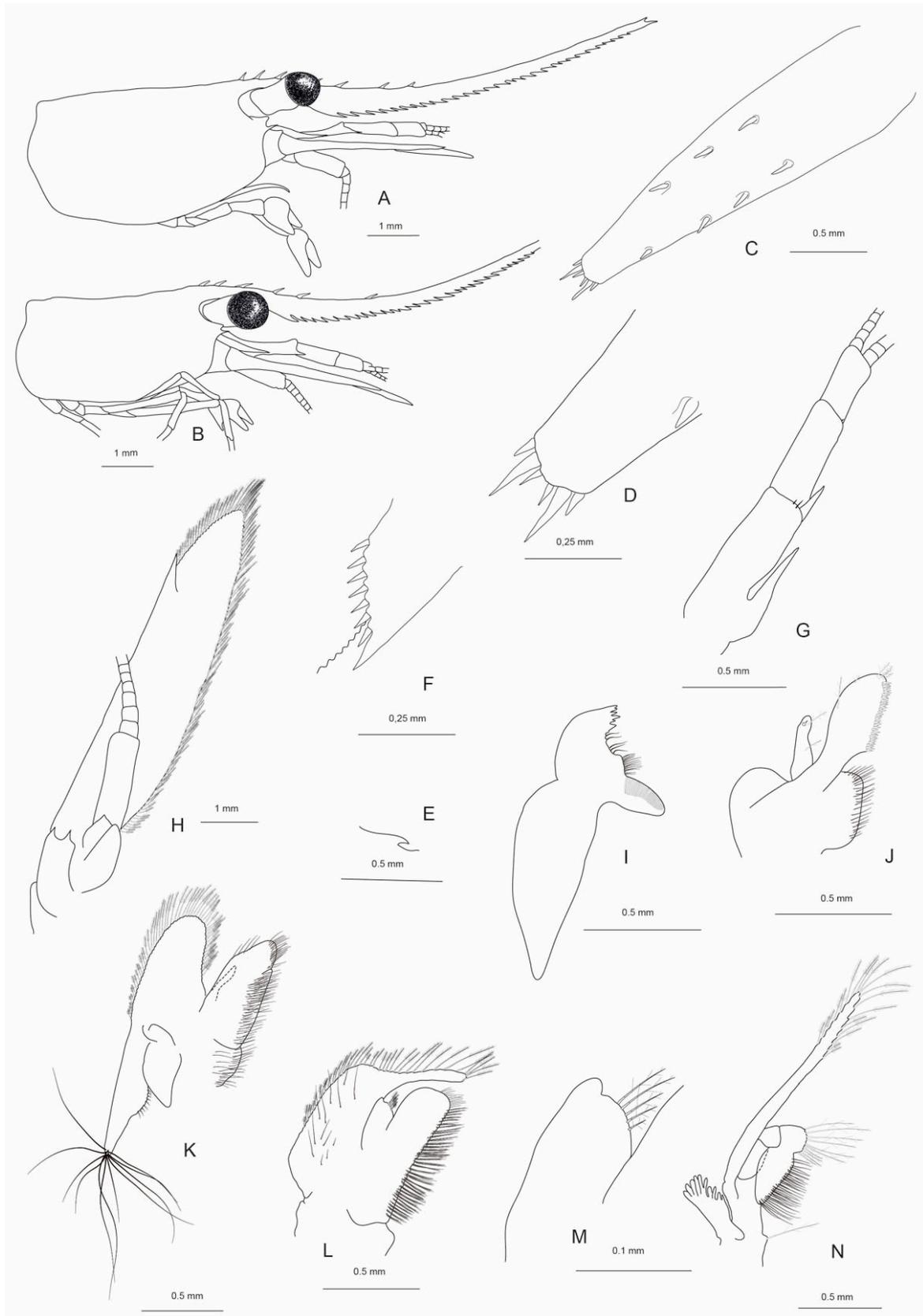
*Caridina* sp. Gulf 1 Page, von Rintelen and Hughes, 2007;

*Caridina* sp. 'Gulf 1' Wilson, 2008;

