

Three New Cryptic Species of the Freshwater Shrimp Genus *Caridina* (Decapoda: Caridea: Atyidae) from Hong Kong, with Notes on the *C. serrata* Species Group

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Three new species of freshwater atyid shrimp, namely *Caridina chui* sp. nov., *C. bauhinia* sp. nov. and *C. argilla* sp. nov., are described from Hong Kong, southern China using an integrative taxonomic approach. All three species belong to the *C. serrata* species group and differ from the other members in characteristics of the rostrum, pereopods, and male first and second pleopods. Phylogenetic analyses based on mitochondrial *COI* and 16S rRNA sequences show that the *C. serrata* species group is polyphyletic and comprises at least four lineages. The validity of the *C. serrata* species group is discussed and more detailed diagnosis of the species group is proposed. The *C. serrata* species group *sensu stricto* is restricted to the nominal lineage containing *C. serrata* and closely related species, distinguished from other species of the *C. serrata* species group mainly by having relatively stout carpus of first pereopod, stout appendix masculina of male second pleopod, and large number of spiniform setae on the uropodal diaeresis.

Keywords: Biodiversity, Crustacean, Systematics, Taxonomy

BACKGROUND

The freshwater atyid shrimp genus, *Caridina* H. Milne Edwards, 1837, is a diverse genus comprising more than 340 species (DecaNet eds. 2025). Several species groups (sometimes called species complexes) were established to accommodate species that share morphological similarities, often also genetic affinity. They include the *C. brevicarpalis* group, *C. gracilirostris* group, *C. nilotica* group, *C. serrata* group, *C. serratirostris* group, *C. typus* group, *C. weberi* group and *C. yunnanensis* group (Bouvier 1925; Cai and Ng

1999 2001 2007; de Mazancourt et al. 2020). Some closely related species were also grouped into species complexes, sometimes involved the presence of cryptic species, such as the *C. indistincta*, *C. thermophila* and *C. zebra* complexes from Australia (Chenoweth and Hughes 2003; Choy et al. 2019; Short et al. 2019), or grouped into geographical clades such as the Poso and Malili clades from Sulawesi, Indonesia (von Rintelen and Cai 2009).

Among the several *Caridina* species groups or complexes, the *C. serrata* species group is especially well-represented in southern China and northern and

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central Vietnam. Taking Hong Kong as an exemplar, among the seven landlocked *Caridina* species recorded (see Chow et al. 2018 2024), six of them belong to the *C. serrata* species group, namely *C. apodosis* Cai & Ng, 1999, *C. cantonensis* Yu, 1938, *C. logemanni* Klotz & von Rintelen, 2014, *C. ngankeeae* Chow, Chan & Tsang, 2024, *C. serrata* Stimpson, 1860 and *C. trifasciata* Yam & Cai, 2003. This species group is characterised by four features according to Cai and Ng (1999), viz. 1) presence of dorsal rostral teeth on the carapace; 2) stylocerite reaching beyond the end of the basal segment of the antennular peduncle; 3) presence of an appendix interna on the endopod of male first pleopod; and 4) large eggs with abbreviated larval development. In 2022–2023, some cryptic specimens conforming to the *C. serrata* species group, initially identified as *C. cantonensis* and *C. serrata* in the field, were collected from Hong Kong. An integrated taxonomic approach revealed that they do not belong to any known members of the species group but represent three new species which are herein described as *C. chui* sp. nov., *C. bauhinia* sp. nov. and *C. argilla* sp. nov. Stimulated by the potential non-monophyly of the *C. serrata* species group indicated in previous preliminary phylogenetic analyses (see Klotz and von Rintelen 2014; Do et al. 2020), an opportunity is herein taken to discuss the validity of this species group.

MATERIALS AND METHODS

Specimen collection

Specimens were collected using hand nets, euthanised by freezing, and preserved in > 95% ethanol. Due to conservation concern, the exact sampling localities are stored with the type materials and are not herein disclosed. Specimens examined were deposited in the Simon F.S. Li Marine Science Laboratory, The Chinese University of Hong Kong (CUHK-LMT) and the Zoological Reference Collection of Lee Kong Chian Natural History Museum, National University of Singapore (ZRC). The abbreviations ‘pocl’ and ‘ov.’ stand for post-orbital carapace length and ovigerous, respectively.

DNA extraction, PCR and sequencing

Total genomic DNA was extracted from pleopods using the QuickExtract DNA Extraction Solution (Lucigen, Middleton, WI, USA) or the DNeasy Blood and Tissue Kit (QIAGEN, Hilden, Germany) following the manufacturer’s instructions. Partial sequences of mitochondrial cytochrome *c* oxidase subunit I (*COI*) and

16S rRNA genes were amplified by PCR with primer pairs Cys F/dgH2198 (Folmer et al. 1994; Ma et al. 2021) and 16S-AR/16S-1472 (Crandall and Fitzpatrick 1996; Palumbi et al. 2002), respectively. PCR reactions were performed in a 25 µl volume containing 3–4 µL template DNA, 1X PCR reaction buffer, 200 µM dNTPs, 0.2 µM of each primer, 0.5 mM MgCl₂ and 1.5U *Taq* polymerase (Takara, Kasatsu, Japan), with the following profile: initial denaturation at 95°C for 3 min, followed by 35 cycles of 95°C for 30 s, 50°C for 40 s and 72°C for 1 min, and a final extension at 72°C for 3 min. The PCR products were purified by the sequencing company (BGI, Shenzhen, China). Sequences were generated using the forward primer on an Applied Biosystems (ABI) 3700 automated sequencer using the ABI Big-dye Ready-Reaction Mix Kit (Life Technologies, Carlsbad, CA, USA), following the standard cycle sequencing protocol.

Phylogenetic analyses

Specimens and GenBank accessions included in the phylogenetic analyses are listed in table 1. The GenBank accessions were retrieved from a number of taxonomic, phylogenetic and population genetic literatures (Page et al. 2007a b; Shih and Cai 2007; Klotz and von Rintelen 2014; Chow et al. 2018 2022; Chen et al. 2020; Do et al. 2020 2021a b; Xu et al. 2020; Ma et al. 2021; Zhou et al. 2021; Guo et al. 2022; Jiang et al. 2023). As two different *COI* gene regions were sequenced among the previous studies, sequences of both regions were included in the analyses to increase species coverage. If the *COI* sequences of the two regions were generated from two different vouchered specimens, they were only concatenated and included in the analysis if the specimens were confirmed to be conspecifics on the ground of showing > 98% similarity in their 16S rRNA sequences. Sequences were aligned using MUSCLE (Edgar 2004) with alignment of *COI* gene confirmed by translating sequences into amino acid sequences. Poorly aligned regions of the 16S rRNA gene were trimmed using trimAl v1.3 (Capella-Gutiérrez et al. 2009) with a gap threshold of 80%. Sequences were then concatenated into a 1,727 bp-long alignment (*COI*: 1,239 bp; 16S: 488 bp). Kimura two-parameter (K2P) pairwise genetic distances among selected species were calculated using MEGA v7 (Kumar et al. 2016). Partitions and best-fit substitution models were determined using PartitionFinder v2.1.1 (Lanfear et al. 2017), according to the corrected Akaike information criterion (AICc). The substitution models used and partitioning for phylogenetic analyses were as follows, partition 1: *COI* 1st codon position (TRN + I + G), partition 2: *COI* 2nd codon position (TIM

+ I), partition 3: *COI* 3rd codon position (GTR + G), and partition 4: 16S rRNA (TVM + I + G). Maximum likelihood (ML) analysis was carried out using IQ-TREE v2.3.1 (Minh et al. 2020) and branch support was assessed by ultrafast bootstrapping (Minh et al. 2013) with 5,000 replicates. Bayesian inference (BI) analysis was carried out using MrBayes v3.2.7 (Ronquist et al. 2012). Two independent Markov chain Monte Carlo (MCMC) runs of four chains were performed for five million generations, sampling every 500th generation. Convergence of chains was determined by having effective sample size (ESS) > 200 for all parameters. One-fourth of the trees were discarded as burn-in. All trees were rooted by two congeners from the *C. nilotica* species group, *C. elongapoda* Liang & Yan, 1977 and *C. gracilipes* De Man, 1892, which was shown to be distantly related to the target group of landlocked atyids from East and Southeast Asia including the *C. serrata* species group, *Neocaridina*, *Paracaridina* and *Sinodina* (von Rintelen et al. 2012).

RESULTS

Phylogenetic analyses of the *C. serrata* species group showed that it is polyphyletic with at least four lineages (Fig. 1), although the relationships among the four lineages were uncertain due to low supports at deep nodes. The nominal lineage comprises *C. serrata* and 12 closely related species, including the three cryptic species herein collected and described as new below, namely *C. chui* sp. nov., *C. bauhinia* sp. nov. and *C. argilla* sp. nov. Species of this lineage are mostly restricted to Hong Kong, Macau and the adjacent Guangdong Province in southern China,

with a few extending to northern and central Vietnam. The second lineage consists of species from Vietnam, including *C. pacbo* Do, von Rintelen & Dang, 2020, *C. pseudoserrata* Dang & Do, 2007 and *C. rubropunctata* Dang & Do, 2007, but the clade also contains the irrelevant *C. namdat* Do, Dang & von Rintelen, 2021. The third lineage comprises *C. caobangensis* Li & Liang, 2002 and *C. sphyrapoda* Liang & Zhou, 1993 from adjacent provinces in northern Vietnam and southern China, respectively. The fourth lineage contains only *C. maculata* Wang, Liang & Li, 2008, which also occurs in the Guangdong Province in southern China. Some singleton species of the species group, including *C. ngankeeae*, *C. nguyeni* Li & Liang, 2002 and *C. stellata* Guo, Chen, Chen, Cai & Guo, 2022, had uncertain phylogenetic position in the current analyses.

The three cryptic species had a genetic distance from their closest relative of 2.8–3.1% (16S rRNA) and 4.9–6.3% (*COI*) (Table 2), which is within the range recognised between sister congeners and confamilials (see Klotz and von Rintelen 2014; Shih et al. 2024), supporting their species level status. *Caridina chui* sp. nov. is phylogenetically the closest to *C. conghuensis* Klotz & von Rintelen, 2014 (Fig. 1) with a genetic distance of 3.1% (16S rRNA) and 4.9% (*COI*) (Table 2), and they formed a clade within the nominal lineage of the *C. serrata* species group. *Caridina bauhinia* sp. nov. and *C. argilla* sp. nov. are the most closely related among congeners, with a genetic distance of 2.8% (16S rRNA) and 6.3% (*COI*) (Table 2). The two species belong to the clade which contains *C. serrata*, *C. nanaoensis* Cai & Ng, 1999, *C. macauensis* Zhou, Zhang, Wong & Huang, 2021 and *C. tetrazona* Chen, Chen, Zheng & Guo, 2020.

