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Caridina longirostris and allied species

V. de Mazancourt *et al.*

Integrative taxonomy helps separate four species of freshwater shrimps commonly overlooked as *Caridina longirostris* (Crustacea : Decapoda : Atyidae) on Indo-West Pacific islands

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Caridina longirostris H. Milne Edwards, 1837 described from specimens supposedly from La Macta River near Oran, Algeria, is an emblematic species of the '*C. nilotica* complex'. Until now this species was thought to have a wide distribution in the Indo-Pacific region. Recently, numerous specimens identified as *C. longirostris* were collected from various Indo-West Pacific localities. In the context of integrative taxonomy, both old and newly collected specimens were morphologically and genetically studied. Four species allied to *C. longirostris* are here identified: *C. appendiculata* Jaliha & Shenoy, 1998, *C. brevidactyla* Roux, 1920, *C. gracilipes* De Man, 1892 and *C. meridionalis* Roux, 1926. Detailed re-descriptions of these four species are given as well as their geographical and ecological distributions. *Caridina nilotica* var. *brevidactyla* is revalidated as the species *C. brevidactyla*, and *C. coulalorensis* Richard & Clark, 2014, *C. fritzi* Richard & Clark, 2014 and *C. solamulieres* Richard & Clark, 2014 are considered junior synonyms of *C. meridionalis*. The position of these species in the troublesome '*C. nilotica* complex' is clarified and some species are synonymised. A key is provided to facilitate identification.

Additional keywords: Indo-Pacific region, morphology, 16S rRNA.

TOC abstract: *Caridina longirostris* is a species of freshwater shrimp formerly thought to be widespread in the Indo-Pacific area, but as new specimens were collected, the validity of this species was questioned for most of the localities. Combined morphological and molecular analyses showed that *C. longirostris* is absent from the Indo-Pacific area and that there are four different species previously confused with it in the region. This study helped resolving part of the taxonomic confusion surrounding the *C. nilotica* complex.

Introduction

One of the aims of the Muséum national d'Histoire naturelle (MNHN), Paris, is to undertake faunistic inventories of rivers on tropical islands in order to establish better protection of these fragile ecosystems and, in this context, to clarify taxonomy of poorly known species. The freshwater shrimp *Caridina* H. Milne Edwards, 1837, comprising 302 valid species (World Register of Marine Species

database as of June 2018) and mainly present in the Indo-Pacific region, is the most diversified genus of the Atyidae (De Grave *et al.* 2015) and an important ecological component in tropical streams (Pringle *et al.* 1993; Covich *et al.* 1999). Their high diversity combined with the lack of informative morphological characters has led to a confused taxonomy (Richard and Clark 2009). Indeed, until recently their taxonomy was mainly based on morphological characters. Some have been proven highly variable within a species (e.g. rostrum shape and indentation or colouration; de Mazancourt *et al.* 2017) and therefore taxonomically non-informative, making it difficult to establish speciation (von Rintelen and Cai 2009). There is thus a need for an integrative and standardised approach to improve the systematics of the group, focusing on informative morphological features and using molecular characters (Page *et al.* 2005; Page and Hughes 2011).

To illustrate this problem, we here focus on *Caridina longirostris* H. Milne Edwards, 1837, a species belonging to the troublesome ‘*C. nilotica* complex’, described in 1837 by H. Milne Edwards from specimens from La Macta River, near Oran, Algeria. The taxonomic complexity within *Caridina* has led previous authors to create groups of species based on shared morphological characters. For example, Bouvier (1925) defined five species-groups: *C. nilotica*-group, *C. laevis*-group, *C. africana*-group, *C. brevirostris*-group and *C. typus*-group. Some of these have been further divided as new species were described, such as the *C. serrata*-group (Cai and Ng 1999; Karge and Klotz 2007), *C. gracilirostris*-group (Cai and Ng 2007a) and *C. weberi*-group (Cai and Anker 2004; Cai *et al.* 2009), while others still exist, such as the *C. nilotica* and *C. typus* groups (Karge and Klotz 2007). According to Bouvier (1925), the *C. nilotica*-group is characterised by the following: (1) antennular peduncles usually equal or exceed three-quarters of the carapace and the sixth abdominal segment by two-thirds; (2) rostrum usually long, curved upwards; (3) uropodal diaeresis with 8–10 short spiniform setae. Until 1900, *C. longirostris* was one of eight species belonging to the ‘*C. nilotica* complex’ that now includes 22 different taxa (Karge and Klotz 2007).

Caridina longirostris has been reported as a widely distributed species ranging from the Indian Ocean including Madagascar (Holthuis 1965) and Reunion Island (Keith *et al.* 2006) and the West Pacific Ocean including New Caledonia (Holthuis 1969; Choy and Marquet 2002; Marquet *et al.* 2003), Fiji (Choy 1991), Vanuatu (Keith *et al.* 2010), Australia (Page *et al.* 2007), Papua New Guinea (Short 2009), Pohnpei (Maciolek and Ford 1987), Sumba (Holthuis 1978), Philippines (Chace 1997) and Taiwan (Hung *et al.* 1993). However, this species does not occur in the Central Pacific (Keith and Marquet 2011, 2013).

Numerous *Caridina* specimens were collected from New Caledonia by the Pedcal Expedition in 1991 and by Chloe Expeditions between 1997 and 2002. Similarly, rivers on the islands of Efate, Santo and Malekula (Vanuatu) were sampled in July 2003 and November 2008 by the Vanuatu Environment Unit and the MNHN. Part of this material was identified as *C. longirostris* (Marquet *et al.* 2003; Keith *et al.* 2010). More recently, additional specimens identified as *Caridina longirostris*

were collected during trips to Micronesia including Babeldaob, Palau, (in February and March 2011) and Pohnpei (in March 2012) and Melanesia including Taveuni, Fiji, in February 2013; Efate and Epi, Vanuatu, in November 2014; Aneityum, Vanuatu, in June 2015; Choiseul in October 2014, Kolombangara in November 2015 and Vella Lavella in October 2016, all Solomon Islands, and New Caledonia in September and November 2016 and November 2017.

Therefore, the aim of the present study was to combine morphological data with a 16S rRNA analysis, so using integrative taxonomy re-examine all old (1991–2008) and recent (2011–2017) specimens from Micronesia and Melanesia and material deposited in five museums to establish the distribution of *C. longirostris*.

Materials and methods

Abbreviations for museums

Muséum national d'Histoire naturelle, Paris (MNHN); Naturhistorisches Museum Basel, Basel, Switzerland (NMB); Museum für Naturkunde, Berlin, Germany (ZMB); Rijksmuseum van Natuurlijke Historie (now in the Naturalis Biodiversity Center, Leiden, Netherlands) (RMNH); Zoölogisch Museum Amsterdam (now in the Naturalis Biodiversity Center, Leiden, Netherlands) (ZMA); Bernice Pauahi Bishop Museum, Honolulu, Hawaii (BPBM); Werner Klotz's collection, Rum, Austria (WK).

Morphological comparison

The rostrum, the general cephalon, pereopods 1, 2, 3 and 5, and the abdomen were observed using a stereoscopic microscope. The proportions of the various joints of the appendages were measured using microphotographs and the AnalySIS Works software (Olympus). Drawings were made using the 'Digital Inking' method (Coleman 2003, 2006) by tracing vectorial paths on high-resolution photographs using Adobe Illustrator (CS6) and a WACOM MPTZ–1230 graphic tablet.

Abbreviations for morphological analyses

The following abbreviations are used in the present text: cl, carapace length (mm) measured from the post-orbital margin to the posterior margin of the carapace; P1, first pereopod; P2, second pereopod; P3, third pereopod; P5, fifth pereopod; Pl1, first male pleopod; Pl2, second male pleopod.

DNA extraction, amplification and sequencing

For recent specimens, DNA was extracted from abdominal tissues using the semi-automatic Eppendorf ep-Motion 5075 robot. Fragments of the mitochondrial 16S rRNA (~520 bp) were amplified using newly designed primers, adapted from Palumbi (1996) to our taxa: 16Sar-Lmod (TACTTCTGCCTGTTTATCAAAAA) and 16Sbmod (GGTCTGAAC TCAAATCATGTAAA). DNA amplification was performed in 20-μL PCR reactions containing ~3 ng of template DNA, 2.5 mM of MgCl₂, 0.26 mM of each nucleotide, 0.3 μM of each primer, 5% DMSO, 1 ng of BSA and 1.5

units of QBIOTAQ polymerase (MP Biomedicals, Santa Ana, CA, USA). Amplification products were generated by an initial denaturation step of 4 min at 94°C followed by 35 cycles of denaturation at 94°C for 30 s, annealing at 52°C for 40 s, extension at 72°C for 60 s and a final extension step at 72°C for 7 min.

For old collection specimens (types and non-types of *C. appendiculata* Jaliha & Shenoy, 1998, *C. brachydactyla* De Man, 1908, *C. brevidactyla* Roux, 1920, *C. coulalorensis* Richard & Clark, 2014, *C. gracilipes* De Man, 1892, *C. fritzi* Richard & Clark, 2014, *C. longirostris*, *C. meridionalis* Roux, 1926, *C. peninsularis* Kemp, 1918 and *C. solamulieres* Richard & Clark, 2014) a CTAB protocol was used to extract DNA from pleopods. A shorter fragment of the 16S rRNA (332 bp) was amplified using the primers 16S-Car-81F (AGGTAGCATAATAAATAGTC) and 16S-Car-413R (CTGTTATCCCTAAAGTAAC) (de Mazancourt *et al.* 2018). If these primers could not amplify successfully, another reverse primer was used to try to amplify a shorter fragment (141 bp): 16S-Car-222R (CTTTATAGGGTCTTATCGT). DNA amplification was performed in 20-μL PCR reactions containing 2.5 of mM MgCl₂, 0.26 mM of each nucleotide, 0.3 μM of each primer, 1 ng of BSA and 1.5 units of QBIOTAQ polymerase (MP Biomedicals). Amplification products were generated by an initial denaturation step of 4 min at 94°C followed by 45 cycles of denaturation at 94°C for 30 s, annealing at 55°C for 30 s, extension at 72°C for 40 s and a final extension step at 72°C for 7 min.

PCR products were sequenced using the same primers and in both directions to ensure the accuracy of base calls. Chromatograms were edited using Geneious v. 8 software (<http://www.geneious.com/> Kearse *et al.* 2012). All sequences were deposited in GenBank (numbers MH497484 to MH497558).

Molecular analyses

DNA sequences were aligned using MEGA7 software (Kumar *et al.* 2016) with the Muscle algorithm (Edgar 2004). Using the Bayesian information criterion in jModelTest (Guindon and Gascuel 2003; Darriba *et al.* 2012) we retained the GTR + G model. Best-scoring maximum likelihood (ML) trees were estimated using RAxML HPC2 v. 8.2.10 (Stamatakis 2014) and best-scoring Bayesian inference trees were estimated using MrBayes v. 3.2.6 (Ronquist and Huelsenbeck 2003). Both methods were implemented in the Cyber Infrastructure for Phylogenetic Research (CIPRES) portal with the previously determined model, running for 10 000 000 generations with a sampling frequency of 2000 and a burn-in of 25%. Support for nodes was determined using posterior probabilities calculated by MrBayes implemented in the CIPRES portal v. 3.1. (Miller *et al.* 2010; <https://www.phylo.org/>). One hundred independent searches were conducted, each starting from distinct random trees. Robustness of the nodes was assessed using non-parametric bootstrapping (Felsenstein 1985) with 1000 bootstrap replicates. We considered a group to be ‘moderately supported’ if it had a bootstrap support value (B) between 75% and 89% and ‘highly supported’ if B ≥ 90%. For the analysis, 11 recent specimens of *C. brevidactyla* from different localities were selected and two sequences retrieved from GenBank, four

recent specimens of *C. leucosticta* from Okinawa and mainland Japan, four specimens of *C. grandirostris* from Taiwan and Okinawa, three recent specimens from Sulawesi, one old collection specimen from Bali and one sequence retrieved from GenBank for *C. brachydactyla*, 11 recent specimens from different localities, four type specimens from Sulawesi, one old collection specimen from Flores and two sequences retrieved from GenBank for *C. gracilipes*, five type specimens for *C. coulalorensis*, two type specimens for *C. fritzi*, six recent specimens and one sequence retrieved from GenBank for *C. meridionalis*, 22 specimens from different localities for *C. appendiculata*, two sequences of *C. sp. indistincta* E retrieved from GenBank and, finally, one old collection specimen of *C. longirostris* from Fiji (see details in Table 1).