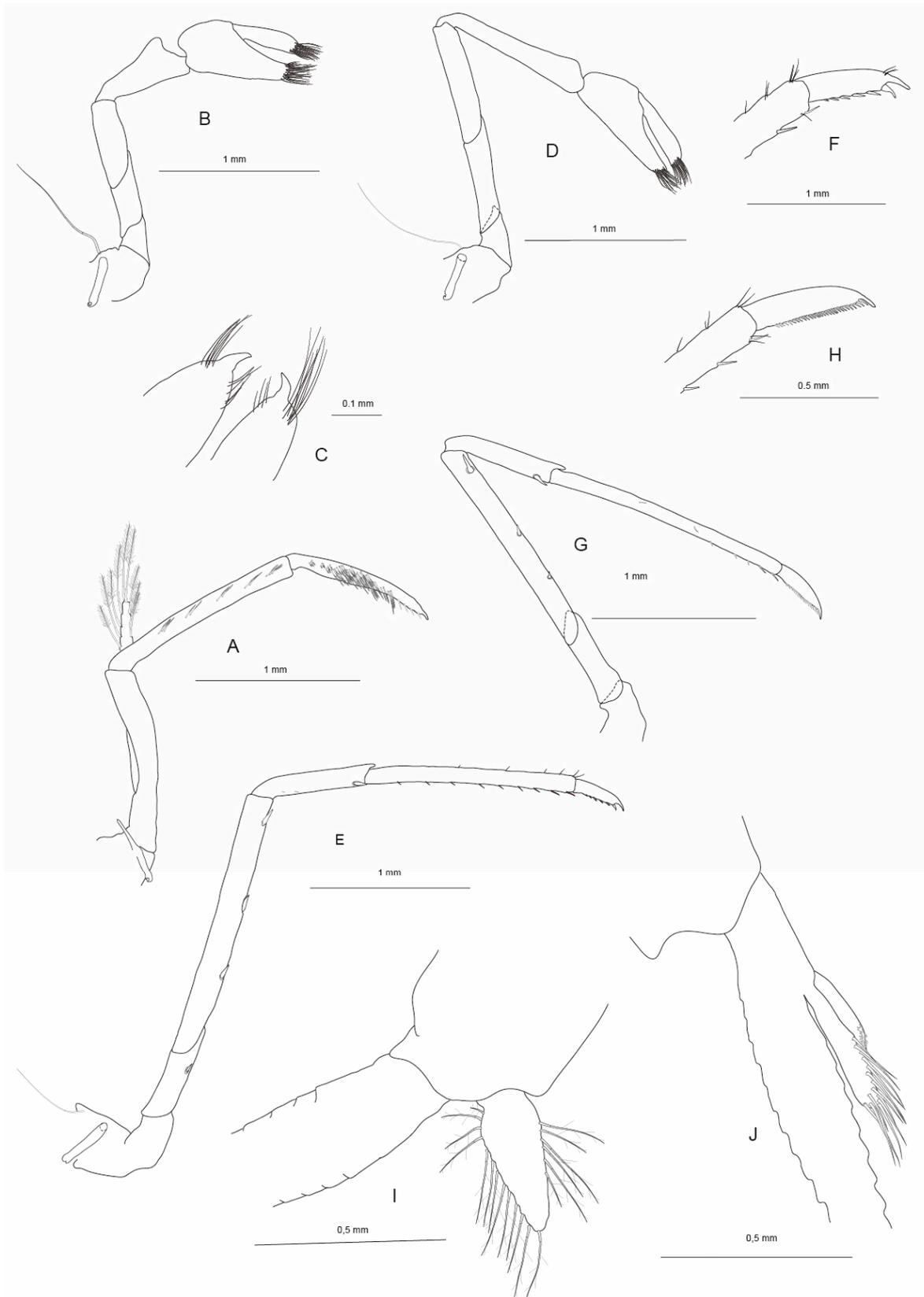
*Caridina* sp. Gulf 1 Cook, Page and Hughes, 2011;

*Caridina* 'sp. Gulf1' Short, Page and Humphrey, 2019;

(Figures 5 and 6).