Table 1. Details of specimens and GenBank accessions included in the phylogenetic analysis. Newly generated sequences are highlighted in bold. –, missing data

Species	Voucher ID	Sampling locality	GenBank accession no.	
			<i>COI</i>	16S
<i>Caridina argilla</i> sp. nov.	CUHK-LMT-CAR476-4 (paratype)	Hong Kong, China	PX525666	PX583144
<i>Caridina bauhinia</i> sp. nov.	CUHK-LMT-CAR425-2 (paratype)	Hong Kong, China	PX525668	PX583142
<i>Caridina breviata</i>	OUMNH.ZC 2013-07-040	Zhapo, Guangdong, China	KP168788	KP168718
<i>Caridina cantonensis</i>	NCHUZOL 13114	Zhapo, Guangdong, China	AB300190	–
	OUMNH.ZC 2013-07-015	Qingyuan, Guangdong, China	KP168802	KP168720
<i>Caridina caobangensis</i>	ZMB 30255	Pac Bo, Cao Bang, Vietnam	MT526826	MT526809
<i>Caridina cavernicola</i>	Unknown in FU	Hechi, Guangxi, China	MZ753499	MZ753802
<i>Caridina chui</i> sp. nov.	CUHK-LMT-CAR444-2 (holotype)	Hong Kong, China	PX525667	PX583143
<i>Caridina clinata</i>	ZMB 31777	Cuc Phuong, Ninh Binh, Vietnam	MT526827	MT526810
<i>Caridina conghuensis</i>	OUMNH.ZC 2013-07-025 (paratype)	Conghua, Guangdong, China	–	KP168735
	CUHK-LMT-CAR406-1	China	PX525670	–

Table 1. (Continued)

Species	Voucher ID	Sampling locality	GenBank accession no.	
			COI	16S
<i>Caridina cucphuongensis</i>	ZMB 31744	Cuc Phuong, Ninh Binh, Vietnam	MT526828	MT526811
<i>Caridina formosae</i>	NCHUZOO 13113	Tamsui, Taipei, Taiwan	AB300189	–
	GU-987	Tamsui, Taipei, Taiwan	DQ478451	DQ478496
<i>Caridina haivanensis</i>	ZMB 30259	Hai Van, Thua Thien-Hue, Vietnam	MT526830	MT526813
<i>Caridina huananensis</i>	Unknown in FU	Qingyuan, Guangdong, China	MN701607	MT446452
<i>Caridina lanceifrons</i>	ZMB 29638	Da Bac, Hoa Binh, Vietnam	MT526831	MT526814
<i>Caridina logemanni</i>	ZMB 28221 (paratype)	Hong Kong, China	–	KP168745
	CUHK_MSL_ClogNWC01	Hong Kong, China	MZ895521	–
<i>Caridina macauensis</i>	SYSBM18-11-21-04 (paratype)	Macau, China	MN879768	–
<i>Caridina maculata</i>	OUMNH.ZC 2013-07-028	Lixi, Guangdong, China	–	KP168748
<i>Caridina mariae</i>	ZMB 28223 (paratype)	Conghua, Guangdong, China	–	KP168753
	Unknown in FU	Huizhou, Guangdong, China	MN701601	–
<i>Caridina namdat</i>	ZMB 30341-3 (paratype)	Nam Dat, Bac Kan, Vietnam	MZ484397	MZ484401
<i>Caridina nanaoensis</i>	ZMB 29473	China	KP168792	KP168755
<i>Caridina ngankeae</i>	CUHK-LMT-CAR408-1 (paratype)	Hong Kong, China	PX525669	PX583141
<i>Caridina nguyenii</i>	ZMB 30280	Pac Bo, Cao Bang, Vietnam	MT526833	MT526816
<i>Caridina pacbo</i>	ZMB 30295-2 (paratype)	Pac Bo, Cao Bang, Vietnam	MT526835	MW525213
<i>Caridina pseudodenticulata</i>	GU-986	Dongshi, Taichung, Taiwan	DQ478459	DQ478511
<i>Caridina pseudoserrata</i>	ZMB 30343	Tu Do, Cao Bang, Vietnam	MT526837	MT526818
<i>Caridina rubropunctata</i>	ZMB 30314	Van Lang, Thai Nguyen, Vietnam	MT526838	MT526819
<i>Caridina serrata</i>	CUHK_MSL_CserHLF01	Hong Kong, China	MZ092943	–
	OUMNH.ZC 2013-07-020	Hong Kong, China	KP168793	KP168758
<i>Caridina sinanensis</i>	Unknown in FU (type series)	Sinan, Guizhou, China	MT433962	MT434873
<i>Caridina sphyrapoda</i>	CUHK_MSL_CapoNCP01	China	MH176649	PX699665
<i>Caridina stellata</i>	Unknown in FU (type series)	Jinxu, Guangxi, China	MZ753496	MZ753799
<i>Caridina tetrazona</i>	Unknown in FU (type series)	Dawanshan Island, Guangdong, China	MN701593	–
<i>Caridina thachlam</i>	ZMB 31781 (paratype)	Thach Lam, Thanh Hoa, Vietnam	MW506000	MW505994
<i>Caridina tricineta</i>	ZMB 30360-1 (paratype)	Lac Nong, Ha Giang, Vietnam	MT526839	MT526822
<i>Caridina trifasciata</i>	OUMNH.ZC 2013-07-033	Hong Kong, China	–	KP168767
	CUHK_MSL_CtriNBK01	Hong Kong, China	MZ092955	–
<i>Caridina venusta</i>	RMNH.CRUS.D.56061	Lixi, Guangdong, China	KP168812	KP168772
<i>Caridina yunnanensis</i>	ZMB DNA-283	China	KP168820	KP168741
<i>Neocaridina ketagalan</i>	NCHUZOO 13107 (type series)	Sijhih, Taipei, Taiwan	AB300182	AB300168
<i>Neocaridina palmata</i>	Unknown in FU	Qingyuan, Guangdong, China	MN701612	–
	ZMB 30256	Pac Ma, Cao Bang, Vietnam	MT526843	MT526825
<i>Neocaridina saccam</i>	NCHUZOO 13103 (type series)	Longci, Tainan, Taiwan	AB300177	AB300164
	GU-1000	Longci, Tainan, Taiwan	DQ681254	–
<i>Neocaridina spinosa</i>	NCHUZOO 13112	Tongan, Fujian, China	AB300188	AB300174
<i>Paracaridina guizhouensis</i>	GBZD-562	Yuping, Guizhou, China	OR536641	OR537883
<i>Paracaridina zijinica</i>	OUMNH.ZC 2013-07-038	Heyuan, Guangdong, China	KP168799	KP168783
<i>Sinodina ashima</i>	GBZD-677 (type series)	Shilin, Yunnan, China	OR536642	OR537885
<i>Sinodina gregoriana</i>	GBZD-238	Weining, Guizhou, China	–	OR537881
Outgroup				
<i>Caridina elongapoda</i>	CUHK_MSL_ClonNTAI11	Hong Kong, China	MZ093015	–
	OUMNH.ZC 2013-07-041	Hong Kong, China	KP168821	KP168733
<i>Caridina gracilipes</i>	MNHN-IU-2018-207	Indonesia	MK190025	–
	ZMB 30231	Thuy Nguyen, Hai Phong, Vietnam	MT526829	MT526812

Voucher ID locations: CUHK, The Chinese University of Hong Kong; FU, Foshan University; GBZD, Guizhou Academy of Sciences; GU, Griffith University; NCHUZOO, National Chung Hsing University; MNHN, Muséum national d'Histoire naturelle; OUMNH, Oxford University Museum of Natural History; RMNH, Naturalis Biodiversity Center Leiden; SYSBM, Sun Yat-Sen University; ZMB, Museum für Naturkunde Berlin.

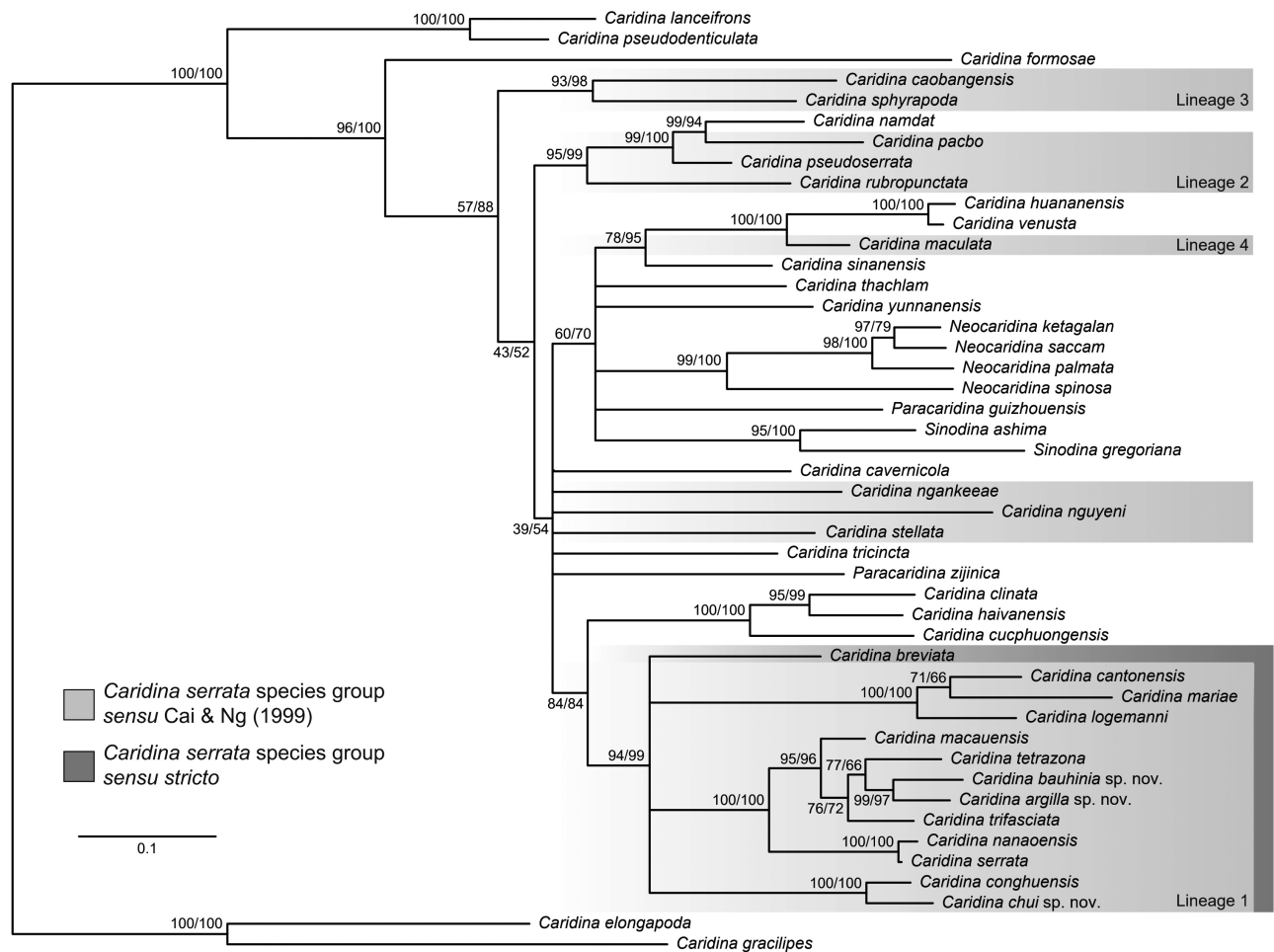


Fig. 1. Bayesian phylogenetic tree of selected landlocked *Caridina*, *Neocaridina*, *Paracaridina* and *Sinodina* species recorded from China and Vietnam, constructed using mitochondrial 16S rRNA and *COI* markers. Branch support values (PP/BP) are indicated as percentages. Species of the *C. serrata* species group under the diagnosis by Cai and Ng (1999) and the *C. serrata* species group sensu stricto rediagnosed in the present study are shaded in light grey and dark grey, respectively.