Results

Molecular results

Due to their old age, DNA could not be extracted with sufficient quantity and quality using our method for the type specimens of *C. appendiculata*, *C. brachydactyla*, *C. brevidactyla*, *C. longirostris*, *C. meridionalis*, *C. peninsularis* and *C. solamulieres*; thus, no 16S sequence was amplified for these specimens. However, the approach was successful for type specimens of *C. coulalorensis*, *C. fritzi*, *C. gracilipes* and non-type specimens of *C. brachydactyla* from Indonesia and *C. 'longirostris'* from Fiji. Furthermore, we tried to obtain recent specimens from as close as possible to the type locality for *C. brachydactyla* (Palopo, Sulawesi, Indonesia) and *C. meridionalis* (New Caledonia). The genetic analysis shows seven well-defined clades (Fig. 1). The first clade (Clade A in Fig. 1) is well supported in the Bayesian analysis (PP = 1) and comprises all the specimens identified as *C. brevidactyla* and a specimen referred to as *C. longirostris* from Fiji. All the others are grouped in a clade sister-group to *C. brevidactyla* (Clade A). This clade is partially unresolved with a polytomy comprising a clade with the specimens of *C. leucosticta* (Clade B, PP = 1; B = 100), another with the specimens of *C. grandirostris* and a GenBank sequence of a specimen referred to as *C. brachydactyla* (Clade C, PP = 0.98; B = 94) and a third with all the remaining specimens. This third clade, well supported in the Bayesian analysis (PP = 0.99), is composed of two clades, each divided into two. On one side, a clade composed of recent and old specimens of *C. brachydactyla* (Clade D, PP = 1; B = 100) is sister-group to another with recent, old and type specimens of *C. gracilipes* (Clade E, PP = 1; B = 100). On the other side, a clade composed of recent specimens of *C. meridionalis*, type specimens of *C. coulalorensis* and type specimens of *C. fritzi* (Clade F, PP = 0.77; B = 76) is sister-group to the specimens of *C. appendiculata* and two specimens referred to as *C. indistincta* E altogether (Clade G, PP = 1; B = 90).

Morphological study

The morphological examination of many specimens previously identified as *C. longirostris* from different localities allowed five species to be distinguished with support from the molecular data (Fig.

1): *C. longirostris*, *C. appendiculata* (Clade G), *C. brevidactyla* (Clade A), *C. gracilipes* (Clade E) and *C. meridionalis* (Clade F). An identification key and the diagnoses of these five species are given below.

Discussion

This study provided molecular data from old type specimens of *C. gracilipes*, *C. coulalorensis* and *C. fritzi*, which will help to stabilise the taxonomy of this group. Indeed, the position of the type specimens of *C. gracilipes* in this phylogenetic analysis (**Fig. 1**) allowed the assignment of other specimens to this species.

Jean Roux (1926a) described *C. nilotica meridionalis* from seven localities in New Caledonia. These type specimens have been separated by Richard and Clark (2014) into five species: *C. meridionalis*, *C. peninsularis* and three new species: *C. coulalorensis*, *C. fritzi* and *C. solamulieres*. Numerous specimens were collected in New Caledonia by the Pedcal Expedition in 1991, by Chloe Expeditions between 1997 and 2002, by two authors (VM and GM) in September 2016 and by one author (VM) in November 2016 and November 2017. By examining them and considering the molecular results (Clade F, **Fig. 1**), *C. coulalorensis*, *C. fritzi* and *C. solamulieres* are considered junior synonyms of *C. meridionalis*. Indeed, specimens captured near the estuary show a long rostrum with a distal unarmed end characteristic of *C. coulalorensis*, whereas specimens captured in middle courses of rivers possess a shorter rostrum with teeth present on the dorsal margin to the tip characteristic of *C. meridionalis* or *C. fritzi*. The single specimen of *C. solamulieres* would be an aberrant specimen of *C. meridionalis*, with an unusually short rostrum. Indeed, when visiting the type locality, no specimen with this morphology was found.

Some specimens that were incorrectly identified before their sequence was submitted to GenBank can now be attributed to the correct species. RMNH.CRUS.D.54674 from Fiji, identified as '*C. longirostris*', was nested within our *C. brevidactyla* specimens. Furthermore, the GenBank sequence DQ478528, attributed to '*C. brachydactyla*' and collected in Bali, is *C. grandirostris*, together with sequences of '*C. indistincta E*' from Australia that are assigned to *C. appendiculata*. Some sequences, however, provided valuable information about the geographical range of species, such as the two sequences of *C. brevidactyla* from specimens collected in Papua New Guinea, a locality not sampled in the present study.

The shorter DNA fragments obtained for old collection specimens introduced a significant amount of missing data to the matrix, which explains the lower support values in the tree for some of the clades that contained such sequences. However, the analyses made without the short sequences yielded the same topology.

The analysis was made from a single marker, 16S rRNA. In these conditions, the phylogenetic relationships shown in the tree are to be considered with caution. Using more markers and combining

mitochondrial and nuclear data would generate more resolved and supported trees. However, this analysis showed that the species are distinct, each clearly separated from the others, a result unlikely to be disproved by further analyses.

The C. nilotica complex

Taxa assigned to the '*C. nilotica* complex' display incredible morphological variation between populations of the same species, so the characters given here take into account this intra-specific variability. Some characters frequently used to separate *Caridina* species are (1) the rostrum, (2) the proportions between the joints of pereiopods, (3) the presence or absence of an appendix interna on the endopod of the first male pleopod, (4) the presence of a postero-median projection at the distal margin of the telson, (5) a pre-anal carina with or without a spine, and (6) the size of eggs. Generally, species should be discriminated based on a combination of characters instead of only one. All the species treated in the present study are part of this complex that we consider to be biologically valid and not only an artificial group, as [Bouvier \(1925\)](#) meant it to be. Shared morphological characters are indeed present, such as the slender morphology, with a mostly long rostrum (longer than the antennular peduncle), the antennal spine ventral to the inferior orbital angle, a long antennular peduncle (subequal to carapace length), long leg segments, a typical dorsal hump over the third abdominal somite, a long sixth abdominal somite (always more than half of carapace length), a small pre-anal carina bearing sometimes an acute spine, a moderate number of spinules on the uropodal diaeresis (<15), few medium to short-terminal simple setae on the telson and a rounded endopod of the first male pleopod with or without an appendix on the subdistal outer margin or even placed at the distal end.

The rostrum

The rostrum length plasticity in atyid shrimps ([Jugovic et al. 2010](#)) is, according to [de Mazancourt et al. \(2017\)](#), linked to the environment. In the present study, specimens of *C. meridionalis* captured near the estuary showed a long rostrum with a remarkable proportion of the rostrum unarmed between proximal and apical teeth, while specimens caught in the middle course of rivers showed a shorter rostrum with teeth present on the dorsal margin to the tip. But, the number of teeth and their placement on the rostrum ([Richard and Clark 2014](#)) remain important identification characters. For example, *C. appendiculata* was moved by [Cai and Ng \(2007a\)](#) from the *C. gracilirostris* species-group to the *C. nilotica* species-group due to the presence of post-orbital teeth on the rostrum, a diagnostic character of this group. Indeed, *C. appendiculata* (1–3), *C. longirostris* (1–2), *C. brevidactyla* (1–3), *C. gracilipes* (1–2) and *C. meridionalis* (1–3) have post-orbital teeth like all *C. nilotica*-group species. *Caridina neglecta*, however, is maintained in its original species-group because it does not possess post-orbital teeth, a diagnostic character of species in the *C. gracilirostris*-group. The rostrum always has some subapical teeth: one for *C. longirostris*, 1–2 for *C. gracilipes*,

and 1–3 for *C. appendiculata*, *C. brevidactyla* and *C. meridionalis*. The number of dorsal teeth on the rostrum is greater for *C. brevidactyla* (16–30), lower for *C. appendiculata* (12–18) and *C. longirostris* (14–17), and intermediate for *C. gracilipes* (12–23) and *C. meridionalis* (16–26). The number of dorsal teeth on the rostrum before the first ventral tooth is greater for *C. brevidactyla* (11–15), *C. gracilipes* (9–15) and *C. meridionalis* (10–15), and lower for *C. appendiculata* (8–12) and *C. longirostris* (9–12).

The proportions between pereopod joints

In our study, P1 and P2 carpus length (respectively 1.4–1.8 and 4.0–4.2) was used to distinguish *C. longirostris* from all the other studied species. It is greater for *C. brevidactyla* (2.5–3.6 and 5.6–7.5), *C. appendiculata* (1.9–2.8 and 4.4–6.3), *C. gracilipes* (1.7–2.6 and 4.4–6.3) and *C. meridionalis* (2.3–3.5 and 4.1–6.2).

The presence or the absence of an appendix interna on the endopod of the male first pleopod

We agree with [Richard and Clark \(2005\)](#) that identifying species based on the presence or absence of appendix interna seems unwarranted. For example, in *C. gracilipes* the appendix interna on the endopod of the male first pleopod can be present or absent (pers. obs.). However, *C. appendiculata*, *C. brevidactyla* and *C. meridionalis* always show an appendix interna, unlike *C. longirostris* in which it is always absent. The presence or absence of the appendix interna in adult specimens could be linked to seasonal variation, depending on the breeding period. During winter, when conditions are less favourable, the appendix interna may disappear and then grows again when the temperatures rise in summer. This could explain the absence of this organ in *C. longirostris*, as the species is known from a single collecting event supposedly during winter (see below) in an area where seasonality is more marked than the rest of the geographical range of *Caridina* (Egypt). However, ovigerous females are common among the type material of *C. longirostris*, raising doubts about the breeding condition of this population, or even this species during winter. Similarly, in *C. gracilipes*, in our material, males without appendix interna were found along with ovigerous females. Furthermore, what would be the evolutionary advantage of reducing and growing the appendix interna several times during the life of the animal? Would some species be able to breed without it? Further investigation should be made to understand the mechanisms of gain and loss of this feature in species where its presence is variable such as *C. gracilipes*.

The telson

The telsons of *C. appendiculata*, *C. brevidactyla*, *C. longirostris* and *C. gracilipes* have a posterior margin ending in a median point. *Caridina meridionalis*, however, is variable in that the posterior margin of the telson does not always end in a medial point. Although the median point is absent in *C. longirostris*, the posterior margin of the telson is sharply triangular compared with relatively triangular in the other species.

The pre-anal carina spine

Caridina appendiculata, *C. gracilipes*, *C. meridionalis* and *C. longirostris* all possess a spine on the pre-anal carina, which is absent in *C. brevidactyla*. This character is regarded as a significant character.