**Figure 5.** (A) *Caridina wilsoni* n. sp. paratype ov. ♀ cl 3.5 mm, ZMB 29180; (B–N) *Caridina wilsoni* n. sp. paratype ♂ cl 3.0 mm, QM W29818. (A,B) Carapace; (C) telson; (D) distal margin of telson; (E) preanal carina; (F) uropodal diaeresis; (G) antennular peduncle; (H) scaphocerite; (I) mandible; (J) maxillulae; (K) maxillae; (L) first maxilliped; (M) palp of first maxilliped; (N) second maxilliped.



**Figure 6.** (A–I) *Caridina wilsoni* n. sp. paratype ♂cl 3.0 mm, QM W29818. (A) Third maxilliped, (B) first pereiopod, (C) tips of dactyli of first pereiopod (setae partially omitted), (D) second pereiopod, (E) third pereiopod, (F) dactylus of third pereiopod, (G) fifth pereiopod, (H) dactylus of fifth pereiopod, (I) first pleopod, (J) second pleopod.

### 3.7. Material Examined

Holotype: ♂ cl 3.4 mm, Australia, Queensland, Archer River catchment, Archer River at telegraph line, FNARH5/216, leg. DERM, 10.04.2000, QM W29816.

Paratypes: One ov. ♀ cl 4.3 mm, same data as holotype, QM W29817; ♂ cl 3.0 mm, Australia, Queensland, Wenlock River catchment, Wenlock River at Stones Xing, leg. DERM, 10.04.2000, QM W29818; one ♀ cl 3.4 mm, commercial production ponds (most likely Blackmore R., could be Darwin R.), Darwin Area, cultured specimens provided by D. Wilson NTM Cr019572; seven ov. ♀♀ cl 3.2–4.0 mm, three ♂♂ cl 2.4–2.5 mm, Australia, Northern Territory, Top End, Darwin River crossing; S 12°49.089', E 130°57.634', 83-04, coll. N. Brinkmann and T. von Rintelen 27.6.2004, ZMB 29180; two ♂♂ cl 1.9 and 2.2 mm, four ♀♀ cl 2.3–2.7 mm, Australia, Northern Territory, Top End, Coomalie Creek, S 13°0.884', E 131°7.371'; coll. N. Brinkmann and T. von Rintelen 28.06.2003, ZMB 29240.

### 3.8. Comparative Material Examined

Syntypes. *Caridina gracilirostris* De Man, 1892. Two ov. ♀♀ cl 5.2 and 5.3 mm, Indonesia, Celebes (=Sulawesi): river near Balangnipa 1888–1889, leg. M. Weber: RMNH.CRUS.D.2557; one ov. ♀ cl 5.3 mm, two ♂♂ cl 4.0 and 4.5 mm, Indonesia, Celebes (=Sulawesi), river near Balangnipa 1888–1889, leg. M. Weber, RMNH.CRUS.D.1076.

Other material. *Caridina gracillima* Lanchester, 1901. Two ♀♀ cl 5.2 and 5.3 mm, Malaysia, Peninsular, Terengganu, Kg. Dawi, Lake Kenyir, 05°08.232' N, 102°48.211' E (loc 56-10); leg. B. Stelbrink, 02. 06. 2010, ZMB 29578.

Three specimens, Malaysia, Sabah, Kinabatangan River at Sukau, N 5°31'37.67" E 118°17'39.23", leg. M. de Bruyn 01.01.2009; two specimens ZMB 29579. Thailand, Phitsanulok, Tributary of Kaek River, c. 28 km E of Phitsanulok, N 16°50.866' E 100°30.709', leg. F. Köhler 27.03.2006, ZMB 29513.