Table 2. K2P pairwise genetic distances of *COI* (above diagonal) and 16S rRNA genes (below diagonal) among the three new species and closely related species. NA, sequence of one of the species not available

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) <i>Caridina chui</i> sp. nov.	/	0.156	0.154	0.147	0.164	0.167	0.049	0.175	NA	0.153	0.151	0.133	NA
(2) <i>Caridina bauhينيا</i> sp. nov.	0.077	/	0.063	0.175	0.174	0.167	0.144	0.145	NA	0.094	0.092	0.095	NA
(3) <i>Caridina argilla</i> sp. nov.	0.081	0.028	/	0.161	0.177	0.156	0.144	0.123	NA	0.094	0.086	0.086	NA
(4) <i>Caridina cantonensis</i>	0.087	0.094	0.088	/	0.105	0.084	0.147	0.168	0.152	0.155	0.152	0.152	0.148
(5) <i>Caridina mariae</i>	0.083	0.088	0.086	0.034	/	0.117	0.159	0.193	NA	0.175	0.166	0.153	NA
(6) <i>Caridina logemanni</i>	0.086	0.098	0.092	0.021	0.034	/	0.172	0.154	NA	0.137	0.121	0.136	NA
(7) <i>Caridina conghuensis</i>	0.031	0.080	0.090	0.090	0.088	0.097	/	0.166	NA	0.126	0.153	0.139	NA
(8) <i>Caridina serrata</i>	0.083	0.044	0.047	0.085	0.076	0.084	0.092	/	0.000	0.126	0.145	0.113	0.128
(9) <i>Caridina nanaoensis</i>	0.085	0.044	0.048	0.083	0.074	0.081	0.094	0.006	/	NA	NA	NA	0.128
(10) <i>Caridina trifasciata</i>	0.077	0.034	0.033	0.077	0.077	0.088	0.081	0.031	0.033	/	0.091	0.075	NA
(11) <i>Caridina tetrazona</i>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	/	0.084	NA
(12) <i>Caridina macauensis</i>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	/	NA
(13) <i>Caridina breviata</i>	0.081	0.087	0.097	0.088	0.072	0.095	0.081	0.077	0.083	0.077	NA	NA	/

SYSTEMATICS

Family Atyidae De Haan, 1849
Genus *Caridina* H. Milne Edwards, 1837

***Caridina chui* sp. nov.**

(Figs. 2A–L, 3)

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Material examined: Holotype: female (pocl 4.0 mm), Shing Mun, central New Territories, Hong Kong, coll. JCF Chan, 02.IV.2022, CUHK-LMT-CAR444-2. Paratypes: 2 females (pocl 4.1 and 4.6 mm), same collection data as holotype, CUHK-LMT-CAR444; 2 males (pocl 3.1 mm), 4 females (pocl 3.3–3.7 mm), 2 ov. females (pocl 3.4 and 4.2 mm), Shing Mun, central New Territories, Hong Kong, coll. JCF Chan, 07.VII.2023, CUHK-LMT-CAR502; 1 male (pocl 2.9 mm), 1 female (pocl 3.6 mm), Shing Mun, central New Territories, Hong Kong, coll. JCF Chan, 07.VII.2023, ZRC 2025.2038.

Comparative material examined: *Caridina cantonensis*, 4 males (pocl 2.8–4.9 mm), 2 females (pocl 4.7 and 5.0 mm), Shing Mun, central New Territories, Hong Kong, coll. JCF Chan, 02.IV.2022, CUHK-LMT-CAR444a; 1 male (pocl 4.0 mm), 3 females (pocl 3.3–4.7 mm), Shing Mun, central New Territories, Hong Kong, coll. JCF Chan, 07.VII.2023, CUHK-LMT-CAR502a.

Etymology: Named after Dr. Ka Hou Chu for his contribution to decapod crustacean biology, including biodiversity and conservation genetics of atyid shrimps in Hong Kong.

Description: Rostrum (Fig. 2A) straight, shallow, usually directed downwards, nearly reaching to the end of basal segment of antennular peduncle to reaching to midlength of second segment, tip sometimes directed slightly upwards, 0.25–0.35 (median 0.32) times poel; rostral formula 2–4 + 4–7 / 0–2. Inferior orbital angle fused with antennal spine. Pterygostomial angle rounded, subrectangular, slightly produced forward. Eyes well developed with globular cornea. Antennular peduncle 0.45–0.55 (median 0.49) times poel, basal segment 2.0–2.5 (median 2.2) times as long as second segment, second segment 1.1–1.5 (median 1.3) times as long as third segment. Stylocerite reaching to 0.00–0.55 (median 0.35) length of second segment of antennular peduncle. Scaphocerite (Fig. 2B) 2.55–2.85 (median 2.76) times as long as wide.

Sixth abdominal somite about 0.5 times poel, about as long as telson. Telson (Fig. 2C) 2.1–2.4 (median 2.3) times as long as proximal wide, with 4 or 5 pairs of short spiniform setae dorsal and one

pair of short spiniform setae dorsolateral, posterior margin (Fig. 2D) convex with a median projection and 4 pairs of spiniform setae, sublateral pair slightly shorter than lateral pairs and inner pairs. Preanal carina (Fig. 2E) rounded, unarmed, with few setae. Uropodal diaeresis (Fig. 2F) with 15–21 movable spiniform setae, outermost one slightly longer than lateral angle.

Mandible (Fig. 2G) with incisor process ending in irregular teeth; molar process truncated. Maxillule (Fig. 2H) with lower lacinia broadly rounded, upper lacinia elongate, with numerous distinct cuspidate setae on inner margin; palp with few simple setae. Maxilla (Fig. 2I) with upper endites subdivided; palp slender; scaphognathite tapering posteriorly, fringed with long setae at posterior margin. First maxilliped (Fig. 2J) with palp ending in a projection. Second maxilliped (Fig. 2K) with well-developed podobranch. Third maxilliped (Fig. 2L) with 2 arthrobranchs, ultimate segment subequal to penultimate in length. First pereopod with an arthrobranch. Pleurobranchs present on all pereopods. Epipods present on third maxilliped and first four pereopods.

First pereopod (Fig. 3A) chela 1.85–2.05 (median 1.99) times as long as wide, 1.2–1.5 (median 1.4) times as long as carpus; tips of fingers rounded, without hooks, fingers 0.95–1.25 (median 1.06) times as long as palm; carpus strongly excavated distally, 1.35–1.60 (median 1.50) times as long as wide, 0.85–0.95 (median 0.91) times as long as merus; merus 2.4–2.9 (median 2.6) times as long as wide, longer than ischium. Second pereopod (Fig. 3B) chela 2.40–2.90 (median 2.59) times as long as wide, 0.70–0.80 (median 0.75) times as long as carpus; tips of fingers rounded, without hooks, fingers 1.45–1.65 (median 1.56) times as long as palm; carpus 4.8–5.3 (median 5.1) times as long as wide, 1.05–1.20 (median 1.16) times as long as merus; merus 4.4–4.9 (median 4.6) times as long as wide, longer than ischium. Third pereopod (Fig. 3C) slender, not sexually dimorphic; dactylus (Fig. 3D) with 3 or 4 accessory spiniform setae on flexor margin, 2.4–3.1 (median 2.9) times as long as wide (terminal claw and accessory spiniform setae included); propodus 7.1–8.5 (median 7.8) times as long as wide, 3.4–4.0 (median 3.5) times as long as dactylus; carpus 3.6–4.2 (median 3.9) times as long as wide, 0.70–0.75 (median 0.74) times as long as propodus, about 0.50 times as long as merus; merus 5.5–6.3 (median 5.6) times as long as wide, bearing 3 or 4 strong spiniform setae on posterior margin of outer surface; ischium with a strong spiniform seta. Fifth pereopod (Fig. 3E) slender; dactylus (Fig. 3F) with 31–41 spinuliform setae on flexor margin, 3.1–4.0 (median 3.3) times as long as wide (terminal claw and accessory spinuliform setae included); propodus 10.2–11.7 (median 10.6) times as long as wide, 2.9–3.5

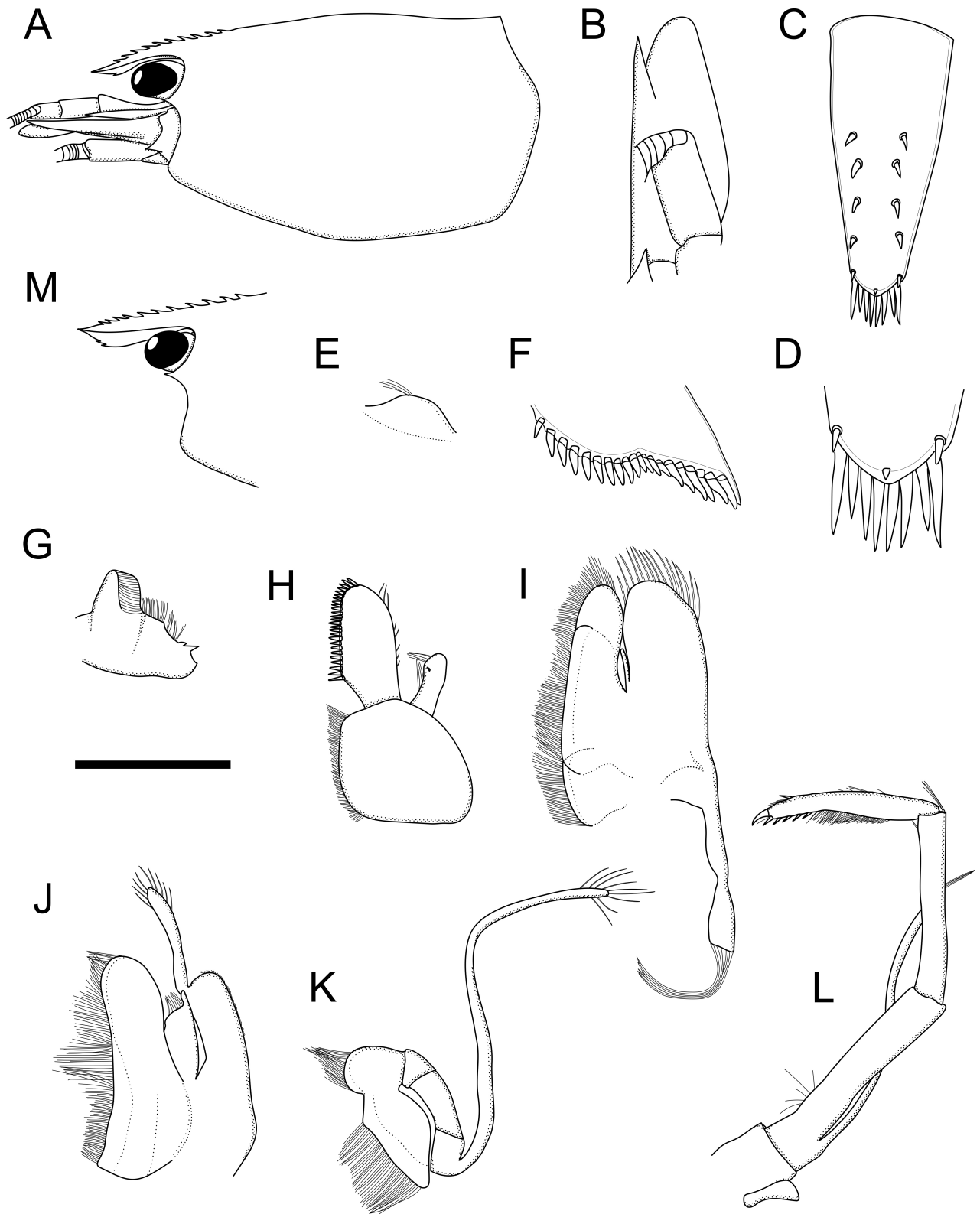


Fig. 2. A–D, *Caridina chui* sp. nov., holotype female, poel 4.0 mm (CUHK-LMT-CAR444-2); E–L, paratype female, poel 4.6 mm (CUHK-LMT-CAR444-8); M, *Caridina cantonensis*, female, poel 4.7 mm (CUHK-LMT-CAR502-8). A, cephalothorax, lateral view; B, scaphocerite; C, telson; D, same, distal margin; E, preanal carina; F, uropodal diaeresis; G, mandible; H, maxillule; I, maxilla; J, first maxilliped; K, second maxilliped; L, third maxilliped; M, frontal region. Scale bars: A = 2 mm; B, C = 1.1 mm; D–F = 0.5 mm; G–K = 0.8 mm; L = 1 mm; M = 2.2 mm.