Egg size

Although all studied species were considered to have small eggs, their size is regarded as a significant character. *Caridina meridionalis* had the largest eggs at $0.34\text{--}0.75 \times 0.24\text{--}0.48$ mm, then intermediate for *C. brevidactyla* ($0.37\text{--}0.47 \times 0.22\text{--}0.30$ mm), *C. appendiculata* ($0.38\text{--}0.46 \times 0.23\text{--}0.28$ mm) and *C. gracilipes* ($0.32\text{--}0.46 \times 0.18\text{--}0.27$ mm), and smallest for *C. longirostris* ($0.33\text{--}0.39 \times 0.21\text{--}0.26$ mm). However, *C. meridionalis* eggs were smaller near the estuary and larger in the middle course of rivers. Also, differences in egg size between riverine and lacustrine specimens were reported for *C. gracilipes* (Han *et al.* 2011).

Distribution (Fig. 2)

The present study considers that *C. longirostris* is not present in the following localities.

Micronesia

This species was reported by Leberer and Nelson (2001) from Guam and Pohnpei by Maciolek and Ford (1987). Recently, a new species, *C. variabilis* de Mazancourt, Rogers & Keith, 2018, was described from Palau and Guam and another from Pohnpei currently under consideration (de Mazancourt *et al.* in press).

Melanesia

Short (2009) described *C. longirostris* with a rostral formula (5–30/2–22 vs 14–17/10–15) and P1 carpus (2–3 times longer than broad vs 1.4–1.8), which suggests that this species does not occur in the Mimika Region, New Guinea. Three allied species occur in the Solomon Islands including *C. appendiculata* (Kolobangara), *C. brevidactyla* (Choiseul, Kolobangara, Vella Lavella) and a new species. *Caridina longirostris* has been confused in Vanuatu (Keith *et al.* 2010) until now with *C. appendiculata* or *C. brevidactyla*, in New Caledonia (Holthuis 1969; Choy and Marquet 2002; Marquet *et al.* 2003) with *C. brevidactyla* and *C. meridionalis* J. Roux, 1926, and in Fiji (Choy 1991) with *C. brevidactyla*.

Australia

According to Page *et al.* (2007), *C. longirostris* does not occur in Australia. Specimen DQ478497 identified as *C. gracilirostris* from north Johnstone River is in fact *C. gracilipes*.

West Pacific

The report of Chace (1997) from the Philippines is either *C. elongapoda* Liang & Yan, 1977 or *C. gracilipes* (see Cai and Shokita 2006). The specimens reported by Holthuis (1978) from Sumba and by Schenkel (1902) from Sulawesi (Indonesia) and Taiwan by Hung *et al.* (1993) are *C. gracilipes*. The latter species is a common atyid shrimp in fresh and brackish waters of Taiwan (Ueno 1935; Yu 1974; Shy and Yu 1998; Cai and Shokita 2006). Characters described by Hung *et al.* (1993) are 14–24 dorsal teeth on rostrum (13–20 in *C. gracilipes* vs 14–17 in *C. longirostris*), P1 carpus more than two times as long as wide (1.7–3.4 in *C. gracilipes* vs 1.4–1.8 in *C. longirostris*), P2 carpus more than five times as long as wide (4.4–6.4 in *C. gracilipes* vs 3.9–4.7 in *C. longirostris*).

In summary, *C. longirostris* is not present in Indo-West Pacific islands but some morphologically close species were identified: *C. appendiculata*, *C. brevidactyla*, *C. gracilipes* and *C. meridionalis* (see Fig. 2 for the distribution range of these species).

Key for the studied species

- 1.1 Pre-anal carina without spine.....*C. brevidactyla*
- 1.2 Pre-anal carina with spine.....2
- 2.1 P1 carpus mostly 1.7–1.8 times as long as wide and P2 carpus mostly 3.9–4.2 as long as wide.....*C. longirostris*
- 2.2 P1 carpus mostly 1.9–3.6 times as long as wide and P2 carpus mostly 4.3–6.5 as long as wide.....3
- 3.1 Relatively large eggs $0.34\text{--}0.75 \times 0.24\text{--}0.48$ mm; telson mostly rounded without a median process.....*C. meridionalis*
- 3.2 Small eggs $0.32\text{--}0.47 \times 0.18\text{--}0.30$ mm; telson always with posterior margin triangular, ending in a posteromedian projection.....4
- 4.1 P3 propodus mostly 4.6–7.1 times as long as dactylus, P5 propodus mostly 4.5–6.2 times as long as dactylus.....*C. appendiculata*
- 4.2 P3 propodus mostly 3.5–4.5 times as long as dactylus, P5 propodus mostly 3.3–4.2 times as long as dactylus.....*C. gracilipes*

Taxonomy

Family **ATYIDAE** De Haan, 1849

Genus *Caridina* H. Milne Edwards, 1837

Caridina longirostris H. Milne Edwards, 1837

Caridina longirostris H. Milne Edwards, 1837: 363; De Man, 1892: 395–397, fig. 291, m; 1908: 264–265, plate XX, fig. 5, 5a, 5b mm; Bouvier, 1905: 78; 1925: 149–151, figs 313–314 (partim) 1925: 150, fig. 314; Richard & Clark, 2009: fig. 4d, e, f.

Not *Caridina longirostris* Bouvier, 1925: 151.

Not *Caridina longirostris*. Bouvier, 1925: 151 (partim); Holthuis, 1969: 94–97; 1978: 36; Maciolek & Ford, 1987: 628; Choy, 1991: 354; Hung *et al.*, 1993: 493–494, fig. 8; Chace, 1997: 14, figs 6, 7; Leberer & Nelson, 2001: 389; Liang, 2004: 195, fig. 94; Choy & Marquet, 2002: 217; Marquet *et al.*, 2003: 60–61; Page *et al.*, 2007: 647; Short, 2009: 42, fig. 31; Keith *et al.*, 2010: 42–43.

Material examined

Paralectotypes. MNHN Na 746, 3♂ cl 2.9–3.1 mm; MNHN-IU–2013–19418, 2♂ 3.2–3.6 mm; MNHN IU–2013–19417, 2♀ ovig. cl 3.1–3.3 mm; from the River Macta, near Oran, Algeria.

Other material examined. Not *C. nilotica longirostris*. **Indonesia:** MNHN-IU–2015–1741, 1♂ cl 2.2 mm; MNHN-IU–2015–1891, 1♂ cl 2.3 mm, Makassar, Sulawesi.

Diagnosis

Carapace (Fig. 3G): smooth, glabrous, with sharp antennal spine placed at lower orbital angle. Pterygostomian margin blunt. Rostrum long, 1.0–1.2 of cl, curved up distally, reaching well beyond scaphocerite; 14–17 dorsal teeth, leaving distally unarmed part of rostrum 0.7–1.1 times that of armed part, except for one or two subapical teeth, 1–2 post-orbital teeth present. 10–15 teeth present on the ventral margin extending from highest part of the rostrum either to tip or with short distal part unarmed. Number of dorsal teeth on the rostrum before the most proximal ventral tooth 9–12. Rostral formula: (1–2) 14–17 + 1–2 / 10–15.

First pereopod (Fig. 3A): stouter than second pereopod; chela ~1.6–2.1 times as long as wide, dactylus 2.2–3.3 times as long as wide, 1.0–1.5 length of palm; carpus 1.4–1.8 times as long as wide with shallow excavation on anterior margin.

Second pereopod (Fig. 3B): more slender and longer than first pereopod; chela 1.9–2.4 times as long as wide, dactylus 3.0–3.6 times as long as wide, 1.3–1.6 times length of palm; carpus 3.9–4.7 times as long as wide.

Third pereopod (Fig. 3C, D): dactylus 4.0–4.8 times as long as wide (terminal spine included) with 7–9 spiniform setae on flexor margin in addition to the terminal one; propodus 11.3–14.3 times as long as wide, 3.4–4.0 times as long as dactylus.

Fifth pereopod (Fig. 3E, F): dactylus 4.5–5.1 times as long as wide with 32–38 spiniform setae on flexor margin; propodus 13.4–16.1 times as long as wide, 3.2–3.7 as long as dactylus.

Telson (Fig. 3M): ending sharply triangular with a posteromedian projection; one pair of longer lateral simple setae and two pairs of clearly shorter intermediate simple setae.

First male pleopod (Fig. 3K): endopod leaf-like without a developed appendix interna.

Second male pleopod (Fig. 3L): appendix masculina on second pleopod reaching 0.62 times length of endopod; appendix interna reaching ~0.58 times length of appendix masculina.

Pre-anal carina (Fig. 3I): with a spine.

Uropodal diaeresis (Fig. 3H): with 9–12 short spinules.

Eggs (Fig. 3J): size 0.36–0.40 × 0.22–0.30 mm.

Colour pattern

Unknown.

Distribution

According to Bouvier (1925), ‘Jusqu’ici les seuls représentants connus de cette variété sont les nombreux exemplaires types du *Caridina longirostris* qui, d’après H. Milne-Edwards, furent capturés dans la rivière de la Macta, près d’Oran, par M. Roux. Or, on ne connaît en Algérie qu’un Atyidé, l’*Atyaephyra Desmaresti*, si bien qu’on peut dire, presque sans aucun doute que les types de Milne-Edwards proviennent d’une région tout autre que l’Algérie’ (‘Until now, the only representatives known for this variety are the numerous type specimens of *Caridina longirostris* which, according to H. Milne Edwards, were captured in La Macta River, near Oran, by M. Roux. However, we only know one Atyidae from Algeria, *Atyaephyra Desmaresti*, so we can say almost without a doubt that Milne Edwards’ type specimens come from a region other than Algeria’). He believed that they would have come from the Celebes area, as he found specimens identified as *C. nilotica gracilipes* by Schenkel (1902) from Makassar (Celebes Island) to be morphologically close to the type specimens (Bouvier 1925). After having examined these specimens, we concluded that they were young individuals of *C. gracilipes*. Thus, the exact type locality remained unknown. We hypothesised that if the locality was erroneous on the specimen label, maybe the collector was not. The ‘M. Roux’ indicated by H. Milne Edwards was his contemporary Jean Louis Florent Polydore Roux (1792–1833), more commonly referred to as Polydore Roux. The life and times of Polydore Roux are well documented including two published letters (J. L. F. P. Roux 1833, 1834) addressed to a M. le baron