### 3.9. Description

Cephalothorax and cephalic appendages: Small shrimp with carapace lengths of 1.9–4.3 mm (median 2.8 mm, n = 22) in apparently adult specimens. Carapace (Figure 5A,B) smooth, antennal spine clearly separated from the suborbital lobe, pterygostomial angle broadly rounded. Rostrum (Figure 5A,B) long, reaching well beyond distal margin of scaphocerite, 1.04–2.31 (median 1.97, n = 8) times as long as carapace, curved upward; dorsal margin armed with 7–9 widely spaced teeth on proximal part of the rostrum, no teeth or occasionally with one tooth behind orbital margin, one subapical tooth near tip, ventral margin with 35 teeth. Rostrum formula based on 18 specimens 0 – 1 + 6 – 9 + 1/19 – 35. Eyes (Figure 5A,B) well developed with pigmented globular cornea. Antennular peduncle (Figure 5A,B,G), 0.86–1.02 (median 0.91, n = 7) times as long as carapace in females, 0.89–1.08 (median 1.00, n = 6) times as long as carapace in males, first segment 1.85–2.33 (median 2.16, n = 12) times as long as second segment, second segment 1.61–2.75 (median 2.05, n = 12) times longer than third segment; distolateral tooth on first segment acute, well developed, 0.23–0.39 (median 0.33, n = 11) times as long as second segment; second and third segments unarmed, with few spiniform setae near distal margin. Stylocerite acuminate, reaching to 0.70–1.04 (median 0.77, n = 11) times the length of basal segment of antennular peduncle. Antennal scaphocerite (Figure 5H) with well-developed distolateral tooth, 3.87–4.95 (median 4.66, n = 5) times as long as wide.

Pleon, telson and uropods: Sixth pleomere was 0.86–1.02 (median 0.92, n = 17) times the length of carapace, 1.81–2.41 (median 2.18, n = 17) times as long as the fifth pleomere, 1.08–1.30 (median 1.13, n = 15) times as long as telson. Telson (Figure 5C,D) slightly tapering distally, distal margin broadly convex, lacking a median point with three or four (n = 10) pairs of dorsal short spiniform setae and one pair of short spiniform setae dorsolaterally; distal margin with two pairs of spiniform setae, lateral pair stronger and longer compared to inner setae. Preanal carina (Figure 5E) with a prominent hook-like tooth. Uropodal diaeresis (Figure 5F) with 5–9 movable spiniform setae, outermost seta clearly shorter than lateral angle.

Mouthparts and branchiae: Shown in Figure 5I–N and Figure 6A. Similar to *Caridina darwin* n. sp. except that palp of first maxilliped (Figure 5L,M) terminates in a short blunt extension. Third maxilliped (Figure 6A) with last segment shorter than penultimate segment. Branchial apparatus as shown in Table 4.

**Table 4.** Branchial formula of *Caridina wilsoni* n. sp. 1, 2: present, well developed; (1): reduced; -: absent.

	Maxillipeds			Pereiopods				
	1	2	3	1	2	3	4	5
Pleurobranchs	-	-	-	1	1	1	1	1
Arthrobranchs	-	-	2	1	-	-	-	-
Podobranchs	-	1	-	-	-	-	-	-
Epipods	-	-	1	1	1	1	1	-
Setobranchs	-	-	-	1	1	1	1	1
Exopods	1	1	1	-	-	-	-	-