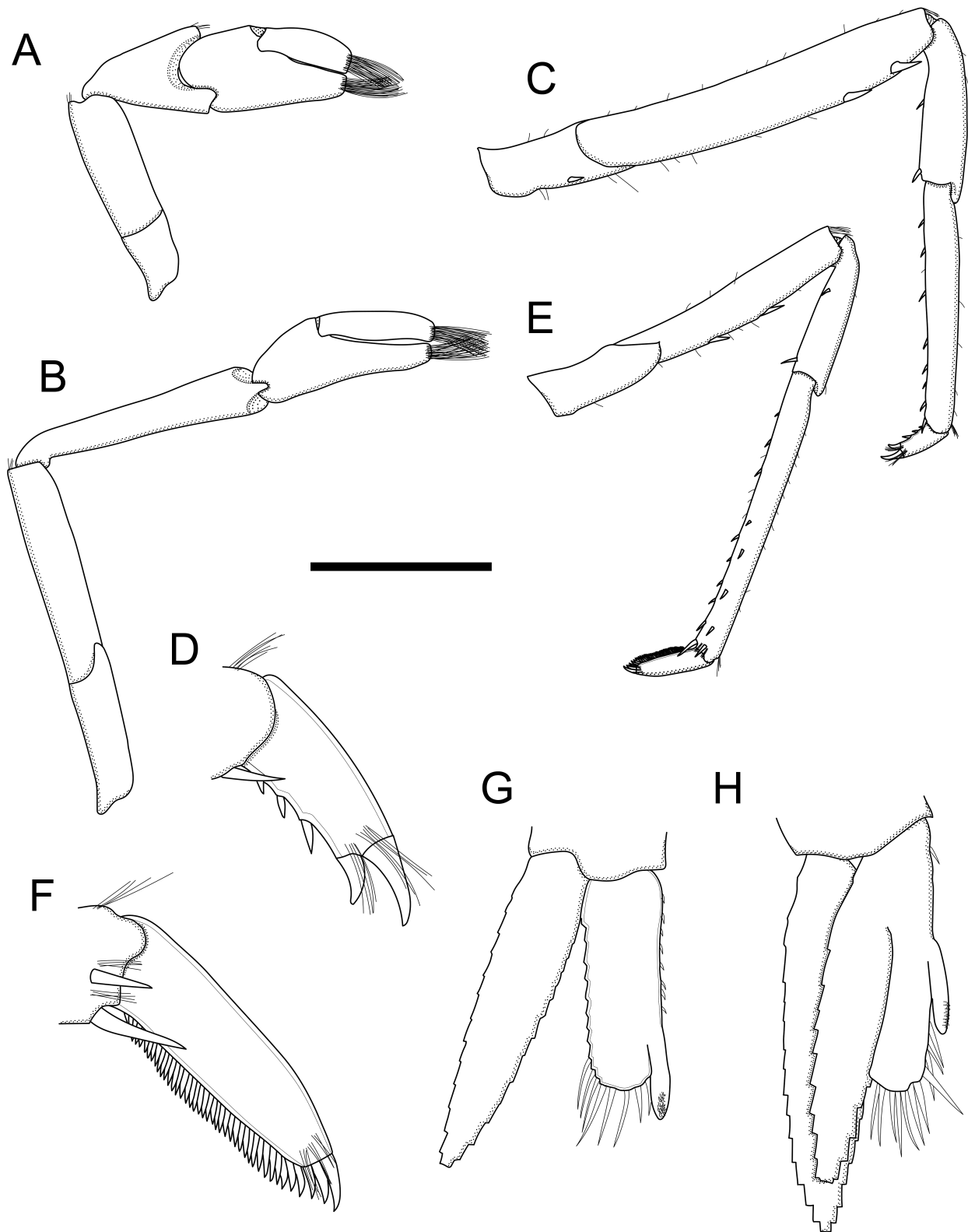


Fig. 3. *Caridina chui* sp. nov., holotype female, pocl 4.0 mm (CUHK-LMT-CAR444-2). A, first pereopod; B, second pereopod; C, third pereopod; D, same, dactylus; E, fifth pereopod; F, same, dactylus; G, male first pleopod; H, male second pleopod. Scale bars: A–C, E = 1 mm; D, F = 0.25 mm; G, H = 0.45 mm.

(median 3.2) times as long as dactylus; carpus 3.6–5.0 (median 4.2) times as long as wide, about 0.55 times as long as propodus, about 0.65 times as long as merus; merus 4.6–6.3 (median 5.4) times as long as wide, bearing three strong spiniform setae on posterior margin of outer surface; ischium unarmed.

Endopod of male first pleopod (Fig. 3G) subrectangular, inner and outer margins almost straight and parallel, 2.45–2.70 (median 2.66) times as long as proximal wide, anterior region only feebly bent or not bent backwards, 0.60–0.70 (median 0.66) times as long as exopod; appendix interna arising from about 0.70 of endopod, reaching beyond the distal margin of endopod by 0.20–0.35 (median 0.31) of its length. Appendix masculina of male second pleopod (Fig. 3H) stout, club-shaped, 4.4–4.8 (median 4.5) times as long as wide, with long spinuliform setae on inner and distal margin, few smaller spiniform setae on basal part, 0.75–0.85 (median 0.78) times as long as endopod; appendix interna arising from about 0.40 and reaching to about 0.75 of appendix masculina.

Eggs large, few. Size of developed eggs (with eyespots) $1.02\text{--}1.13 \times 0.60\text{--}0.73$ mm in diameter.

Colouration: Adult females with body tinted with yellow and scattered with red chromatophores, without apparent stripes or spots. Colouration of males unknown.

Remarks: It is unfortunate that the majority of the paratype specimens are in poor condition, where many of their pereopods were detached and mixed with those of *C. cantonensis* collected together. This population of *C. cantonensis* is rather atypical that the rostrums of many individuals are very short viz. falling short of the end of basal segment of antennular peduncle (Fig. 2M), resembling the sympatric *C. chui* sp. nov. Nevertheless, based on the intact specimens, *C. chui* sp. nov. differs from the co-occurring *C. cantonensis* by the 1) more tapered and shallower rostrum with fewer ventral rostral teeth (0–2, mode 1 vs 0–4, mode 3 in *C. cantonensis*); 2) shorter second pereopod fingers (1.45–1.65, median 1.56 times as long as palm vs 1.65–1.95, median 1.80 times); 3) stouter second pereopod merus (4.4–4.9, median 4.6 times as long as wide vs 4.8–5.3, median 5.0 times); 4) slenderer third pereopod propodus (7.1–8.5, median 7.8 times as long as wide vs 7.6–9.4, median 9.0 times) but stouter carpus (3.6–4.2, median 3.9 times as long as wide vs 4.5–5.3, median 4.6 times); 5) shorter fifth pereopod propodus (2.9–3.5, median 3.2 times as long as dactylus vs 3.7–4.4, median 3.9 times); 6) broader telson (2.1–2.4, median 2.3 times as long as proximal wide vs 2.5–2.7, median 2.6 times); 7) longer appendix interna of male first pleopod (reaching beyond distal margin of endopod by 0.20–0.35, median 0.31 of its length vs 0.00–0.10, median 0.06); and 8) longer

appendix masculina of male second pleopod (0.75–0.85, median 0.78 times as long as endopod vs 0.60–0.65, median 0.62 times).

With a relatively more tapered rostrum, stout subrectangular endopod of male first pleopod and club-shaped appendix masculina of male second pleopod, *C. chui* sp. nov. is also similar to *C. conghuensis*, *C. logemanni* and *C. mariae* Klotz & von Rintelen, 2014 within the *C. serrata* species group, but is easily distinguished by life colouration (see Klotz and von Rintelen 2014). It can be separated from *C. conghuensis* by the 1) shorter rostrum (0.25–0.35, median 0.32 times poel vs 0.36–0.47, median 0.42 times in *C. conghuensis*) with fewer rostral teeth (2–4 + 4–7 / 0–2 vs 3–5 + 7–9 / 2–4); 2) broader scaphocerite (2.55–2.85, median 2.76 times as long as wide vs 2.93–3.44, median 3.13 times); 3) longer second pereopod fingers (1.45–1.65, median 1.56 times as long as palm vs 1.31–1.37, median 1.33 times) and stouter merus (4.4–4.9, median 4.6 times as long as wide vs 4.56–5.22, median 4.96 times); 4) stouter third pereopod dactylus and propodus (2.4–3.1, median 2.9 times and 7.1–8.5, median 7.8 times as long as wide vs 3.07–3.83, median 3.23 times and 8.63–9.67, median 8.80 times, respectively); and 5) fewer spiniform setae on the flexor margin of third pereopod dactylus (3–4 vs 5–7).

Caridina chui sp. nov. differs from *C. logemanni* by the 1) fewer rostral teeth (2–4 + 4–7 / 0–2 vs 3–7 + 7–15 / 0–6 in *C. logemanni*); 2) slenderer first pereopod carpus (1.35–1.60, median 1.50 times as long as wide vs 1.11–1.46, median 1.30 times); 3) stouter third pereopod propodus and carpus (7.1–8.5, median 7.8 times and 3.6–4.2, median 3.9 times as long as wide vs 8.72–11.68, median 9.36 times and 4.18–5.78, median 4.57 times, respectively); 4) shorter fifth pereopod propodus (2.9–3.5, median 3.2 times as long as dactylus vs 4.29–5.31, median 4.73 times); 5) broader telson (2.1–2.4, median 2.3 times as long as proximal wide vs 2.68–2.89, median 2.82 times); and 6) longer appendix interna of male first pleopod (clearly reaching beyond distal margin of endopod vs not reaching or only feebly beyond).

Caridina chui sp. nov. can be separated from *C. mariae* by the 1) fewer dorsal rostral teeth (2–4 + 4–7 vs 4–6 + 6–9 in *C. mariae*); 2) shorter stylocerite (reaching at most to 0.55 length of second segment of antennular peduncle vs reaching to at least 0.7 length); 3) stouter second pereopod merus (4.4–4.9, median 4.6 times as long as wide vs 4.81–5.91, median 5.09 times); 4) stouter third pereopod (dactylus 2.4–3.1, median 2.9 times, propodus 7.1–8.5, median 7.8 times, carpus 3.6–4.2, median 3.9 times and merus 5.5–6.3, median 5.6 times as long as wide vs 2.95–3.60, median 3.2 times, 9.72–11.38, median 10.21 times, 4.54–5.21, median 5.03

times and 5.80–7.07, median 6.79 times, respectively); 5) fewer spiniform setae on the flexor margin of third pereopod dactylus (3–4 vs 5–6); 6) broader telson (2.1–2.4, median 2.3 times as long as proximal wide vs 2.22–3.43, median 2.86 times); and 7) uniform endopod of male first pleopod (vs distally dilated) with longer appendix interna of male first pleopod (clearly reaching beyond distal margin of endopod vs not reaching or only feebly beyond).

A comparison of selected morphological characters among *Caridina* species from the nominal lineage of the *C. serrata* species group recorded in Hong Kong is provided in table 3.

***Caridina bauhinia* sp. nov.**

(Figs. 4, 5)

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Material examined: Holotype: male (pocl 3.9 mm), Tai Lam, western New Territories, Hong Kong, coll. JCF Chan, 29.I.2022, CUHK-LMT-CAR425-6. Paratypes: 5 females (pocl 3.9–5.1 mm), same collection data as holotype, CUHK-LMT-CAR425; 3 males (pocl 2.8–3.9 mm), 3 females (pocl 3.8–4.6 mm), 2 ov. females (pocl 4.5 and 4.9 mm), Tai Lam, western New Territories, Hong Kong, coll. JCF Chan, 24.IV.2022, CUHK-LMT-CAR469; 1 male (pocl 3.5 mm), 1 female (pocl 3.7 mm), Tai Lam, western New Territories, Hong Kong, coll. JCF Chan, 24.IV.2022, ZRC 2025.2039.