de Férussac, an obituary (Barthélemy 1834) and a biographical account by P.-M. Roux (son of Polydore) (P.-M. Roux 1834). Accordingly, Polydore Roux was appointed the conservateur du Cabinet d'histoire naturelle de Marseille on 1 June 1819. Consequently, it would have been relatively easy for him to travel to Algeria and collect at 'Rivière de la Macta, près d'Oran', but there is no mention of J. L. F. P. Roux visiting Algeria, although there are several references that confirm he left France on 6 September 1831 with Baron Karl von Hugel and the pair arrived in Egypt towards the end of that month. They both travelled widely in the region including up the Nile to Nubia (now in Sudan), along the coast of the Red Sea and part of Arabia, collecting specimens along the way. While in Egypt, J. L. F. P. Roux (1833) addressed a letter to M. le Baron de Férussac, which was published by the Annales des Sciences Naturelles and figured *Pelias* (now *Caridina*) *niloticus* and *Palaemon niloticus* (now *Macrobrachium niloticum*). According to Richard and Clark (2005), the figured type specimen is no longer extant as P.-M. Roux later sold his father's collections to dealers such as Dupont in Paris. Furthermore, Baron Karl von Hugel and Polydore parted company in Egypt with J. L. F. P. Roux travelling up the Nile to Kené (now Qena or Qiná) and catching a caravan to Cosseyyre (Al Qusayr or Quseir) on the Red Sea. Here he caught a steamship to Bombay (now Mumbai). On 8 March 1832 he sailed through the Strait of Bab el Mandael on the coast of Abyssinia and a few days later arrived in Bombay. According to P.-M. Roux (1834), Polydore explored the chain of Ghats and collected freshwater Crustacea before he died of the plague in Bombay on 12 April 1833. We think that he may have collected other species of shrimps in Egypt that somehow ended up in the collections of the MNHN in Paris. There was at this time a locality named Arawat el Macta (Linant de Bellefonds 1843), now called Hawwarat Al Maqta (29°15.471'N 30°53.785'E), in the Faiyum Governorate crossed by a channel linking the Lake Qarun to the Nile river. We know that Roux visited the Faiyum Oasis in winter 1831 (P.-M. Roux 1834), so it is not unlikely that he collected shrimps from this locality that he preserved with the indication 'El Macta'. Henri Milne Edwards, examining specimens from this collect in 1837 would have assumed that the specimens came from the well-known Macta River in Algeria (where a military battle took place between French troops and the Algerian resistance just two years before), unaware of the existence of such a name in Egypt and was not able to get the locality corrected by P. Roux who died in 1833 in India. The probability is indeed much higher that *C. longirostris* is present in Egypt than in Algeria since *Caridina* exists in the Nile watershed, about a thousand kilometres of desert away from Oran. A new field trip to Hawwarat Al Maqta may allow confirmation or not of the presence of *C. longirostris* in this locality and validate it as the type locality. Considering the locality, the only congeneric species present would be *C. nilotica*, a species that can morphologically be separated from *C. longirostris*. Furthermore, new samples of this species may allow verification of the morphological data provided here and obtain molecular data to place this species in the phylogeny and ascertain its validity.

Habitat

Unknown.

Remarks

The paralectotypes re-examined for this study fit well with the description given by [De Man \(1908\)](#): rostrum long, reaching well beyond scaphocerite, curved up distally with presence of 0–2 post-orbital teeth (vs 1–2 in the present study), 14–21 dorsal teeth (vs 14–17 in the present study) and 11–17 ventral teeth (vs 10–15 in the present study); P1 carpus 1.5–1.9 times as long as wide (vs 1.4–1.8 in the present study); P2 carpus 3.4–4.7 times as long as wide (vs 3.9–4.7 in the present study). P3 dactylus with 7–10 spiniform setae (vs 7–9 in the present study) propodus 3.4–3.7 as long as dactylus (vs 3.4–4.0 in the present study); P5 dactylus with ~30–39 spiniform setae (vs 32–38 in the present study), propodus 14.7–18.0 times as long as wide (vs 13.4–16.1 in the present study) and propodus 3.2–3.5 times as long as dactylus (vs 3.2–3.7 in the present study); uropodal diaeresis 11–13 spinules (vs 9–12 in the present study); small eggs $0.33\text{--}0.39 \times 0.21\text{--}0.26$ mm (vs $0.36\text{--}0.40 \times 0.22\text{--}0.30$ mm in the present study). Some values given by [Bouvier \(1925\)](#) are also similar to the *C. longirostris* material examined for the present study: P3 dactylus with 7–10 spines (vs 7–9 in the present study), P5 dactylus with ~29–38 spiniform setae (vs 32–38 in the present study), uropodal diaeresis with 11–13 spinules (vs 9–12 in the present study), small eggs $0.33\text{--}0.39 \times 0.20\text{--}0.22$ mm (vs $0.36\text{--}0.40 \times 0.22\text{--}0.30$ mm in the present study). Also, our specimens fit well with the brief description given by [Richard and Clark \(2009\)](#): 13) with a rostral formula (1–2) 14–20/13–16 (vs (1–2) 14–17/10–15 in the present study), a telson that terminates in a sharply triangular posterior margin with a posteromedian projection and three pairs of distal spiniform setae, the lateral pair of which is distinctly longer than intermediates (see also [Bouvier 1925](#): 150, fig. 315), and a pre-anal carina having a distinct spine.

Thus, the morphology of *C. longirostris* is defined by its short P1 and P2 carpus respectively 1.4–1.8 and 3.9–4.7 times as long as wide. Consequently, *C. longirostris* could be separated from all the members of the *C. nilotica*-group studied here: *C. appendiculata*, *C. brevidactyla*, *C. gracilipes* and *C. meridionalis* (see below).

According to [Schenkel \(1902\)](#): fig. 5a, pl. 8), who examined specimens collected in Makassar, Sulawesi, the P1 of *C. gracilipes* appears similar to that of *C. longirostris* ([De Man 1892](#): fig. 20l, tab. XXIV). In addition, [Schenkel \(1902\)](#) indicates further similarities between these two species including P1 carpus 1.5 times as long as wide (vs 1.4–1.8 for *C. longirostris*, present study) and P5 dactylus with 27 spiniform setae (vs 32–38 for *C. longirostris*, present study). According to [Bouvier \(1925\)](#), specimens of *C. gracilipes* reported by [Schenkel \(1902\)](#) from Makassar include two young specimens of *C. longirostris* (MNHN-IU-2015-1741 and MNHN-IU-2015-1891), the P5 propodus being 3.5 times as long as dactylus as in *C. longirostris* (vs 3.2–3.7 for *C. longirostris*, present study). These two specimens of Bouvier were re-examined and were found not to be *C. longirostris*.

according to their longer P1 and P2 carpus 2.1–2.2 times as long as wide (vs 1.4–1.8 for *C. longirostris*, present study) and 5.0–5.1 (vs 3.9–4.7 for *C. longirostris*, present study). The P3 propodus dimension of the Makassar specimens are 10.1–12.2 and are within the range variation of *C. gracilipes* (vs 10.2–16.0) but not for *C. appendiculata* (vs 13.8–22.7) or *C. brevidactyla* (vs 13.2–24.9). These two specimens from Makassar are considered juveniles of *C. gracilipes*.

Caridina appendiculata Jalihal & Shenoy, 1998

(Fig. 4)

Caridina appendiculata Jalihal & Shenoy, 1998: 128; Klotz *et al.*, 2007: 7–9, figs 3 (part), 4.

Caridina sp. *E* Page *et al.*, 2007: 648, table 1; Cook *et al.*, 2011: 278, fig 3.

Material examined

Lectotype. ZMA.CRUS.D.102646, 1♂ cl 3.1 mm; *Caridina gracilirostris* De Man, 1892, Indonesia: Flores: river near Bari, coll. M. Weber, 1888.

Paralectotypes. 1♂ cl 2.9 mm, 3♀ cl 2.2–4.3 mm; same data as lectotype.

Other material examined. **Australia:** MNHN-IU–2018–117, 1♂ cl 2.8 mm (DNA: CA1668) and MNHN-IU–2018–118, 1♂ cl 4.0 mm (DNA: CA1667); River Hastings: Bain Bridge crossing near Crossroads, 31°26.150'S 152°42.283'E, coll. B. Mos, 9.vii.2016; MNHN-IU–2018–119, 1♀ cl 3.1 mm, MNHN-IU–2018–120, 1♀ cl 3.5 mm, MNHN-IU–2018–121, 1♀ cl 4.8 mm (DNA: CA1665), MNHN-IU–2018–122, 1♀ cl 5.4 mm and MNHN-IU–2018–123, 1♂ cl 3.1 mm; River Clarence: near Cowper/Brushgrove, 29°34.067'S 153°04.633'E, coll. B. Mos, 2.vii.2016; MNHN-IU–2018–124, 1♂ cl 2.8 mm (DNA: CA1670) and MNHN-IU–2018–125, 1♂ cl 3.5 mm (DNA: CA1669); Warrell Creek, 30°45.583'S 152° 53.217'E, coll. B. Mos, 9.vii.2016. **Indonesia:** Sulawesi: ZMB 29000, 4♂ cl 3.4–3.7 mm, 2♀ ovig. cl 4.3–5.1 mm; Luwuk Peninsula: freshwater spring in Malontong, west of Ampana, brackish water pool, 0°53.125'S 121°31.371'E, coll. M. Glaubrecht, T. von Rintelen and K. Zitzler, 27.v.2005. Obira: ZMB 29001, 2♂ cl 3.4–3.5 mm; West of Laiwui: 1°21.613'S 127°36'421. 9.ix.2005. **Palau:** MNHN-IU–2018–127, 1♀ ovig. cl 3.9 mm (DNA: CA1021); Babeldaob, small stream East Coast, near the estuary, altitude 0 m, 07°29.909'N, 134°38.099'E, coll. P. Keith, P. Gerbeaux, G. Marquet, L. Taillebois and M. Castelin, 2.iii.2011. **Micronesia:** MNHN-IU–2018–128, 1♀ ovig. cl 3.2 mm and MNHN-IU–2018–129, 1♀ ovig. cl 3.6 mm (DNA: CA1333); River Nanpil: estuary, Pohnpei Island, altitude 5 m, 06°56.609'N, 158°13.550'E, coll. P. Keith, P. Gerbeaux, G. Marquet, L. Taillebois and M. Castelin, 13.iii.2012; MNHN-IU–2018–130, 1♀ ovig. cl 3.0 mm (DNA: CA1330), MNHN-IU–2018–131, 1♀ ovig. cl 3.4 mm and MNHN-IU–2018–132, 1♀ cl 3.1 mm; unnamed river, estuary, Pohnpei Island, altitude 5 m, 06°48.579'N, 158°12.639'E, coll. P. Keith, P. Gerbeaux, G. Marquet, L. Taillebois and M. Castelin, 15.iii.2012. **Solomon Islands:** Kolobangara: MNHN-IU–2018–133, 1♂ cl 3.5 mm (DNA: CA1493) and MNHN-IU–2018–134, 1♂ cl 3.6 mm; River Zamba, altitude 0 m, 08°05.934'S 157°00.830'E, coll. P. Keith, G. Marquet and C. Lord, 9.xi.2015; MNHN-IU–2018–135, 1♀ ovig. cl 4.0 mm (DNA: CA1494), MNHN-IU–2018–136, 1♀ ovig. cl 4.1 mm and MNHN-IU–2018–137, 1♂ cl 3.3 mm; River Vanga, altitude 5 m,

07°54.825'S 156°57.762'E, coll. P. Keith, G. Marquet and C. Lord, 18.xi.2015. **Vanuatu**: Aneityum: MNHN-IU-2018-138, 1♀ cl 3.7 mm; River Inuje, altitude 0 m, 20°13.321'S 169°45.899'E, coll. C. Lord and G. Segura, 25.vi.2015; MNHN-IU-2018-139, 1♀ 3.8 mm and MNHN-IU-2018-140, 1♂ 2.5 mm (DNA: CA1489) River Inwe Lengei, altitude 9 m, 20°13.915'S 169°47.385'E, coll. C. Lord and G. Segura, 24.vi.2015; EPI: MNHN-IU-2018-141, 1♀ ovig. cl 4.5 mm; River Buavinai, 16°48.189'S 168°11.079'E, coll. P. Keith, G. Marquet and M. Mennesson, 27.x.2014; EFATE: MNHN-IU-2018-146, 1♀ ovig. cl 4.6 mm, MNHN-IU-2018-143, 1♀ ovig. cl 4.7 mm (DNA: CA1264), MNHN-IU-2018-144, 1♀ ovig. cl 4.7 mm (DNA: CA1268), MNHN-IU-2018-145, 1♀ ovig. cl 4.8 mm, MNHN-IU-2018-147, 1♀ cl 4.7 mm, MNHN-IU-2018-148, 1♀ cl 4.9 mm, MNHN-IU-2018-149, 1♂ cl 3.4 mm and MNHN-IU-2018-150, 1♂ cl 3.8 mm; Creek Ai, altitude: 2 m, 17°36.627'S 168°14.525'E, coll. P. Keith, G. Marquet and M. Mennesson, 9.xi.2014. MNHN-IU-2018-156, 1♀ ovig. cl 4.2 mm (DNA: CA1259) and MNHN-IU-2018-157, 1♀ ovig. cl 4.6 mm (DNA: CA1261); Creek Marona, altitude 5 m, 17°33.860'S 168°17.140'E, coll. P. Keith, G. Marquet and M. Mennesson, 9.xi.2014; SANTO: MNHN-IU-2018-158, 1♀ cl 4.2 mm; Jackie's Blue Hole, 15°18.788'S 167°10.208'E, coll. P. Keith and G. Marquet, 22.vii.2003.