Pereiopods: Chela of first pereiopod (Figure 6B) was caridinoid in shape, with well-developed palm, 1.75–2.32 (median 2.10, n = 9) times as long as wide, 1.16–1.54 (median 1.41, n = 9) times as long as carpus; fingertips rounded, with prominent hooks hidden by tufts of setae (Figure 6C); dactylus 3.00–3.80 (median 3.29, n = 7) times as long as wide, 0.80–1.36 (median 1.13, n = 9) times as long as palm. Carpus slender, hardly excavated distally, 1.73–2.27 (median 2.00, n = 9) times as long as wide, 0.65–1.27 (median 1.14, n = 9) times as long as merus. Merus not inflated, 2.33–4.58 (median 2.48, n = 9) times as long as wide, 0.96–1.96 (median 1.06, n = 8) times as long as ischium. Chela of second pereiopod (Figure 6D) slender, caridinoid in shape, with well-developed palm, 2.21–2.75 (median 2.47, n = 9) times as long as wide, 0.80–0.94 (median 0.88, n = 9) times as long as carpus; fingertips rounded, with prominent hooks hidden by tufts of setae, dactylus 3.80–4.44 (median 4.17, n = 7) times as long as wide, 1.25–1.73 (median 1.33, n = 9) times as long as palm. Carpus slender, 3.73–4.94 (median 4.31, n = 9) times as long as wide, 1.17–1.41 (median 1.32, n = 9) times as long as merus. Merus not inflated, 3.50–5.00 (median 4.40, n = 9) times as long as wide, 0.91–1.06 (median 0.97, n = 8) times as long as ischium. Third pereiopod (Figure 6E–F) slender, dactylus (Figure 6F) not sexually dimorphic, 2.71–3.75 (median 3.75, n = 3) times as long as wide (including terminal claw and spiniform setae on flexor margin), terminating in one claw, with 6–8 accessory spiniform setae on flexor margin; propodus not dilated or curved distally, distal spiniform seta not enlarged, 7.88–10.60 (median 10.00, n = 3) times as long as wide, 3.00–3.53 (median 3.32, n = 3) times as long as dactylus; carpus 5.38–6.67 (median 5.65, n = 4) times as long as wide, 0.62–0.64 (n = 2) times as long as propodus, 0.50–0.56 (median 0.52, n = 4) times as long as merus, with one large spiniform seta near distal margin and one small spiniform setae proximal; merus 8.56–9.67 (median 8.85, n = 4) times as long as wide, 1.79–2.00 (median 1.93, n = 4) times as long as carpus, with two or three strong movable spiniform setae on externo-inferior margin; ischium with one spiniform seta (absent in one specimen examined). Fourth pereiopod similar to third one but slightly smaller. Fifth pereiopod (Figure 6G,H) slender; dactylus (Figure 6H) 3.00–3.80 (median 3.63, n = 6) times as long as wide (including terminal claw and spiniform setae on flexor margin), terminating in one large claw, with 21–35 spiniform setae on flexor margin; propodus with small spiniform setae on ventral margin, distal pair of spiniform setae not markedly enlarged, propodus 10.75–12.14 (median 11.54, n = 5) times as long as wide, 3.07–3.54 (median 3.33, n = 5) times as long as dactylus; carpus 5.17–5.75 (median 5.43, n = 3) times as long as wide, 0.51–0.55 (median 0.53, n = 4) times as long as propodus, 0.53–0.61 (median 0.56, n = 4) times as long as merus, with one strong spiniform seta near distal margin; merus 8.33–10.73 (median 9.57, n = 3) times as long as wide, 1.63–1.90 (median 1.79, n = 4) times as long as carpus, with two or three strong, appressed, movable spiniform setae on the externo-inferior margin. Ischium without spiniform setae.

Pleopods: Endopod of male first pleopod (Figure 6I) elongated triangular, lacking appendix interna, 2.00–2.57 (median 2.45,  $n = 4$ ) times as long as proximal width, 0.23–0.26 (median 0.24,  $n = 3$ ) times as long as exopod, with long pappose setae on distal, inner and outer margins. Male second pleopod with appendix masculina rod-shaped (Figure 6J), 9.33–11.50 ( $n = 2$ ) times as long as wide, 0.68–0.72 ( $n = 2$ ) times as long as endopod, armed with strong spiniform setae on inner and distal margins; appendix interna originating from about 0.4 times the length of appendix masculina, reaching to 0.74–0.81 ( $n = 2$ ) times the length of appendix masculina.

Reproductive biology: Ovigerous females with medium-sized embryos (0.59 – 0.66 × 0.34 – 0.43 mm ( $n = 8$ )). A total of 25–108 embryos counted in four ovigerous specimens.

*Size.* Postorbital carapace length of apparently adult specimens 1.9–4.3 mm.

*Colouration:* Body transparent. Rostrum red, red chromatophores also arranged in a narrow line running along the sternites of the pleon, on the distal part of the exopod of the uropod and a red transverse line at the dorsal margin of the third pleomere. Embryos are greenish (Wilson 2008; Short, Page and Humphrey 2019).

*Distribution:* The species is known from rivers flowing into the Gulf of Carpentaria (Queensland) and to the Timor Sea near Darwin (Northern Territory).