Comparative material examined: *Caridina serrata* Stimpson, 1860, 3 males (pocl 3.6–4.6 mm), 2 females (pocl 4.5 and 4.7 mm), Fan Lau, Lantau Island, Hong Kong, coll. JCF Chan, 03.II.2022, CUHK-LMT-CAR426; 3 females (pocl 4.7–5.4 mm), Discovery Valley, Lantau Island, Hong Kong, coll. JCF Chan, 05.III.2022, CUHK-LMT-CAR432; 1 male (pocl 4.2 mm), 1 female (pocl 4.3 mm), 1 ov. female (pocl 5.3 mm), San Tau, Lantau Island, Hong Kong, coll. JCF Chan, 16.II.2022, CUHK-LMT-CAR433; 5 males (pocl 4.1–4.8 mm), 2 females (pocl 3.5 and 3.9 mm), Lung Fu Shan, Hong Kong Island, Hong Kong, coll. JCF Chan, 14.I.2022, CUHK-LMT-CAR434; 1 ov. female (pocl 4.6 mm), Sze Pak Wan, Lantau Island, Hong Kong, coll. JCF Chan, 05.III.2022, CUHK-LMT-CAR436.

Etymology: Named after the common name of the floral emblem of Hong Kong (the type locality) *i.e.*, *Bauhinia* × *blakeana* Dunn. Used as a noun in apposition.

Description: Rostrum (Fig. 4A) straight, slightly directed downwards, nearly reaching to or slightly reaching beyond the end of basal segment of antennular peduncle, tip sometimes directed slightly upwards, 0.25–0.35 (median 0.29) times pocl; rostral formula 2–6

+ 3–10 / 0–4. Inferior orbital angle fused with antennal spine. Pterygostomial angle rounded, subrectangular, slightly produced forward. Eyes well developed with globular cornea. Antennular peduncle 0.45–0.55 (median 0.48) times pocl, basal segment 2.0–2.4 (median 2.1) times as long as second segment, second segment 1.6–2.0 (median 1.8) times as long as third segment. Stylocerite reaching to 0.00–0.50 (median 0.27) length of second segment of antennular peduncle. Scaphocerite (Fig. 4B) 2.40–2.65 (median 2.56) times as long as wide.

Sixth abdominal somite about 0.5 times pocl, about 0.9 times as long as telson. Telson (Fig. 4C) 2.2–2.5 (median 2.3) times as long as proximal wide, with 4 or 5 pairs of short spiniform setae dorsal and one pair of short spiniform setae dorsolateral, posterior margin (Fig. 4D) convex with a median projection and 6–9 spiniform setae, sublateral pair slightly shorter than or subequal to lateral pairs, shorter than inner pairs. Preanal carina (Fig. 4E) rounded, unarmed, with few setae. Uropodal diaeresis (Fig. 4F) with 19–23 movable spiniform setae, outermost one slightly longer than lateral angle.

Mandible (Fig. 4G) with incisor process ending in irregular teeth; molar process truncated. Maxillule (Fig. 4H) with lower lacinia broadly rounded, upper lacinia elongate, with numerous distinct cuspidate setae on inner margin; palp with few simple setae. Maxilla (Fig. 4I) with upper endites subdivided; palp slender; scaphognathite tapering posteriorly, fringed with long setae at posterior margin. First maxilliped (Fig. 4J) with palp ending in a projection. Second maxilliped (Fig. 4K) with well-developed podobranch. Third maxilliped (Fig. 4L) with two arthrobranchs, ultimate segment subequal to penultimate in length. First pereopod with an arthrobranch. Pleurobranchs present on all pereopods. Epipods present on third maxilliped and first four pereopods.

First pereopod (Fig. 5A) chela 1.85–2.20 (median 2.07) times as long as wide, 1.3–1.5 (median 1.4) times as long as carpus; tips of fingers rounded, without hooks, fingers 0.85–1.10 (median 0.96) times as long as palm; carpus strongly excavated distally, 1.35–1.60 (median 1.54) times as long as wide, 0.85–1.00 (median 0.92) times as long as merus; merus 2.3–2.6 (median 2.4) times as long as wide, longer than ischium. Second pereopod (Fig. 5B) chela 2.50–3.00 (median 2.76) times as long as wide, 0.70–0.80 (median 0.74) times as long as carpus; tips of fingers rounded, without hooks, fingers 1.35–1.60 (median 1.49) times as long as palm; carpus 4.5–5.7 (median 5.2) times as long as wide, 1.05–1.15 (median 1.12) times as long as merus; merus 4.7–5.5 (median 4.9) times as long as wide, longer than ischium. Third pereopod (Fig. 5C) slender, not sexually dimorphic; dactylus (Fig. 5D) with 4 or

Table 3. Comparison of selected morphological characters among *Caridina* species from the nominal lineage of the *C. serrata* species group recorded in Hong Kong

Species	Rostrum	Rostral formula	First pereopod fingers	Telson	Appendix interna of male first pleopod	Colour pattern
<i>Caridina apodosis</i>	Reaching to end of antennular peduncle or beyond	4-7+9-15/7-10	Longer than palm in length	Relatively slender	Not reaching beyond distal margin of endopod	Unknown
<i>Caridina argilla</i> sp. nov.	Reaching to about end of 1 st segment of antennular peduncle	0-4+1-10/0-2	Shorter or subequal to palm in length	Relatively stout	Slightly reaching beyond distal margin of endopod	Unknown
<i>Caridina bauhinia</i> sp. nov.	Reaching to about end of 1 st segment of antennular peduncle	2-6+3-10/0-4	Shorter or subequal to palm in length	Relatively stout	Not or feebly reaching beyond distal margin of endopod	Finely striped and spotted
<i>Caridina cantonensis</i>	Reaching to about end of 1 st segment of or end of antennular peduncle	2-8+4-15/0-6	Subequal to or longer than palm in length	Relatively slender	Not or feebly reaching beyond distal margin of endopod	Usually finely striped and spotted, sometimes uniform
<i>Caridina chui</i> sp. nov.	Reaching to end of 1 st segment or midlength of 2 nd segment of antennular peduncle	2-4+4-7/0-2	Subequal to or longer than palm in length	Relatively stout	Clearly reaching beyond distal margin of endopod	Uniform (female)
<i>Caridina logemanni</i>	Reaching to end of 1 st segment or midlength of 2 nd segment of antennular peduncle	3-7+7-15/0-6	Subequal to or longer than palm in length	Relatively slender	Not or feebly reaching beyond distal margin of endopod	Dark-banded
<i>Caridina serrata</i>	Reaching to about end of 1 st segment of antennular peduncle	0-7+5-12/0-6	Shorter or subequal to palm in length	Relatively stout	Clearly reaching beyond distal margin of endopod	Usually finely striped and spotted, sometimes uniform
<i>Caridina trifasciata</i>	Reaching to about end of 2 nd segment of antennular peduncle	4+7-10/1-4	Shorter or subequal to palm in length	Relatively stout	Clearly reaching beyond distal margin of endopod	Dark-banded

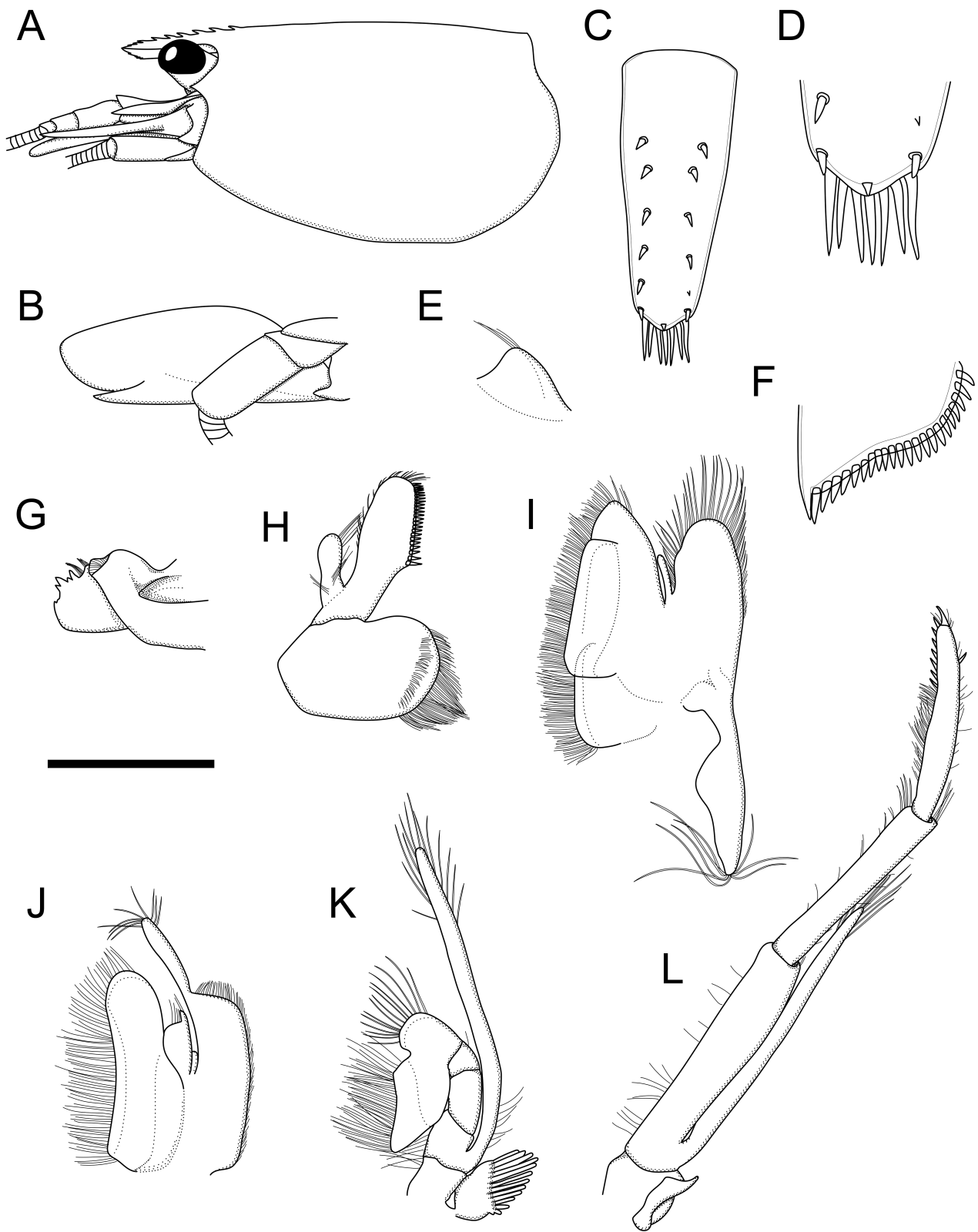


Fig. 4. *Caridina bauhinia* sp. nov., A–D, holotype male, pocl 3.9 mm (CUHK-LMT-CAR425-6); E–L, paratype female, pocl 5.1 mm (CUHK-LMT-CAR425-4). A, cephalothorax, lateral view; B, scaphocerite; C, telson; D, same, distal margin; E, preanal carina; F, uropodal diaeresis; G, mandible; H, maxillule; I, maxilla; J, first maxilliped; K, second maxilliped; L, third maxilliped. Scale bars: A = 2 mm; B, C = 1.2 mm; D–F = 0.6 mm; G–K = 1 mm; L = 1.5 mm.