Diagnosis

Carapace (**Fig. 4G, N, O**): smooth, glabrous, with sharp antennal spine placed at lower orbital angle. Pterygostomian margin blunt. Rostrum long, 1.3–2.1 of cl, curved up distally, reaching well beyond scaphocerite. 12–18 dorsal teeth somewhat irregular spaces, leaving distally unarmed part of rostrum 0.5–1.2 times that of armed part, except for 1–3 subapical teeth, 1–3 post-orbital teeth present; 8–25 teeth present of the ventral margin extending from proximal end either to tip or with short distal part unarmed. Number of dorsal teeth on the rostrum before the first ventral tooth 8–12. Rostral formula: (1–3) 12–18 + 1–3 / 8–25.

First pereopod (**Fig. 4A**): slender, chela ~1.7–2.4 times as long as wide, dactylus 3.1–4.3 times as long as wide, 1.1–1.7 length of palm; carpus 1.9–2.8 times as long as wide with shallow excavation on anterior margin.

Second pereopod (**Fig. 4B**): more slender and longer than first pereopod: chela 2.0–2.7 times as long as wide, dactylus 3.3–5.5 times as long as wide, 1.1–1.6 times length of palm; carpus 4.8–7.1 times as long as wide.

Third pereopod (**Fig. 4C, D**): dactylus 2.9–4.1 times as long as wide, terminal spine included, with 6–8 spines on flexor margin in addition to the terminal one; propodus 13.8–22.7 times as long as wide, 4.4–7.1 times as long as dactylus.

Fifth pereopod (**Fig. 4E, F**): dactylus 3.8–5.2 times as long as wide with 33–44 spiniform setae on flexor margin; propodus 13.7–26.2 times as long as wide, 4.3–6.2 times as long as dactylus.

Telson (**Fig. 4M**): ending in a posteromedian projection; three pairs of distal simple setae, lateral pair slightly longer than intermediate.

Pre-anal carina (Fig. 4I): with a prominent finger-like backward striking tooth.

First male pleopod (Fig. 4K): endopod leaf-like with well-developed appendix interna.

Second male pleopod (Fig. 4L): appendix masculina on second pleopod reaching 0.61–0.66 times length of endopod; appendix interna reaching 0.70–0.71 times length of appendix masculina.

Uropodal diaeresis (Fig. 4H): with 8–12 short spinules.

Eggs (Fig. 4J): size $0.38\text{--}0.46 \times 0.23\text{--}0.28$ mm.

Colour pattern

Colour varies in live specimens and tends to match their background. The colour of the body is hyaline with many red dots (Fig. 8A, B).

Distribution

Caridina appendiculata is now known from Australia (present study), Indonesia (Flores (Cai and Ng 2007a), Obira (present study) and Sulawesi (Klotz *et al.* 2007)), Solomon Islands (Kolobangara, present study), Micronesia (Pohnpei, present study), Palau (present study) and Vanuatu (Aneityum, Efate, Epi and Santo, present study) (Fig. 2).

Habitat

All specimens were collected in a typical brackish water environment (brackish water pool or the lower part of rivers, near the estuary).

Remarks

Our specimens of *C. appendiculata* agree well with the descriptions by Klotz *et al.* (2007) of this species from Sulawesi (Indonesia): long rostrum reaching well beyond scaphocerite 1.3–2.2 (vs 1.3–2.1 in the present study), curved up distally with presence of 2–3 post-orbital teeth (vs 1–3 in the present study), 9–20 dorsal teeth (vs 12–18 in the present study) and 13–29 ventral teeth (vs 8–25 in the present study); P1 carpus 1.8–3.2 (vs 1.9–2.8 in the present study); P2 carpus 5.0–7.7 (vs 4.8–7.1 in the present study). P3 dactylus with 6–8 spines (vs 6–8 in the present study) propodus 4.5–7.1 as long as dactylus (vs 4.4–7.1 in the present study); P5 dactylus with ~37 spiniform setae (vs 33–44 in the present study), propodus 16.0–26.7 times long as width (vs 13.7–26.2 in the present study) and propodus 4.5–6.0 times as long as dactylus (vs 4.3–6.2 in the present study); P11 endopod with a long appendix interna; pre-anal carina with a prominent finger-like backward striking tooth; telson ending in a median point, three pairs of distal spiniform setae, lateral pair slightly longer than intermediate; uropodal diaeresis 9–13 spinules (vs 8–12 in the present study) and egg size $0.41\text{--}0.46 \times 0.16\text{--}0.26$ mm (vs $0.38\text{--}0.46 \times 0.23\text{--}0.28$ mm in the present study).

Our specimens with a long and upcurved rostrum and apical teeth were for a long time associated with the *C. gracilirostris* species-group. According to Cai and Ng (2007a), *C. appendiculata* was

moved from the *C. gracilirostris* species-group to the *C. nilotica* species-group due to the presence of post-orbital teeth (1–3) on the rostrum, a diagnostic character of the latter. Moreover, our specimens differed from this group by the larger number of teeth on the dorsal margin of the rostrum, 12–18 (vs 3–11 in the *C. gracilirostris*-group), a smaller number of ventral teeth, 8–25 (vs 19–36 in the *C. gracilirostris*-group).

Comparison

In the *C. nilotica* species-group, *C. appendiculata* resembles *C. longirostris*, *C. brevidactyla*, *C. gracilipes* and *C. meridionalis*, particularly by the long rostrum with subapical teeth.

Caridina appendiculata can be distinguished from *C. longirostris* by the carpus length in P1, 1.9–2.8 (vs 1.4–1.8 in *C. longirostris*); the carpus length in P2, 4.8–7.1 (vs 3.9–4.7 in *C. longirostris*), P3 with stouter dactylus 2.9–4.1 times as long as wide (vs 4.0–4.8 in *C. longirostris*); P3 propodus 4.4–7.1 times as long as dactylus (vs 3.4–4.0 in *C. longirostris*); P5 stouter with propodus 4.3–6.2 times as long as dactylus (vs 3.2–3.7 in *C. longirostris*).

Although difficult, *C. appendiculata* can be differentiated from *C. brevidactyla* by the prominent spine on the pre-anal carina (vs absent in *C. brevidactyla*); the smaller number of teeth on the proximal part of the dorsal margin of the rostrum being 12–18 somewhat irregular spaced (vs 16–30 more closely set in *C. brevidactyla*); a smaller number of dorsal teeth behind the first ventral teeth 8–12 (vs 11–15 in *C. brevidactyla*); a shorter P1 carpus, 1.9–2.8 (vs 2.5–3.6 in *C. brevidactyla*); a slightly smaller number of spiniform setae on the dactylus of P5, 33–44 (vs 35–53 in *C. brevidactyla*); a more slender appendix masculina on second pleopod reaching 0.61–0.66 times length of endopod (vs 0.54–0.55 in *C. brevidactyla*); and a shorter appendix interna reaching 0.70–0.71 times length of appendix masculina (vs 0.77–0.81 in *C. brevidactyla*).

Caridina appendiculata differs from *C. gracilipes* in a higher number of ventral teeth on rostrum, 8–25 (vs 7–17 in *C. gracilipes*); a smaller number of dorsal teeth behind the first ventral teeth, 8–12 (vs 9–15 in *C. gracilipes*); a more slender P3 propodus, 13.8–22.7 times as long as wide (vs 10.2–16.0 in *C. gracilipes*); a slightly smaller number of spiniform setae on the P5 dactylus, 33–44 (vs 34–58 in *C. gracilipes*) and a more slender P5 propodus, 4.3–6.2 times as long as dactylus (vs 3.3–4.5 in *C. gracilipes*).

Specimens of *C. appendiculata* examined for the present study only differ from *C. meridionalis* in a smaller number of dorsal teeth on the rostrum, 12–18 (vs 16–26 in *C. meridionalis*); a smaller number of dorsal teeth behind the first ventral teeth, 8–12 (vs 10–15 in *C. meridionalis*); a slightly smaller number of spiniform setae on the P5 dactylus, 33–44 (vs 42–62 in *C. meridionalis*) and smaller eggs $0.38\text{--}0.46 \times 0.23\text{--}0.28$ mm (vs $0.34\text{--}0.75 \times 0.24\text{--}0.48$ mm in *C. meridionalis*).

***Caridina brevidactyla* Roux, 1920**

(Fig. 5)

Caridina nilotica var. *brevidactyla* J. Roux, 1920: 320–321; 1926a: 204–206.

Caridina brevidactyla Cai & Ng, 2001: 671, fig. 5.

Material examined

Lectotype (here designated). NMB 4 VI b1, 1♂ cl 4.8 mm; Indonesia: Aru: Wokam Island: Sungai Manumbai 14–15.iv.1908.

Paralectotypes. NMB 4 VI a, 1♂ cl 3.3 mm; Indonesia: Udjir Island, 15.iv.1908. NMB 4 VI b, 2♀ cl 5.8–6.4 mm; Sungai Manumbai: Wokam Island: Aru, 14–15.iv.1908. NMB 4 VI c, 1♀ cl 5.7 mm; Wokamar: Wokam Island: Aru; 17.iv.1908. NMB 4 VI d, 2♀ ovig. cl 5.7 mm; Kobroor Island: Seltutti: Aru; 2.v.1908.