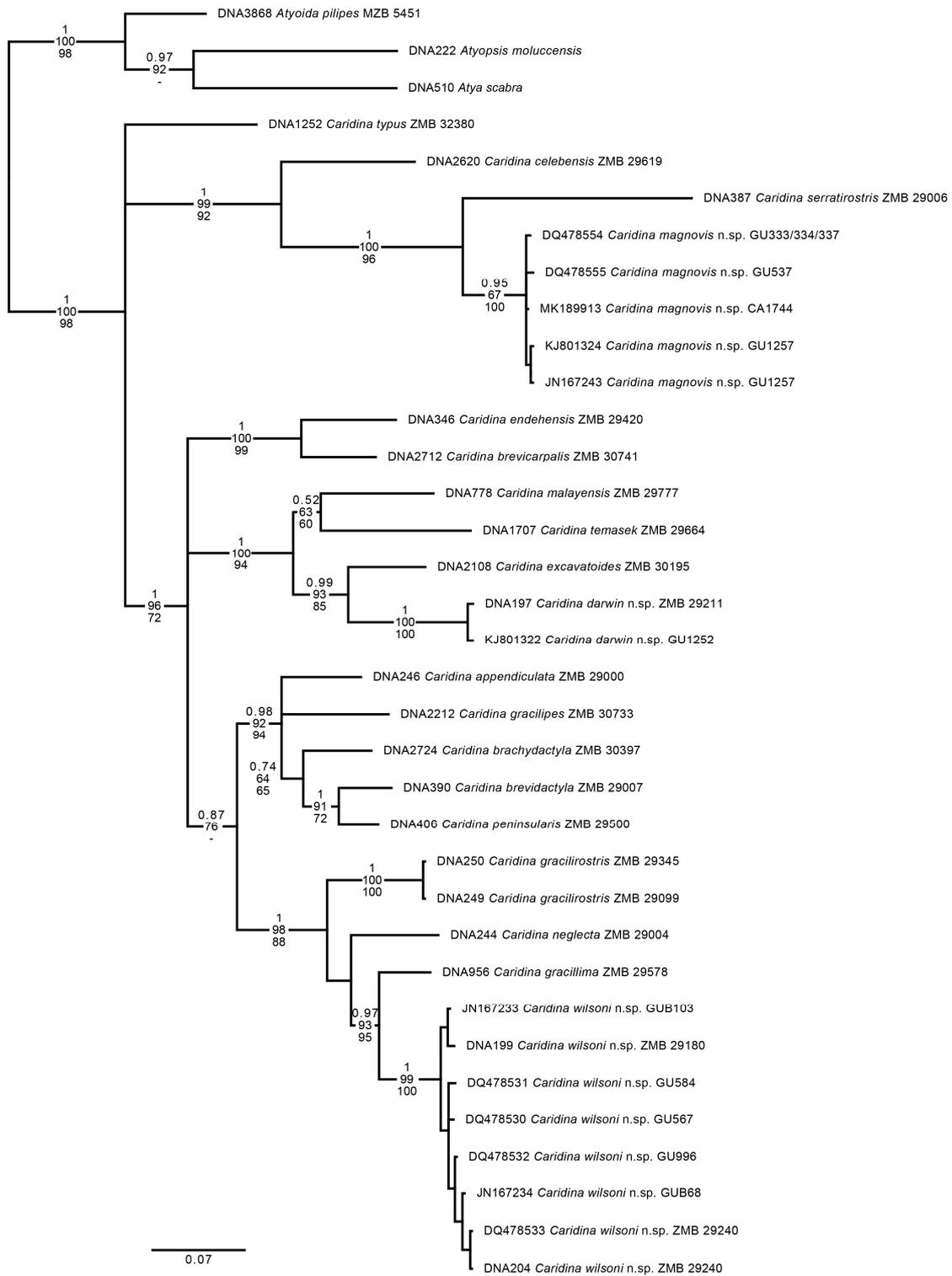
*Etymology:* The species is named after the biologist and aquarist Dave Wilson, collector of some of the type material and an enthusiast on Australian fish and shrimp fauna.

*Common name:* Darwin Red Nose Shrimp.