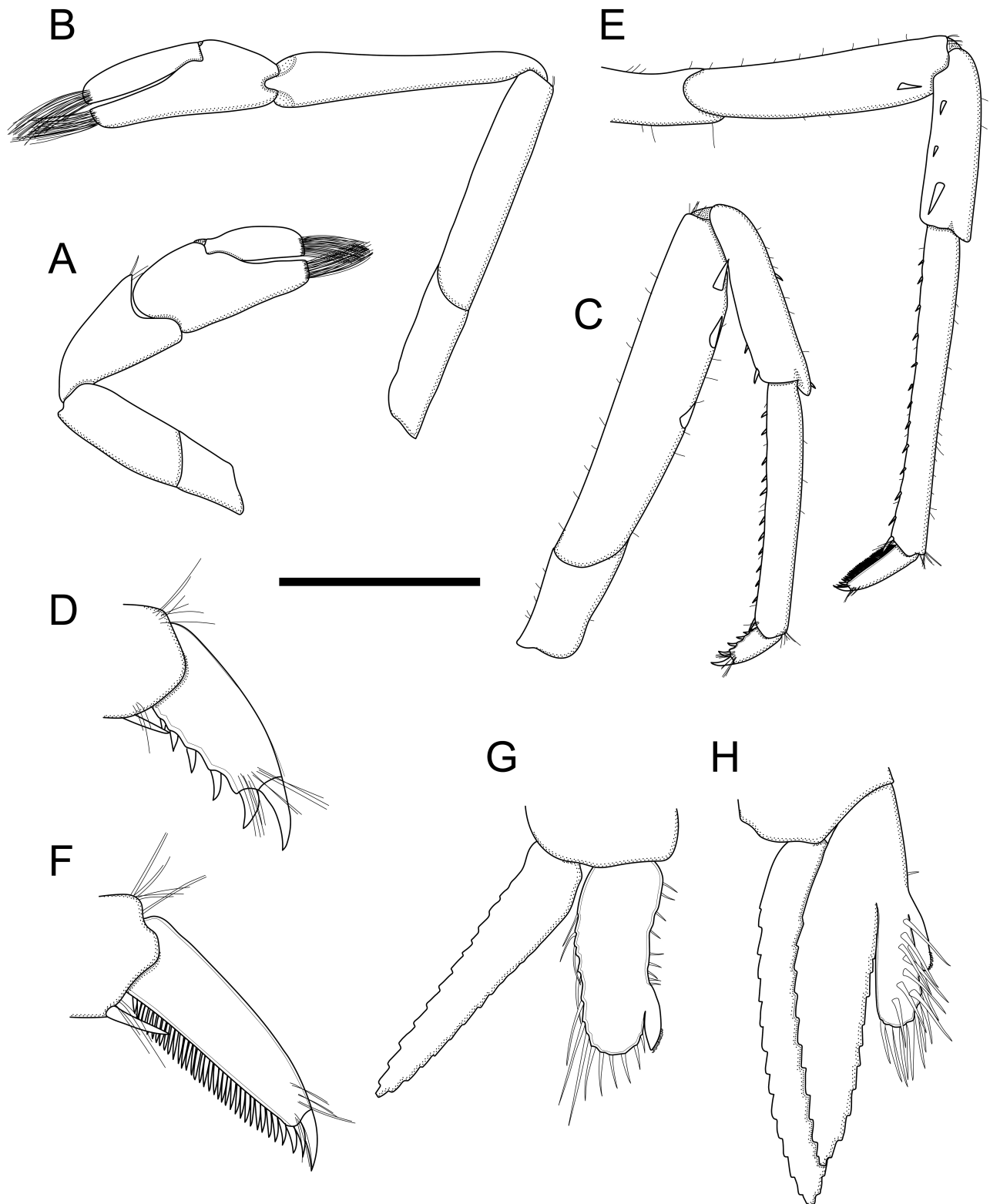


Fig. 5. *Caridina bauhinia* sp. nov., holotype male, pool 3.9 mm (CUHK-LMT-CAR425-6). A, first pereiopod; B, second pereiopod; C, third pereiopod; D, same, dactylus; E, fifth pereiopod; F, same, dactylus; G, male first pleopod; H, male second pleopod. Scale bars: A–C, E = 1 mm; D, F = 0.3 mm; G, H = 0.6 mm.

5 accessory spiniform setae on flexor margin, 2.4–3.0 (median 2.7) times as long as wide (terminal claw and accessory spiniform setae included); propodus 7.1–8.2 (median 7.6) times as long as wide, 3.3–3.9 (median 3.7) times as long as dactylus; carpus 3.7–4.6 (median 4.0) times as long as wide, 0.75–0.85 (median 0.76) times as long as propodus, 0.50–0.60 (median 0.53) times as long as merus; merus 4.4–5.6 (median 5.4) times as long as wide, bearing 3 or 4 strong spiniform setae on posterior margin of outer surface; ischium with or without a strong spiniform seta. Fifth pereopod (Fig. 5E) slender; dactylus (Fig. 5F) with 28–41 spinuliform setae on flexor margin, 2.4–3.3 (median 2.9) times as long as wide (terminal claw and accessory spinuliform setae included); propodus 10.0–12.8 (median 11.1) times as long as wide, 3.5–4.6 (median 4.1) times as long as dactylus; carpus 3.7–5.2 (median 4.3) times as long as wide, 0.50–0.60 (median 0.54) times as long as propodus, 0.65–0.75 (median 0.70) times as long as merus; merus 4.7–5.8 (median 5.0) times as long as wide, bearing 2 or 3 strong spiniform setae on posterior margin of outer surface; ischium unarmed.

Endopod of male first pleopod (Fig. 5G) subrectangular, inner margin almost straight or slightly concave, outer margin almost straight to slightly convex, 2.40–2.70 (median 2.43) times as long as proximal wide, anterior region only feebly bent backwards, 0.65–0.80 (median 0.73) times as long as exopod; appendix interna arising from 0.65–0.70 (median 0.66) of endopod, not reaching or only feebly beyond the distal margin of endopod viz. by 0.05 of its length. Appendix masculina of male second pleopod (Fig. 5H) stout, club-shaped, 4.1–5.2 (median 4.3) times as long as wide, with long spinuliform setae on inner and distal margin, few smaller spiniform setae on basal part, 0.70–0.80 (median 0.72) times as long as endopod; appendix interna arising from 0.40–0.45 (median 0.43) and reaching to 0.70–0.80 (median 0.72) of appendix masculina.

Eggs large, few. Size of developed eggs (with eyespots) $1.00\text{--}1.07 \times 0.68\text{--}0.75$ mm in diameter; size of undeveloped eggs $0.97\text{--}1.06 \times 0.56\text{--}0.68$ mm in diameter.

Colouration: Body pinkish to orangish, scattered with red chromatophores. Posterolateral margin of carapace with a red longitudinal, bent stripe. Tergum of third somite with a red transverse stripe. Distinct red spots are present on the lateral midline of pleurites. Ovigerous females are generally more deeply pigmented.

Remarks: The new species belong to a clade within the nominal lineage of the *C. serrata* species group that is characterised by a relatively short rostrum, often relatively large distal spine on the propodus of

fifth pereopod, stout subrectangular endopod of male first pleopod and club-shaped appendix masculina of male second pleopod. Members of the clade include *C. serrata*, *C. nanaoensis*, *C. macauensis*, *C. tetrazona*, *C. trifasciata* and *C. argilla* sp. nov. (Fig. 1). *Caridina bauhينيا* sp. nov. is morphologically very similar to *C. serrata* (and its potential synonym *C. nanaoensis*, see Klotz and von Rintelen 2014) in terms of morphometrics and body pattern. The new species can be distinguished from *C. serrata* by having 1) fewer dorsal rostral teeth (6–15, median 9 vs 11–17, median 13 in *C. serrata*); 2) stouter fifth pereopod propodus and merus (10.0–12.8, median 11.1 and 4.7–5.8, median 5.0 times as long as wide vs 10.8–15.7, median 12.4 and 5.0–7.0, median 5.8 times, respectively); 3) longer endopod of male first pleopod (0.65–0.80, median 0.73 times as long as exopod vs 0.55–0.70, median 0.60 times); and 4) shorter appendix interna of male first pleopod (not reaching or only feebly beyond the distal margin of endopod vs clearly reaching beyond).

The other species of the clade, including *C. tetrazona*, *C. macauensis* and *C. trifasciata*, stand out from *C. bauhينيا* sp. nov. with their prominently banded appearance. In terms of morphometrics, *Caridina bauhينيا* sp. nov. differs from *C. tetrazona* by the 1) broader scaphocerite (2.40–2.65 times as long as wide vs 3.6 times in *C. tetrazona*); 2) third pereopod with stouter dactylus (2.4–3.0 times as long as wide vs 2.9–3.5 times) and stouter and shorter propodus (7.1–8.2 times as long as wide vs 8.4–9.7 times; 3.3–3.9 times as long as dactylus vs 4.5–4.9 times); 3) shorter fifth pereopod propodus (3.5–4.6 times as long as dactylus vs 4.7–5.1 times); 4) shorter appendix interna of male first pleopod (not reaching or only feebly beyond the distal margin of endopod vs clearly reaching beyond); and 5) presence of a median projection on the posterior margin of telson (vs absent).

Caridina bauhينيا sp. nov. can be separated from *C. macauensis* by a number of characters, including 1) broader scaphocerite (2.40–2.65 times as long as wide vs 3.9–4.2 times in *C. macauensis*); 2) first pereopod with stouter chela (1.85–2.20 times as long as wide vs 2.4–2.6 times), longer fingers (0.85–1.10 times as long as palm vs 0.67–0.85 times), and shorter and stouter merus (1.0–1.2 times as long as carpus vs 1.50–1.65 times; 2.3–2.6 times as long as wide vs 3 times); 3) second pereopod with shorter fingers (1.35–1.60 times as long as palm vs 1.8–2.2 times) and stouter carpus (4.5–5.7 times as long as wide vs 7.1–8.4 times); 4) shorter fifth pereopod merus (1.35–1.55 times as long as carpus vs 1.71–1.78 times); 5) longer endopod of male first pleopod (0.65–0.75 times as long as exopod vs 0.45–0.50 times); and 6) shorter appendix interna of male first pleopod (not reaching or only feebly

beyond the distal margin of endopod vs clearly reaching beyond).

Caridina bauhinia sp. nov. differs from *C. trifasciata* by the 1) shorter rostrum (reaching about end of basal segment of antennular peduncle vs reaching about end of second segment in *C. trifasciata*); 2) broader scaphocerite (2.40–2.65 times as long as wide vs 2.8 times); 3) slenderer first pereopod merus (2.3–2.6 times as long as wide vs 2.0–2.2 times); 4) stouter and shorter third pereopod propodus (7.1–8.2 times as long as wide vs 9.3–9.5 times; 3.3–3.9 times as long as dactylus vs 4.2–4.6 times); 5) shorter fifth pereopod propodus (3.5–4.6 times as long as dactylus vs 4.5–4.8 times); and 6) shorter appendix interna of male first pleopod (not reaching or only feebly beyond the distal margin of endopod vs clearly reaching beyond).

A comparison of selected morphological characters among *Caridina* species from the nominal lineage of the *C. serrata* species group recorded in Hong Kong is provided in table 3.

***Caridina argilla* sp. nov.**

(Fig. 6)

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Material examined: Holotype: male (pocl 4.5 mm), Pak Nai, western New Territories, Hong Kong, coll. JCF Chan, 14.VII.2022, CUHK-LMT-CAR476-6. Paratypes: 3 males (pocl 2.7–4.0 mm), 8 females (pocl 2.9–5.1 mm), 1 ov. female (pocl 5.0 mm), same collection data as holotype, CUHK-LMT-CAR476; 1 male (pocl 3.0 mm), 1 female (pocl 3.1 mm), same collection data as holotype, ZRC 2025.2037.

Etymology: Refers to the name of the type locality, Pak Nai in Hong Kong, which literally translated as “white clay”.