Other material examined. **Fiji**: Ovalau: RMNH.CRUS.D.54674, 1♀ cl 4.6 mm; River Lovoni, 17°41'20"S 178°47'45"W, coll. S. C. Choy, 26.vii.1980; Taveuni: MNHN-IU-2018-159, 1♂ cl 3.1 mm (DNA: CA1426); Bouma National Heritage Park, altitude 13 m, 16°49.599'S 179°52.557'W, coll. P. Keith and G. Marquet, 26.ii.2013; unknown island: BPBM 3947, 1♀ cl 4.3 mm; unknown locality, coll. C. H. Edmonson, 1933. **New Caledonia**: MNHN-IU-2018-160, 1♀ ovig. cl 4.3 mm, MNHN-IU-2018-161, 1♀ cl 4.5 mm (DNA: CA1007), MNHN-IU-2018-162, 1♀ cl 4.6 mm and MNHN-IU-2018-163, 1♀ cl 5.0 mm; River Tibarama, altitude 5 m, 20°56.300'S 165°22.700'E, coll. G. Marquet and L. Taillebois, 23.x.2010; MNHN-IU-2018-164, 1♂ cl 4.0 mm and MNHN-IU-2018-165, 1♂ cl 4.0 mm; River Poueo, altitude 0 m, 21°32.966'S 165°30.062'E, coll. G. Marquet and V. de Mazancourt, 28.ix.2016. **Solomon Islands**: Choiseul: MNHN-IU-2018-168, 1♀ ovig. cl 5.3 mm (DNA: CA1305); River Gu'ma, altitude 50 m, 07°01.764'S 156°49.899'E, coll. P. Keith, G. Marquet and M. Mennesson, 17.x.2014; MNHN-IU-2018-169, 1♀ ovig cl 5.0 mm, MNHN-IU-2018-170, 1♀ ovig cl 5.1 mm, MNHN-IU-2018-171, 1♀ ovig cl 5.7 mm (DNA: CA1346) and MNHN-IU-2018-172, 1♀ ovig cl 5.8 mm (DNA: CA1345); River Lokasereke, altitude 45 m, 06°58.024'S 156°47.861'E, coll. P. Keith, G. Marquet and M. Mennesson, 13.x.2014. MNHN-IU-2018-XXX, 1♀ cl 4.4 mm and MNHN-IU-2018-XXX, 1♂ cl 3.3 mm; River Lopakare, upstream, altitude 50 m, 07°01.613'S 156°45.567'E, coll. P. Keith, G. Marquet and M. Mennesson, 20.x.2014; MNHN-IU-2018-XXX, 1♀ ovig. cl 5.0 mm (DNA: CA1302), MNHN-IU-2018-173, 1♀ ovig. cl 5.3 mm and MNHN-IU-2018-174, 1♂ cl 3.1 mm; River Vorama, altitude 15 m, 06°58.687'S 156°46.746'E, coll. P. Keith, G. Marquet and M. Mennesson, 11.x.2014. **KOLOBANGARA**: MNHN-IU-2018-178, 1♀ ovig. cl 4.2 mm and MNHN-IU-2018-179, 1♀ ovig. cl 4.9 mm; River Lodumoe, altitude 0 m, 07°50.961'S 157°04.320'E, coll. P. Keith, G. Marquet and C. Lord, 16.xi.2015; MNHN-IU-2018-180, 1♀ ovig. cl 3.7 mm, MNHN-IU-2018-181, 1♀ ovig. cl 3.9 mm and MNHN-IU-2018-182, 1♂ cl 3.8 mm; River Vanga, altitude 5 m, 07°54.825'S 156°57.762'E, coll. P. Keith, G. Marquet and C. Lord, 18.xi.2015; Vella Lavella: MNHN-IU-2018-183, 1♀ ovig cl 4.6 mm and MNHN-IU-2018-184, 1♂; River Maravari, 07°51.703'S 156°41.748'E, coll. P. Keith and C. Lord, 31.x.2016; MNHN-IU-2018-186, 1♀ ovig. cl 4.0 mm and MNHN-IU-2018-187, 1♂ cl 4.2 mm; River Wariassi, coll. P. Keith and C. Lord, 29.x.2016. **Vanuatu**: EPI: MNHN-IU-2018-188, 1♀ cl 5.1 mm (DNA: CA1307); River Buavinai, 16°48.189'S 168°11.079'E, coll. P. Keith, G. Marquet and M. Mennesson, 27.x.2014. **EFATE**: MNHN-IU-

2018–189, 1♂ cl 3.0 mm and MNHN–IU–2018–190, 1♂ cl 3.2 mm; Mele stream, altitude 32 m, 17°40.545'S 168°15.558'E, coll. P. Keith, G. Marquet and M. Mennesson, 9.xi.2014; Malekula: MNHN–IU–2018–191, 1♀ ovig. cl. 4.3 mm and MNHN–IU–2018–192, 1♀ cl 4.0 mm; River Brenwe, 16°07.986'S 167°17.148'E, coll. P. Keith, L. Taillebois and C. Lord, 20.xi.2008; Santo: MNHN–IU–2018–193, 1♀ ovig. cl 5.0 mm and MNHN–IU–2018–194, 1♀ ovig. cl 5.1 mm; Jackie's Blue Hole, altitude 0 m, 15°18.788'S 167°10.208'E, coll. P. Keith and G. Marquet, 22.vii.2003.

Comparative material

Caridina grandirostris Stimpson, 1860

Japan: ZRC 2004–0519, 1♂ cl 3.4 mm, 1♂ cl 3.8 mm (DNA: CA1892), 1♀ ovig. cl 6.1 mm and 1♀ cl 4.7 mm (DNA: CA1891); upstream of Tima River, ~1–2 km from river mouth, Okinawa Island, Ryukyu Islands, 26°33.42'N 128°04.60'E, coll. Cai, Ng, Taruse and Islam, 11.vi.2000. ZRC 2004–0530, 1♀ ovig. cl. 5.0 mm (DNA: CA1893); freshwater stream draining to a small patch of mangrove, Oura River, Okinawa Island, Ryukyu Islands, 26°33.48'N 128°02.48'E, coll. Cai *et al.* 11.vi.2000. **Taiwan:** MNHN–IU–2018–195, 1♂ cl 3.1 mm (DNA: CA1676); Pingtung, river near Jialeshui Coastal rock formations, altitude 2 m, 21°59.305'N 120°49.956'E, coll. W. and M. Klotz and M.-C. Liu, 25.vii.2013.

Caridina leucosticta Stimpson, 1860

Japan: ZRC 2004–0530, 1♂ cl 3.1 mm (DNA: CA1894), 1♂ cl 3.6 mm, 1♂ cl 3.8 mm, 1♀ ovig. cl 5.3 mm and 1♀ ovig. cl 6.1 mm (DNA: CA1896); freshwater stream draining to a small patch of mangrove, Oura River, Okinawa Island, Ryukyu Islands, 26°33.48'N 128°02.48'E, coll. Y. Cai, N. K. Ng, T. Naruse and S. Islam. 11.vi.2000.

Diagnosis

Carapace (**Fig. 5G, N, O**): smooth, glabrous, with sharp antennal spine placed at lower orbital angle. Pterygostomian margin rounded. Rostrum long, 1.1–2.1 of cl, curved up distally, reaching well beyond scaphocerite; 16–30 dorsal teeth regular spaces, leaving distally unarmed part of rostrum 0.6–1.3 times that of armed part, except for 1–3 subapical teeth, 1–3 post-orbital teeth present; 12–24 teeth present of the ventral margin extending from proximal end either to tip or with short distal part unarmed. Number of dorsal teeth on the rostrum before the first ventral tooth 11–15. Rostral formula: (1–3) 16–30 + 1–3 / 12–24.

First pereopod (**Fig. 5A**): slender, chela ~2.1–2.5 times as long as wide, dactylus 3.4–4.8 times as long as wide, 1.1–1.9 length of palm; carpus 2.5–3.6 times as long as wide with shallow excavation on anterior margin.

Second pereopod (**Fig. 5B**): more slender and longer than first pereopod, chela 2.6–3.5 times as long as wide, dactylus 4.6–6.8 times as long as wide, 1.3–2.1 times length of palm; carpus 5.6–7.5 times as long as wide.

Third pereopod (Fig. 5C, D): dactylus 2.8–4.6 times as long as wide, terminal spine included, with 4–8 spines on flexor margin in addition to the terminal one; propodus 13.2–24.9 times as long as wide, 4.7–8.4 times as long as dactylus.

Fifth pereopod (Fig. 5E, F): dactylus 3.6–7.4 long as wide with 35–53 spiniform setae on flexor margin; propodus 19.1–29.1 times as long as wide, 4.7–6.2 as long as dactylus.

Telson (Fig. 5M): ending in a posteromedian projection; 3–4 pairs of distal simple setae, lateral pair longer than intermediate.

First male pleopod (Fig. 5K): endopod leaf-like with well-developed appendix interna.

Second male pleopod (Fig. 5L): appendix masculina on second pleopod reaching 0.54–0.55 times length of endopod; appendix interna reaching 0.77–0.81 times length of appendix masculina.

Pre-anal carina (Fig. 5I): without a spine.

Uropodal diaeresis (Fig. 5H): with 9–13 spinules.

Eggs (Fig. 5J): size $0.37\text{--}0.47 \times 0.22\text{--}0.30$ mm.

Colour pattern

The colour of the body is hyaline with many red dots. An oblique carmine red band on the cephalothorax is characteristic (Fig. 8C, D).

Distribution

Caridina brevidactyla is now known from Indonesia (Aru Island (Roux 1920), Halmahera (Cai and Ng 2001)), Solomon Islands (Kolobangara, Vella Lavella, present study), Vanuatu (Efate, Epi, Malekula and Santo, present study), New Caledonia and Fiji (present study) (Fig. 2).

Habitat

The specimens were collected in the lower reach of the rivers, rarely found in brackish conditions.

Remarks

The specimens examined for the present study fit well with the descriptions by Cai and Ng (2001) of this species from Halmahera (Indonesia): the long rostrum reaching well beyond scaphocerite curved up distally with the presence of 2–3 post-orbital teeth (vs 1–3 for the present study); 19–25 dorsal teeth (vs 16–30 for the present study) and 18–23 ventral teeth (vs 12–24 for the present study); P1 carpus 2.2 (vs 2.5–3.6 for the present study); P2 carpus 5.8 (vs 5.6–7.5 for the present study); P3 dactylus with 5–6 spines (vs 4–8 for the present study); propodus 6.2 times as long as dactylus (vs 4.7–8.4 for the present study); P5 dactylus with ~57 spiniform setae (vs 38–53 for the present study); propodus 6.0 times as long as dactylus (vs 4.7–6.2 for the present study); P11 endopod with a long appendix interna (vs P11 endopod with a long appendix interna for the present study); pre-anal carina

without spine (vs without for the present study); telson ending in a median point, seven distal simple setae, lateral pair longer than intermediate (vs telson ending in a median point, 3–4 pairs of distal simple setae, lateral pair longer than intermediate for the present study); uropodal diaeresis with 12 spinules (vs 9–13 for the present study); eggs size 0.41×0.25 mm (vs $0.37\text{--}0.46 \times 0.22\text{--}0.30$ mm for the present study).

The co-types have an equal number of specimens showing a pre-anal carina with a spine and without a spine and are likely a mix of species. For example, the specimen NMB 4 VI c with 17 dorsal teeth on the rostrum somewhat irregularly spaced, 17 ventral teeth and nine dorsal teeth on the rostrum behind the first ventral one is probably *C. appendiculata*.

Comparison

In the *C. nilotica* species-group, *C. brevidactyla* resembles *C. longirostris*, *C. appendiculata* (see above), *C. grandirostris*, *C. gracilipes* and *C. meridionalis* particularly by the long rostrum with subapical teeth.

Caridina brevidactyla is distinct from *C. longirostris*: the spine on the pre-anal carina present in *C. longirostris* is absent in *C. brevidactyla*, P1 carpus is longer, 2.5–3.6 (vs 1.4–1.8 in *C. longirostris*); P2 carpus longer 5.6–7.5 (vs 3.9–4.7 in *C. longirostris*); P3 dactylus stouter, 2.8–4.6 times as long as wide (vs 4.0–4.8 in *C. longirostris*); a longer propodus, 4.7–8.4 times as long as wide (vs 3.4–4.0 in *C. longirostris*); P5 stouter with propodus 4.7–6.2 times as long as dactylus (vs 3.2–3.7 in *C. longirostris*).