*Remarks:* *Caridina wilsoni* n. sp. Resembles *Caridina gracilirostris* De Man, 1892, both in coloration and in general morphology (body very slender; rostrum strongly curved upwards with few widely spaced teeth on proximal part of dorsal margin, no postorbital teeth; preanal carina with one hook-like tooth; distal margin of telson with few spiniform setae). The proposed new species differs from this species in the larger size of the embryos (0.59–0.66 × 0.34–0.43 mm vs. 0.34–0.39 × 0.21–0.25 mm in *C. gracilirostris*), a slightly stouter carpus of the second cheliped (3.73–4.94 times as long as wide vs. 4.69–5.26 times as long as wide in *C. gracilirostris*), merus of third pereopod 8.56–9.67 times as long as wide vs. 9.55–10.22 in *C. gracilirostris*, propodus of fifth pereopod 3.07–3.54 times as long as dactylus vs. 4.0–4.25 in *C. gracilirostris*. Some of these morphological characters overlap slightly (length-to-width ratio of carpus of second cheliped, length-to-width ratio of merus of third pereopod), but by combining the morphological characters, these two species can be distinguished. The proposed new species also resembles *C. gracillima* Lanchester, 1901, known from the Malayan peninsula, especially in the size of the embryos (0.59–0.66 × 0.34–0.43 mm vs. 0.55–0.66 × 0.35–0.40 mm in *C. gracillima*) [26], but differs from this species in its preanal carina, bearing a hook-like spine vs. preanal carina rounded without a spine in *C. gracillima*.

#### 4. Molecular Systematics and General Discussion

In the molecular phylogeny based on a fragment of the mitochondrial 16S rRNA gene, the sequences of each of the three new species form a strongly supported clade (Figure 7). Their relationships with their closest relatives are also well supported. *Caridina darwin* n. sp. is closely related to *Caridina excavatoides*, which is its sister species, and the allied species *Caridina malayensis* and *C. temasek*. *Caridina magnovis* n. sp. are found in a sister group relationship with *C. serratirostris*. *Caridina wilsoni* n. sp. is the sister species of *C. gracillima* and is also closely related to *Caridina gracilirostris* and *C. neglecta*. These relationships closely reflect the morphological similarities of the new Australian species as described above. Each species also differs greatly genetically from its closest relative (minimum p-distances: 6.5% *Caridina wilsoni* n. sp.—*C. gracillima*; 9.1% *C. darwin* n. sp.—*C. excavatoides*; 12.6% *C. magnovis* n. sp.—*C. serratirostris*), providing additional clear support for their status as distinct species.



**Figure 7.** Molecular phylogenetic tree (BI, 16S) showing the relationship of the three new species to morphologically similar congeners. Numbers on branches are, from the top, Bayesian posterior probabilities and ML/MP bootstrap values. The scale bar indicates the substitution rate.

Page et al. [7] found close evolutionary relationships of Australian species with non-Australian taxa from the surrounding regions and suggested that *Caridina wilsoni* (“Gulf1”) and *C. magnovis* (“W WA4”) are endemic to Australia. This is not surprising for amphidromous species, nor in cases such as *Caridina magnovis* n. sp., whose closest relative, *C. serratiostris*, is a species that is widespread throughout the Indo-Australian Archipelago

(IAA), and from which *C. magnovis* n. sp. appears to have evolved into an Australian endemic species. The sister species of *Caridina wilsoni* n. sp., *C. gracillima*, has a similar embryo size to *C. wilsoni* n. sp., but both are closely related to the very widespread amphidromous species *Caridina gracilirostris* (the extent of the distribution of the equally closely related *C. neglecta* is poorly known), so it is not too surprising that *Caridina gracillima* and *C. wilsoni* n. sp. occur at the western and eastern ends of the IAA, respectively. Perhaps most interesting of all in this context is *C. darwin* n. sp., which has relatively small embryos in comparison to its closest relatives with medium- to large-sized embryos and a distribution restricted to the Sunda Shelf. Although Australian endemism is likely for all three new species, their medium embryo size differs from other Australian endemic species with large embryos, indicating highly suppressed larval development, such as *Caridina biyiga* from Leichhardt Springs, Kakadu National Park, Northern Territory (embryo size 0.75–1.0 mm) [4].

In conclusion, the rather limited molecular dataset presented here to support morphospecies in an integrative taxonomic approach is not suitable to discuss evolutionary and biogeographic aspects in more detail. But the few observations made above underline once again the diverse biogeographic origin of the Australian atyid fauna and its potential for more extensive studies of the adaptations associated with the colonization of this continent.

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