Description: Rostrum (Fig. 6A) straight, slightly directed downwards, slightly falling short of or reaching to the end of basal segment of antennular peduncle, tip sometimes directed slightly upwards, 0.25–0.30 (median 0.29) times poel; rostral formula 0–4 + 1–10 / 0–2. Inferior orbital angle fused with antennal spine. Pterygostomial angle rounded, subrectangular, slightly produced forward. Eyes well developed with globular cornea. Antennular peduncle 0.40–0.55 (median 0.46) times poel, basal segment 2.1–2.8 (median 2.4) times as long as second segment, second segment 1.1–1.6 (median 1.2) times as long as third segment. Stylocerite reaching to 0.00–0.55 (median 0.22) length of second segment of antennular peduncle. Scaphocerite (Fig. 6B) 2.45–2.85 (median 2.62) times as long as wide.

Sixth abdominal somite about 0.5 times poel, about as long as telson. Telson (Fig. 6C) 2.3–2.6 (median

2.4) times as long as proximal wide, with 4 or 5 pairs of short spiniform setae dorsal and one pair of short spiniform setae dorsolateral, posterior margin (Fig. 6D) convex with a median projection and 3–5 pairs of spiniform setae, sublateral pair slightly shorter than lateral and inner pairs. Preanal carina (Fig. 6E) rounded, unarmed, with few setae. Uropodal diaeresis (Fig. 6F) with 16–21 movable spiniform setae, outermost one slightly longer than lateral angle. Mouthparts not dissected, morphology and gill formula as described for *C. bauhinia* sp. nov. in external view.

First pereopod (Fig. 6G) chela 1.85–2.20 (median 2.00) times as long as wide, 1.4–1.5 (median 1.4) times as long as carpus; tips of fingers rounded, without hooks, fingers 0.70–1.00 (median 0.95) times as long as palm; carpus strongly excavated distally, 1.40–1.60 (median 1.47) times as long as wide, 0.85–1.00 (median 0.90) times as long as merus; merus 2.0–2.6 (median 2.5) times as long as wide, longer than ischium. Second pereopod (Fig. 6H) chela 2.30–2.80 (median 2.54) times as long as wide, 0.65–0.75 (median 0.73) times as long as carpus; tips of fingers rounded, without hooks, fingers 1.40–1.65 (median 1.50) times as long as palm; carpus 4.6–5.6 (median 5.2) times as long as wide, 1.05–1.15 (median 1.13) times as long as merus; merus 4.6–5.5 (median 4.9) times as long as wide, longer than ischium. Third pereopod (Fig. 6I) slender, not sexually dimorphic; dactylus (Fig. 6J) with 4–6 accessory spiniform setae on flexor margin, 2.3–3.1 (median 2.8) times as long as wide (terminal claw and accessory spiniform setae included); propodus 7.9–9.3 (median 8.8) times as long as wide, 3.5–4.3 (median 3.9) times as long as dactylus; carpus 4.2–4.9 (median 4.6) times as long as wide, 0.70–0.80 (median 0.74) times as long as propodus, 0.50–0.55 (median 0.51) times as long as merus; merus 5.2–6.3 (median 5.8) times as long as wide, bearing 3 or 4 strong spiniform setae on posterior margin of outer surface; ischium with a strong spiniform seta. Fifth pereopod (Fig. 6K) slender; dactylus (Fig. 6L) with 23–36 spinuliform setae on flexor margin, 2.3–3.1 (median 2.8) times as long as wide (terminal claw and accessory spinuliform setae included); propodus 9.8–12.7 (median 11.8) times as long as wide, 3.5–5.1 (median 4.2) times as long as dactylus; carpus 4.1–5.3 (median 4.7) times as long as wide, 0.55–0.60 (median 0.56) times as long as propodus, 0.65–0.70 (median 0.68) times as long as merus; merus 5.1–6.5 (median 5.6) times as long as wide, bearing 2 or 3 strong spiniform setae on posterior margin of outer surface; ischium unarmed.

Endopod of male first pleopod (Fig. 6M) subrectangular, inner margin slightly concave, outer margin slightly convex, 2.40–2.85 (median 2.58) times as long as proximal wide, anterior region not or

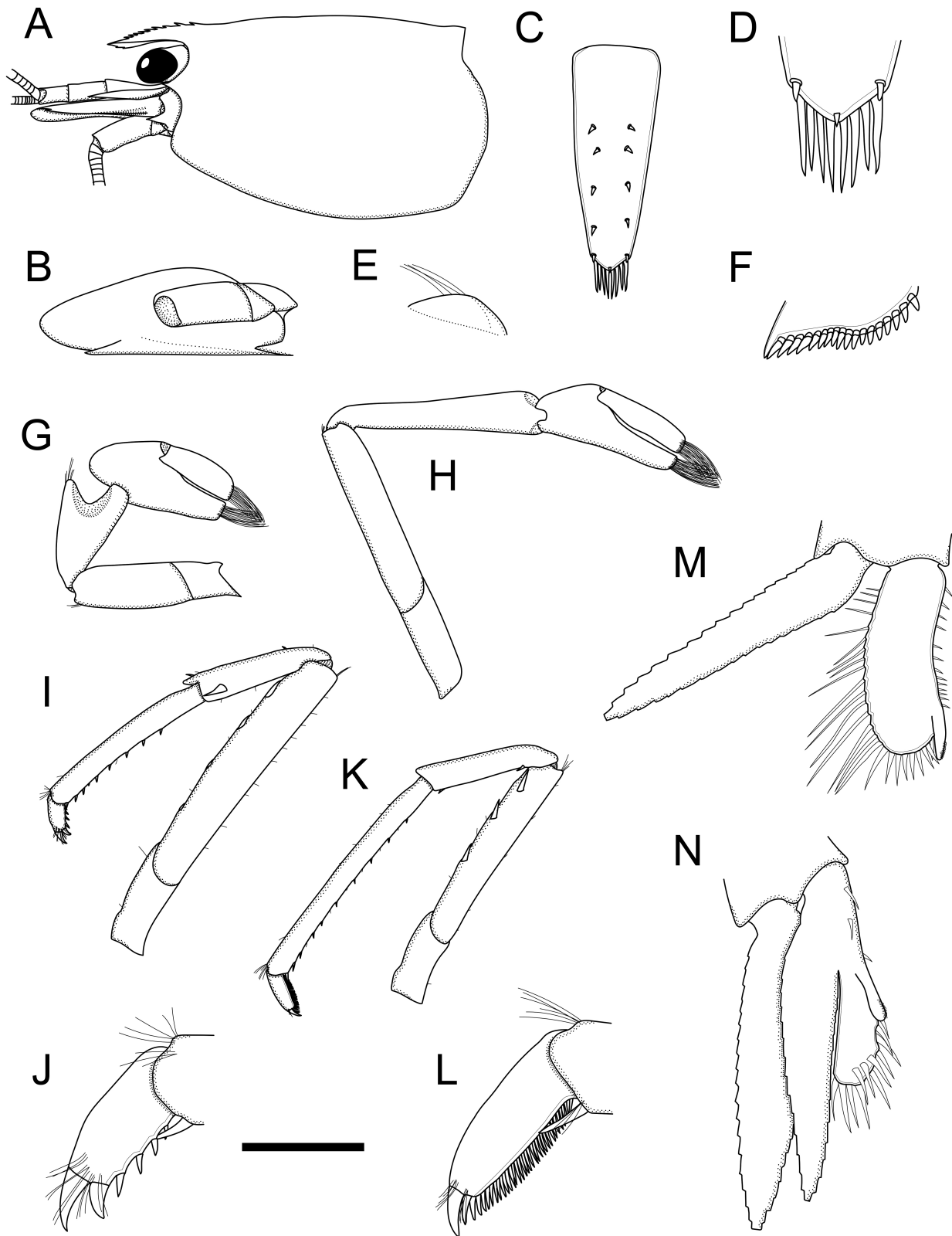


Fig. 6. *Caridina argilla* sp. nov., A–D, G–N, holotype male, poel 4.5 mm (CUHK-LMT-CAR476-6); E, F, paratype female, poel 4.8 mm (CUHK-LMT-CAR476-3). A, cephalothorax, lateral view; B, scaphocerite; C, telson; D, same, distal margin; E, preanal carina; F, uropodal diaeresis; G, first pereiopod; H, second pereiopod; I, third pereiopod; J, same, dactylus; K, fifth pereiopod; L, same, dactylus; M, male first pleopod; N, male second pleopod. Scale bars: A = 2 mm, B, C = 1.2 mm; D–F, M, N = 0.5 mm; G–I, K = 1 mm; J, L = 0.25 mm.

only feebly bent backwards, 0.65–0.80 (median 0.68) times as long as exopod; appendix interna arising from 0.70–0.75 (median 0.72) of endopod, slightly reaching beyond distal margin of endopod by 0.05–0.25 (median 0.12) of its length. Appendix masculina of male second pleopod (Fig. 6N) stout, club-shaped, 4.6–5.1 (median 4.8) times as long as wide, with long spinuliform setae on inner and distal margin, few smaller spiniform setae on basal part, 0.70–0.75 (median 0.73) times as long as endopod; appendix interna arising from 0.40–0.50 (median 0.46) and reaching to 0.70–0.80 (median 0.75) of appendix masculina.

Eggs large, few. Size of undeveloped eggs (without eyespots) $0.97\text{--}1.05 \times 0.69\text{--}0.75$ mm in diameter.

Colouration: Unknown.

Remarks: *Caridina argilla* sp. nov. is very similar to its sister species *C. bauhinia* sp. nov. (Fig. 1). Most of the morphometrics overlap between the two species, but *C. argilla* sp. nov. differs by having 1) fewer dorsal rostral teeth on carapace but more on rostrum (0–4, mode 0–1 + 1–10, mode 8 vs 2–6, mode 3–4 + 3–10, mode 6 in *C. bauhinia* sp. nov.); 2) stouter second pereopod chela (2.30–2.80, median 2.54 times as long as wide vs 2.50–3.00, median 2.76 times); 3) slenderer third pereopod propodus, carpus and merus (7.9–9.3, median 8.8 times, 4.2–4.9, median 4.6 times and 5.2–6.3, median 5.8 times as long as wide vs 7.1–8.2, median 7.6 times, 3.7–4.6, median 4.0 times and 4.4–5.6, median 5.4 times, respectively); 4) slenderer fifth pereopod carpus and merus (4.1–5.3, median 4.7 times and 5.1–6.5, median 5.6 times vs 3.7–5.2, median 4.3 times and 4.7–5.8, median 5.0 times, respectively); 5) fewer spiniform setae on the uropodal diaeresis (16–21, mode 18 vs 19–23, mode 21); and 5) longer appendix interna of male first pleopod (reaching beyond distal margin of endopod by 0.05–0.25, median 0.12 of its length vs not reaching or only feebly beyond by 0.05 of its length, cf. 0.15–0.55, median 0.43 in *C. serrata*). Morphological differences between *C. argilla* sp. nov. and other closely related species are similar to what have been described for *C. bauhinia* sp. nov.

A comparison of selected morphological characters among *Caridina* species from the nominal lineage of the *C. serrata* species group recorded in Hong Kong is provided in table 3.

DISCUSSION

To date, at least 25 species from southern China and northern and central Vietnam can be assigned to the *C. serrata* species group under the current diagnosis (Table 4). Three of the four diagnostic features listed by Cai and Ng (1999), namely the presence of dorsal

rostral teeth on carapace, appendix interna on male first pleopod and large eggs, are now recognised to be very common among the > 100 primary freshwater species from China and Vietnam. Although, for a number of these species, the ovigerous females and hence their egg sizes remain unknown, they are expected to be landlocked and produce large and few eggs. The most exclusive and indicative character of the *C. serrata* species group is probably the relatively long stylocerite viz. reaching beyond basal segment of the antennular peduncle, which excludes about 75% of the Chinese and Vietnamese landlocked species. Nevertheless, intraspecific variation may introduce an ambiguity in some species, where their individuals may usually have ‘intermediate’ stylocerite viz. reaching just to the end of the basal segment of the antennular peduncle, but a subset of them may also clearly qualify for the definition of having ‘long’ stylocerite. These species with such ‘intermediate’ stylocerite were often not considered a member of the species group (see Ng and Cai 2000 for *C. breviata* Ng & Cai, 2000). On the other hand, new information on the extent of intraspecific variation may well question the status of known members of the group (LH Chow, unpubl. data for *C. sphyrapoda*).