Choy (1991) described *C. longirostris* from Fiji (specimens RMNH 54674, 54691, 54733) and considered the specimens identified as *C. nilotica brachydactyla* (specimens BPBM S3941, S3947) collected by Edmondson (1935) as belonging to this species. Re-examination of all these specimens show that they belong to *C. brevidactyla* with the spine absent from the pre-anal carina (vs spine present on the pre-anal carina in *C. longirostris* and *C. brachydactyla*) and numerous dorsal teeth on the rostrum, 20–24 (vs 14–17 in *C. longirostris* and 16–22 in *C. brachydactyla*). Also, some specimens from Vanuatu (Keith *et al.* 2010) and New Caledonia (Marquet *et al.* 2003) were confused with *C. longirostris*.

Specimens of *C. grandirostris* examined for the present study compare well with the material from Japan re-described by Cai *et al.* (2006) and this species is here reported from Taiwan (specimen wk04–13 g3) for the first time. *Caridina brevidactyla* can be distinguished from *C. grandirostris* by the absence of a spine on the pre-anal carina (vs present in *C. grandirostris*); P1 carpus being longer, 2.5–3.6 (vs 2.4–2.8 in *C. grandirostris*).

Specimens of *C. leucosticta* examined for the present study compare well with the material from Ryukyu Islands, Japan, and re-described by Cai *et al.* (2006) and like *C. brevidactyla*, the spine on the

pre-anal carina is absent. However, *C. brevidactyla*, when compared with *C. leucosticta*, have a longer P1 carpus, 2.5–3.6 (vs 2.2–2.4 in *C. leucosticta*); a slender P3 propodus, 13.2–24.9 times as long as wide (vs 12.4–15.7 in *C. leucosticta*) and a slender P5 propodus 19.1–29.1 times as long as wide (vs 18.5–19.9 in *C. leucosticta*).

Specimens of *C. brevidactyla* examined for the present study are similar to *C. gracilipes* but differ in the absence of a tooth on the pre-anal carina (vs present in *C. gracilipes*); by the P3 propodus slender 4.7–8.4 times as long as dactylus (vs 3.5–4.9 in *C. gracilipes*) and by a P3 propodus slender 13.2–24.9 times as long as wide (vs 10.2–16.0 in *C. gracilipes*).

Our specimens of *C. brevidactyla* resemble *C. meridionalis* but can be distinguished by the tooth on the pre-anal carina always being absent (vs present in *C. meridionalis*); by a longer P2 carpus, 5.6–7.5 (vs 4.1–6.2 in *C. meridionalis*); by a slender P5 propodus, 4.7–6.2 times as long as dactylus (vs 3.2–5.3 in *C. meridionalis*), by a slender P5 propodus 19.1–29.1 times as long as wide (vs 15.3–22.7 in *C. meridionalis*) and by smaller eggs, $0.37\text{--}0.47 \times 0.22\text{--}0.30$ mm (vs $0.34\text{--}0.75 \times 0.24\text{--}0.48$ mm in *C. meridionalis*).

According to Richard and Clark (2010), *C. nilotica* var. *brevidactyla* is a junior synonym of *C. brachydactyla*. Nevertheless, agreeing with Cai and Ng (2001), we consider *C. brevidactyla* as a valid species. Indeed, the spine on the pre-anal carina present in *C. brachydactyla* is absent in *C. brevidactyla*.

Caridina gracilipes De Man, 1892

(Fig. 6)

Caridina wyckii var. *gracilipes* De Man, 1892: 387, fig. 29a–e.

Caridina wyckii var. *gracilipes* Schenkel, 1902: 498.

Caridina nilotica var. *gracilipes* De Man, 1908: 270, pl. XX, fig. 7a, b; Kemp, 1918: 275.

Caridina gracilipes Cai, 2014: 208–209, figs 1–3; Cai & Shokita, 2006: 250.

Caridina gracilipes Richard & Clark, 2014: 310–314, fig. 4–5.

Caridina longirostris Bouvier, 1925: 151.

Caridina longirostris Holthuis, 1978: 36. *C. nilotica* var. *gracilipes*, Roux, 1926a: 203–204 (partim).

Caridina brachydactyla Richard & Clark, 2010: 308–310, fig. 3.

Material examined

Paralectotypes. Indonesia: *Caridina gracilipes* De Man, 1892. ZMA.CRUS.D.102635, 1♂ cl 4.1 mm (DNA: CA025), 1♀ ovig. cl 5.9 mm (DNA: CA023), 3♀ cl 5.1 mm (DNA: CA027), 5.2 mm (DNA: CA024) and

5.6 mm; in a rice field, Makassar, Sulawesi, coll. M. Weber, 1888; NMB 1061e, 1♂ 3.8 mm; 2♀ cl 5.8–5.9 mm; same data.

Other material examined. **Australia:** MNHN-IU-2018-196, 1♀ cl 6.3 mm and MNHN-IU-2018-197, 1♂ cl 3.7 mm; River Mulgrave, near Aloomba, altitude 8 m, 17°08.783'S 145°52.783'E, coll. B. Mos, 7.vi.2016; MNHN-IU-2018-198, 1♀ ovig cl 4.6 mm; Captain Cook Highway crossing, altitude 7 m, 16°22.217'S 145°24.683'E, coll. B. Mos, 14.vi.2016. MNHN-IU-2018-200, 1♀ ovig. cl 4.7 mm; River Johnstone, near Innisfail, altitude 7 m; 17°30.317'S 145°59.517'E, coll. B. Mos 11.vi.2016; MNHN-IU-2018-201, 1♂ cl 3.4 mm (DNA: CA1689); River Barron, Kamerunga, altitude 6 m, 16°52.450'S 145°40.817'E, coll. B. Mos 08.vi.2016; MNHN-IU-2018-203, 1♂ cl 4.5 mm (DNA: CA1700); Gordon's Creek, Cairns, altitude 15 m, 16°57.967'S 145°43.833'E, coll. B. Mos, 3.vi.2016; MNHN-IU-2018-204, 1♂ cl 2.9 mm; River Mowbray, upstream of Diggers Bridge, altitude 18 m, 16°33.800'S 145°27.850'E, coll. B. Mos, 14.vi.2016. MNHN-IU-2018-206, 1♀ ovig. cl 6.5 mm; Tributary of Moody's Creek, near Moorooloolool, altitude 18 m, 16°56.550'S 145°43.700'E, coll. B. Mos, 3.vi.2016. **Indonesia:** Flores Island: Konga: Nusa Tenggara Timur: NMB 1061f, 1♂ cl 2.9 mm; 1♀ cl 4.5 mm (DNA: CA029) and 1♀ cl 4.9 mm; MNHN-IU-2018-207, 1♂ cl 4.4 mm (DNA: CA1348); Lombok Island: not *C. longirostris* NMB 990a, 1♂ cl 4.1 mm and 1♀ ovig. cl 5.9 mm; Sumba Island: East Sumba: Laiwuhi Brook, S. of Melolo, coll. E. Sutter, 31.v.1949. **Taiwan:** MNHN-IU-2018-208, 1♂ cl 3.6 mm (DNA: CA1674); Pingtung, river near Jialeshui Coastal rock formations, altitude 2 m, 21°59.305'N 120°49.956'E, coll. W. and M. Klotz and M.-C. Liu, 25.vii.2013. **Borneo:** MNHN-IU-2018-209, 1♀ cl 4.7 mm (DNA: CA1673); from ornamental shrimp wholesaler in Singapore. **Sri Lanka:** MNHN-IU-2018-210, 1♀ ovig cl 4.8 mm (DNA: CA1825) and MNHN-IU-2018-211, 1♂ cl 3.2 mm; Kandalama Reservoir, near to the shore in dead aquatic plants, altitude 184 m, 07°52.612'N 80°41.503'E, coll. W. Klotz, 8.ii.2017. MNHN-IU-2018-212, 1♀ cl 4.2 mm (DNA: CA1823) and MNHN-IU-2018-213, 1♂ cl 2.8 mm; small stream near Kekirawa, altitude 130 m, 08°2.050'N 80°35.999'E, coll. W. Klotz 8.ii.2017; MNHN-IU-2018-214, 1♀ ovig. cl 3.9 mm and MNHN-IU-2018-215, 1♂ cl 2.6 mm; brackish lagoon, near Maggona, 06°29.920'N 79°58.849'E, coll. W. Klotz, 13.ii.2017.

Diagnosis

Carapace (Fig. 6G, N, O): smooth, glabrous, with sharp antennal spine placed at lower orbital angle. Pterygostomian margin blunt. Rostrum long, 0.8–1.5 of cl, curved up distally, reaching well beyond scaphocerite; 12–23 dorsal teeth closely set, leaving distally unarmed part of rostrum 0.5–1.2 times that of armed part, except for one or two subapical teeth, 1–2 post-orbital teeth present; 7–17 teeth present of the ventral margin extending from proximal end either to tip or with short distal part unarmed. Number of dorsal teeth on the rostrum behind the first ventral tooth 9–15. Rostral formula: (1–2) 12–23 + 1–2 / 7–17.

First pereopod (Fig. 6A): chela ~1.8–2.5 times as long as wide, dactylus 2.8–4.6 times as long as wide, 0.8–1.4 length of palm; carpus 1.8–2.6 times as long as wide with shallow excavation on anterior margin.

Second pereopod (Fig. 6B): more slender and longer than first pereopod, chela 2.4–2.8 times as long as wide, dactylus 3.8–5.1 times as long as wide, 1.1–1.7 times length of palm; carpus 4.4–6.3 times as long as wide.

Third pereopod (Fig. 6C, D): dactylus 3.2–4.6 times as long as wide, terminal spine included, with 7–9 spines on flexor margin in addition to the terminal one; propodus 10.2–16.0 times as long as wide, 3.3–4.5 times as long as dactylus.

Fifth pereopod (Fig. 6E, F): dactylus 4.4–6.6 as long as wide with 34–58 spiniform setae on flexor margin; propodus 15.1–19.9 times as long as wide, 3.4–5.8 as long as dactylus.

Telson (Fig. 6M): broad, posterior margin triangular, ending in a posteromedian projection; one pair of long lateral spiniform setae and 2–3 pairs of intermediate simple setae clearly shorter than lateral simple setae.

First male pleopod (Fig. 6K): endopod leaf-like with or without appendix interna in males.

Second male pleopod (Fig. 6L): appendix masculina on second pleopod reaching 0.62 times length of endopod; appendix interna reaching 0.73 times length of appendix masculina.

Pre-anal carina (Fig. 6I): with a spine.

Uropodal diaeresis (Fig. 6H): with 8–13 short spinules.

Eggs (Fig. 6J): size $0.32\text{--}0.46 \times 0.18\text{--}0.27$ mm.

Colour pattern

The colour of the body is hyaline with many red dots. An oblique punctiform band on the cephalothorax is visible (Fig. 8E, F).

Distribution

Caridina gracilipes is known from Australia (present study), Borneo (Wowor *et al.* 2004; present study), Indonesia (Flores, Selayar, Sulawesi (De Man 1892) and Lombok (present study)), India (Kemp 1918), Peninsular Malaysia (Wowor *et al.* 2004), the Philippines (Cai and Shokita 2006), Singapore (Cai and Ng 2007b), southern China (Kemp 1918; Cai 2014), Sri Lanka (present study), Taiwan (Cai and Shokita 2006; present study) and Vietnam (Li and Liang 2002) (Fig. 2).

Habitat

Caridina gracilipes can be found in lowlands rivers in freshwater, near estuaries in brackish water or in lakes.