The genus *Caridina* is known to be polyphyletic and in need of revision (von Rintelen et al. 2012), and the species groups currently recognised will likely form a framework for establishing new genera in the future. The *C. serrata* species group is herein shown to be polyphyletic with at least four lineages (Fig. 1) and species with ‘intermediate’ or ‘short’ stylocerite viz. falling short of the end of the basal segment of the antennular peduncle, are embedded within the lineages, supporting the need for a rediagnosis of the species group to facilitate the systematic revision of *Caridina*. For example, the nominal lineage contains *C. breviata* with ‘intermediate’ stylocerite; and the second lineage includes *C. namdat* with ‘short’ stylocerite. Based on the concept of morphologically ‘validated’ molecular taxonomy (*sensu* Page et al. 2005), the nominal lineage exhibits a distinct suite of morphological characters and thus could be considered the sole members of the *C. serrata* species group in a restricted sense. Following de Mazancourt et al. (2020), a more detailed diagnosis of the *C. serrata* species group *sensu stricto* is proposed to differentiate it from the other closely related species. Information of certain characters (*e.g.*, preanal carina) is unavailable for some species from both textual descriptions and illustrations, so it can only be generalised from other species where available. Based on morphological description alone, *C. apodosis* and *C. wumingensis* Cai & Ng, 1999 are tentatively also included in the species group *sensu stricto* (Table 4).

Caridina serrata* species group *sensu stricto

Diagnosis: Body moderately robust or robust; rostrum straight, short to medium in length, at most only slightly exceeding the distal margin of scaphocerite,

armed or not on the dorsal carina, without apical teeth; antennal spine fused with inferior orbital angle; antennular peduncle about or more than half of carapace in length; stylocerite long, reaching to or beyond end of basal segment of antennular peduncle; carpus of

Table 4. List of landlocked *Caridina* species recorded from southern China (SC), and northern (NV) and central Vietnam (CV). +, species qualified into the *C. serrata* species group under the original diagnosis by Cai and Ng (1999) and the new diagnosis, respectively; +?, species with some ambiguity

Species	Distribution	<i>C. serrata</i> species group	
		Cai and Ng (1999)	<i>Sensu stricto</i> (Present study)
<i>Caridina apodosis</i>	Hong Kong (SC)	+	+
<i>Caridina argilla</i> sp. nov.	Hong Kong (SC)	+	+
<i>Caridina bamaensis</i>	Guangxi (SC)		
<i>Caridina baoting</i>	Hainan (SC)		
<i>Caridina bauhinia</i> sp. nov.	Hong Kong (SC)	+	+
<i>Caridina beiliu</i>	Guangxi (SC)		
<i>Caridina breviata</i>	Macau, Guangdong (SC)	+	+
<i>Caridina cantonensis</i>	Hong Kong, Macau, Guangdong, Guangxi (SC), Quang Nam (CV)	+	+
<i>Caridina caobangensis</i>	Cao Bang (NV)	+	
<i>Caridina cavernicola</i>	Guangxi (SC)		
<i>Caridina chui</i> sp. nov.	Hong Kong (SC)	+	+
<i>Caridina clinata</i>	Hainan (SC), Ninh Binh (NV)		
<i>Caridina conghuensis</i>	Guangdong (SC)	+	+
<i>Caridina cucphuongensis</i>	Ninh Binh (NV)	+	
<i>Caridina danxiaensis</i>	Guangdong (SC)	+	
<i>Caridina guangxiensis</i>	Guangxi (SC)	+	
<i>Caridina guilin</i>	Guangxi (SC)		
<i>Caridina haivanensis</i>	Thua Thien-Hue (CV)		
<i>Caridina huananensis</i>	Guangdong (SC)		
<i>Caridina lanceifrons</i>	Widespread in SC, NV and CV		
<i>Caridina laticarpalis</i>	Guangxi (SC)		
<i>Caridina logemanni</i>	Hong Kong (SC)	+	+
<i>Caridina macauensis</i>	Macau (SC)	+	+
<i>Caridina maculata</i>	Guangdong (SC)	+	
<i>Caridina mariae</i>	Guangdong (SC)	+	+
<i>Caridina namdat</i>	Bac Kan (NV)		
<i>Caridina nanaoensis</i>	Guangdong (SC)	+	+
<i>Caridina ngankeae</i>	Hong Kong (SC)	+	
<i>Caridina nguyeni</i>	Cao Bang (NV)	+	
<i>Caridina pacbo</i>	Cao Bang (NV)	+	
<i>Caridina pseudoserrata</i>	Cao Bang (NV)	+	
<i>Caridina qingyuanensis</i>	Guangdong (SC)		
<i>Caridina rubropunctata</i>	Thai Nguyen (NV)	+	
<i>Caridina serrata</i>	Hong Kong, Guangdong (SC), Quang Nam (CV)	+	+
<i>Caridina sphyrapoda</i>	Guangxi (SC)	+	
<i>Caridina spinicrus</i>	Guangxi (SC)		
<i>Caridina stellata</i>	Guangxi (SC)	+	
<i>Caridina tetrazona</i>	Guangdong (SC)	+	+
<i>Caridina thachlam</i>	Ninh Binh (NV)		
<i>Caridina tricincta</i>	Tuyen Quang, Ha Giang (NV)	+	
<i>Caridina trifasciata</i>	Hong Kong, Guangdong (SC)	+	+
<i>Caridina venusta</i>	Guangdong (SC)		
<i>Caridina wumingensis</i>	Guangxi (SC)	+	+
<i>Caridina zhongshanica</i>	Guangdong (SC)	+	

first pereopod deeply excavated distally (usually < 1.6 times as long as wide); walking legs stout, not sexually dimorphic; dactyli of third and fifth pereopod with moderate number of accessory spiniform setae on flexor margin (≤ 7 and ≤ 45 respectively); sixth abdominal somite short (around half of carapace length); preanal carina without a spine; telson with moderate number of robust spiniform terminal setae (3–5 pairs) without chitinous plug; uropodal diaeresis with large number of spiniform setae (≥ 14); endopod of male first pleopod subrectangular or subtriangular, inner margin not abruptly incised, at least about half as long as exopod but not markedly elongated (≤ 3.2 times as long as proximal wide), appendix interna subdistal; appendix masculina of male second pleopod club-shaped (usually < 5.5 times as long as wide), not reduced nor elongated (more than half as long as endopod but not reaching close to or beyond its distal margin).

Compared to the other lineages of the *C. serrata* species group *sensu* Cai and Ng (1999), the *C. serrata* species group *sensu stricto* differs in several morphological characters. The second lineage and the singleton species of the species group *sensu* Cai and Ng (1999), together with most of the other primarily Vietnamese species with ‘short’ or ‘intermediate’ stylocerite are morphologically the closest to the nominal lineage. Apart from the relative length of stylocerite, these species differ mainly from the *C. serrata sensu stricto* in the stoutness of the appendix masculina of male second pleopod which is usually > 5.5 times as long as wide in the former. *Caridina caobangensis* from the third lineage, by having a morphology resembling other Vietnamese species, similarly differs from the *C. serrata* species group in the form of the appendix masculina. In contrast, *C. sphyrapoda*, also from the third lineage, resembles more some species from Guizhou Province, western China, in particular the stygobitic *C. incolor* Feng, Chen & Guo, 2021 and *C. caverna* Liang, Chen & Li, 2005. Compared to the *C. serrata* species group *sensu stricto*, *C. sphyrapoda* is different in its slenderer carpus of first pereopod, fewer number of spiniform setae on uropodal diaeresis and shorter endopod of male first pleopod. The fourth lineage, despite occurring in the same region as the *C. serrata* species group *sensu stricto*, they are grouped with species from Guizhou Province instead in the current phylogenetic analyses and bear a slight likeness to species from the nearby Hunan and Jiangxi provinces. They are distinctive from the *C. serrata* species group *sensu stricto* in their shorter rostrum, larger number of spinuliform setae on flexor margin of fifth pereopod dactylus, and slenderer endopod of male first pleopod and appendix masculina of male second pleopod.

Although the *C. serrata* species group *sensu stricto* would likely be valid on its own, its potential phylogenetic position at the crown might pose a systematic issue for congeners. This is especially so for the morphologically similar, primarily Vietnamese species, which form part of the stem group of the *C. serrata* species group *sensu stricto*. Given that these Vietnamese species are distributed across lineages in the phylogeny, if the species group *sensu stricto* was to be expanded to include these morphologically similar congeners, this would introduce a large degree of morphological variation by including some deviants (e.g., *C. sphyrapoda*, *C. namdat*). Therefore, it is possible, from a more comprehensive analyses in the future that most of the Chinese and Vietnamese species would need to be considered in the same species group in a broad sense. In fact, this assemblage exhibits a combination of morphological characters that is distinctive from other congeners, including the non-depressed rostrum; the distally excavated, relatively stout carpus of first pereopod (viz. usually < 2 times as long as wide, at most about 2.5 times); the relatively short carpus of second pereopod compared with merus (viz. subequal to or at most 0.2 times longer); the non-sexually dimorphic walking legs; telson with moderate number of robust spiniform terminal setae (viz. 3–6 pairs); and the relatively large endopod of male first pleopod (viz. at least half as long as exopod except in some subterranean species) with the presence of appendix interna. Future efforts to resolve the *C. serrata* species group relies on a more comprehensive phylogeny considering 1) all Chinese and Vietnamese landlocked *Caridina* species, 2) other closely related genera including *Paracaridina*, *Neocaridina* and *Sinodina*, and 3) the phylogenetic position of this assemblage with respect to the other *Caridina* species/species groups and genera of the *Caridella* group (*sensu* von Rintelen et al. 2012). An updated key to the recognised species groups of *Caridina* with reference to de Mazancourt et al. (2020 2023) is provided below.

Key to the recognised species groups of *Caridina*

1. Many (usually > 6) dorsal rostral teeth situated on carapace behind orbital margin; a long stylocerite, reaching at least the beginning of the second segment of antennular peduncle *C. serratirostris* species group
- Few (usually < 6) dorsal rostral teeth situated on carapace behind orbital margin; a long or short stylocerite 2
2. Few (6–10) spiniform setae on uropodal diaeresis; a very long and upcurved rostrum with few (5–9), widely spaced dorsal teeth *C. gracilirostris* species group
- Usually many (8–22) spiniform setae on uropodal diaeresis; a long or short rostrum with closely set dorsal teeth 3
3. Endopod of male first pleopod not reduced in size 4
- Endopod of male first pleopod reduced in size 5

4. Long stylocerite, usually reaching beyond end of the basal segment of antennular peduncle; many (15–24) spiniform setae on uropodal diaeresis *C. serrata* species group
- Short stylocerite, usually falling short of the end of the basal segment of antennular peduncle; relatively fewer (10–18) spiniform setae on uropodal diaeresis *C. yunnanensis* species group
5. Relatively more (14–22) spiniform setae on uropodal diaeresis; rostrum short, armed or not; preanal carina high, unarmed 6
- Relatively few (8–17) spiniform setae on uropodal diaeresis; rostrum variable in shape and length; preanal carina low, armed or not 7
6. Telson with numerous and very long plumose intermediate setae at posterior margin *C. weberi* species group
- Telson with few long intermediate setae at posterior margin *C. typus* species group
7. Carpus of first pereopod stout and deeply excavated; without subapical teeth on the rostrum *C. brevicarpalis* species group
- Carpus of first pereopod slender and not deeply excavated; with subapical teeth on the rostrum *C. nilotica* species group

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