Remarks

Specimens of *C. gracilipes* examined for the present study fit well with the descriptions by De Man (1908) of this species: the long rostrum reaching well beyond scaphocerite, curved up distally with

presence of 1–2 post-orbital teeth (vs 2 by De Man 1908); 13–20 dorsal teeth (vs 13–20 by De Man 1908) and 9–17 ventral teeth (vs 11–17 by De Man 1908); P1 carpus 1.7–3.4 (vs 2–2.3 by De Man 1908); P2 carpus 4.4–6.4 (vs 5.4–5.5 by De Man 1908); P3 dactylus with 6–9 spines (vs 9–10 by De Man 1908); propodus 3.5–5.1 as long as dactylus (vs 3.8–4.4 by De Man 1908); P5 dactylus with ~28–58 spiniform setae (vs 46–57 by De Man 1908); propodus 14.3–27.4 times long as width (vs 17–19 by De Man 1908) and propodus 3.2–5.4 times as long as dactylus (vs 3.7–3.8 by De Man 1908).

Our specimens agree with the description given by Richard and Clark (2014), with a bifid slender rostrum 0.8–1.7 of cl (vs 1.0–1.1 by Richard and Clark 2014); 13–20 dorsal teeth (vs 12–24 by Richard and Clark 2014) and 9–17 ventral teeth (vs 12–21 by Richard and Clark 2014); P1 carpus 1.7–3.4 (vs 1.9–2.2 by Richard and Clark 2014); P2 carpus 4.4–6.4 (vs 5.5–6.3 by Richard and Clark 2014); P3 propodus 3.5–5.1 as long as dactylus (vs 3.5–5.3 by Richard and Clark 2014); P5 dactylus 3.2–5.4 times long as wide (vs 3.3–4.3) with 28–58 spiniform setae (vs 55–70 by Richard and Clark 2014); small eggs $0.32\text{--}0.42 \times 0.20\text{--}0.18$ mm (vs $0.35\text{--}0.39 \times 0.19\text{--}0.23$ mm by Richard and Clark 2014); pre-anal carina with a spine; diaeresis with 9–13 spinules (vs 9–12 by Richard and Clark 2014). Our material also compare well with the study of Cai and Shokita (2006) with 13–20 dorsal teeth rostrum (vs 11–27 by Cai and Shokita 2006) and 9–17 ventral teeth (vs 8–18 by Cai and Shokita 2006); P1 carpus 1.7–3.4 (vs 2.0–2.5 by Cai and Shokita 2006); P2 carpus 4.4–6.4 (vs 5.4–6.3 by Cai and Shokita 2006); P3 propodus 3.5–5.1 as long as dactylus (vs 3.8–4.4 by Cai and Shokita 2006); P5 dactylus 3.6–5.3 times long as wide (vs 3.1–3.8 by Cai and Shokita 2006) with 28–58 spiniform setae (vs 36–57 by Cai and Shokita 2006); smaller eggs ($0.32\text{--}0.43 \times 0.18\text{--}0.25$ mm vs $0.42\text{--}0.53 \times 0.23\text{--}0.33$ mm by Cai and Shokita 2006); pre-anal carina with a spine and diaeresis with 9–13 spinules (vs 8–12 by Cai and Shokita 2006).

Comparison

In comparison with *C. longirostris*, *C. gracilipes* has a similar rostral formula, (1–2) 12–23 + 1–2 / 7–17 (vs (1–2) 14–17 + 1 / 14–17 for *C. longirostris*) but the number of dorsal teeth on the rostrum behind the first ventral tooth is greater, 9–15 (vs 9–12 for *C. longirostris*); P1 and P2 carpus are respectively longer, 1.7–2.6 and 4.4–6.3 (vs 1.4–1.8 and 3.9–4.7 for *C. longirostris*) and P5 propodus 3.3–4.5 times as long as dactylus (vs 3.2–3.7 for *C. longirostris*).

Caridina gracilipes is distinguishable from *C. meridionalis* by the P1 carpus being shorter, 1.7–2.6 (vs 2.3–3.5 in *C. meridionalis*) and smaller eggs, $0.32\text{--}0.46 \times 0.18\text{--}0.27$ mm (vs $0.34\text{--}0.75 \times 0.24\text{--}0.48$ mm in *C. meridionalis*).

Caridina meridionalis Roux, 1926

(Fig. 7)

Caridina nilotica var. *meridionalis* J. Roux, 1926a: 207, partim.

Caridina meridionalis Richard & Clark, 2014: 321–323, figs 11–12.

Caridina coulaborensis Richard & Clark, 2014: 324–326, fig. 13.

Caridina fritzi Richard & Clark, 2014: 326–329, fig. 14.

Caridina solamulieres Richard & Clark, 2014: 329–331, fig. 15.

Not *Caridina nilotica* var. *meridionalis* Roux, 1926b: 246–247.

Material examined

Holotype. *Caridina coulaborensis* Richard & Clark, 2014. New Caledonia: River Coula, near Boréaré, NMB 1057a, 1♂ cl 4.1 mm (DNA: CA064); coll. F. Sarasin and J. Roux, 6.ii.1912.

Paratype. *Caridina coulaborensis* Richard & Clark, 2014, 1♀ ovig. cl 5.0 mm; NMB 1057b, 1♀ cl 5.8 mm; same data as holotype.

Paratypes. *Caridina coulaborensis* Richard & Clark, 2014. NMB 1057c, 1♂ 4.3 mm and 1♀ cl 5.0 mm; Koné, coll. F. Sarasin and J. Roux, 9.viii.1911; NMB 1057d, 1♂ cl 2.6 mm and 1♀ cl 4.4 mm (DNA: CA048); La Foa, coll. F. Sarasin and J. Roux, 16.i.1912.

Holotype. *Caridina fritzi* Richard & Clark, 2014. New Caledonia: River Coula, near Boréaré, NMB 1058a, 1♂ cl 2.8 mm; coll. F. Sarasin and J. Roux, 6.ii.1912.

Paratypes. *Caridina fritzi* Richard & Clark, 2014, New Caledonia: Coindé, NMB 1058c, 2♂ cl 2.5 mm (DNA: CA052) and 2.6 mm (DNA: CA053); coll. F. Sarasin and J. Roux, 12.i.1912.

Holotype. *Caridina solamulieres* Richard & Clark, 2014, New Caledonia: Tiouaka, NMB 1059a, 1♀ cl 4.5 mm; coll. F. Sarasin and J. Roux, 20.viii.1911.

Lectotype. *Caridina meridionalis* Roux, 1926. New Caledonia: near Pemboa, NMB 1056a, 1♂ cl 2.7 mm; coll. F. Sarasin and J. Roux, 1.v.1911;

Paralectotype. *Caridina meridionalis* Roux, 1926. NMB 1056b, 1♀ ovig cl 4.2 mm and 1♀ cl 4.1 mm; same data as lectotype.

Other material examined. **New Caledonia:** River Iouanga, 20°41.032'S 164°23.676'E, MNHN-IU-2018-216, 1♀ ovig. cl 4.2 mm; coll. V. de Mazancourt, 9.xi.2016; River Hienghène: MNHN-IU-2018-217, 1♂ cl 3.7 mm (DNA: CA1726), 20°44.058'S 164°54.061'E, coll. V. de Mazancourt, 14.xi.2016; River Dumbea, altitude 4 m, 22°08.332'S 166°28.013'E, MNHN-IU-2018-218, 1♀ ovig. cl 4.0 mm, MNHN-IU-2018-219, 1♀ ovig. cl 5.0 mm (DNA: CA1575) and MNHN-IU-2018-220, 1♂ cl 3.7 mm; coll. G. Marquet and V. de Mazancourt, 16.xi.2016; River La Foa, altitude 6 m, 21°39.051'S 165°55.202'E, MNHN-IU-2018-221, 1♀ ovig. cl 5.6 mm and MNHN-IU-2018-222, 1♀ ovig. cl 6.5 mm (DNA: CA1610), coll. G. Marquet and V. de Mazancourt, 27.xi.2016; River Courrie, altitude 6 m, 21°34.676'S 165°29.716'E, MNHN-IU-2018-223, 1♀ ovig. cl 5.3 mm (DNA: CA1621); coll. G. Marquet and V. de Mazancourt, 28.xi.2016; River Coula, altitude 240 m, 21°21.656'S 165°20.370'E, MNHN-IU-2018-224, 1♂ cl 4.3 mm; coll. G. Marquet and V. de Mazancourt,

26.xi.2016; River La Couvelée, altitude 21 m, 22°07.778'S 166°28.014'E, MNHN-IU-2018-225, 1♂ cl 3.9 mm, coll. G. Marquet and V. de Mazancourt, 16.xi.2016.

C. nilotica var. *gracilipes*. NMB 1061h, 1♂ cl 3.7 mm; River La Foa, coll. F. Sarasin and J. Roux, 16.i.1912; NMB 1061 g, 1♀ ovig. cl 4.5 mm, 2♀ cl 3.6–4.4 mm and 2♂ cl 2.9–3.4 mm; Koné, coll. Sarasin and Roux, 9.viii.1911.

Caridina wyckii var. *gracilipes* De Man, 1892 **New Caledonia**: BPBM S5060, 1♀ cl 4.2 mm, coll. F. X. Williams, 1940.

Comparative material. *Caridina brachydactyla* De Man, 1908.

Type material. Indonesia: *Caridina nilotica* var. *brachydactyla* De Man, 1908.

Lectotype. Indonesia: Flores Island: river near Reo, RMNH.CRUS.D.977, 1♀ ovig cl 4.8 mm; coll. M. Weber.

Paralectotypes. Indonesia: Sulawesi: Luwu: river near Palopo, RMNH.CRUS.D.2552, 2♀ ovig cl 5.3–5.4 mm, coll. M. Weber.

Other material. **Indonesia**: Bali: *C. brachydactyla*: NMB 1054a, 1♀ cl 5.8 mm (DNA: CA037); coll. P. Wirz, 1926; WK 63–10, 2♂ cl 2.7 mm (DNA: CA1129) and 3.7 mm (DNA: CA1130) 1♀ ovig cl 4.3 mm and 1♀, cl 4.8 mm; Palopo, Macaui, Sulawesi, 02°55.210'S 120°10.758'E, coll. W. Klotz, 2010; Palopo, Tojo, Sulawesi, WK 64–10–3 1♀ ovig cl 4.0 mm (DNA: CA1131), coll. W. Klotz, 2010.

Caridina nilotica var. *meridionalis*. **Australia**: Cari Creek: Cook Town: N. Queensland, NMB 1054d, 1♂ cl 4.7 mm, 1♀ ovig cl 5.6 mm and 2♀ cl 5.8–6.5 mm; 1923.

Diagnosis

Carapace (Fig. 7G, N, O): smooth, glabrous, with sharp antennal spine placed at lower orbital angle. Pterygostomian margin blunt. Rostrum variable, 0.8–2.1 of cl, reaching sometimes well beyond scaphocerite; 16–26 dorsal teeth, leaving distally unarmed part of rostrum 0.8–2.1 times that of armed part, except for 1–3 subapical teeth, 1–3 post-orbital teeth; 5–33 teeth on the ventral margin extending from proximal end either to tip or with short distal part unarmed. Number of dorsal teeth on the rostrum behind the first ventral tooth 10–15. Rostral formula: (1–3) 16–26 + 1–3 / 5–33.

First pereopod (Fig. 7A): slender, chela ~2.0–2.7 times as long as wide, dactylus 2.8–4.6 times as long as wide, 1.1–1.7 length of palm; carpus 2.3–3.5 times as long as wide with shallow excavation on anterior margin.

Second pereopod (Fig. 7B): more slender and longer than first pereopod; chela 2.1–3.4 times as long as wide, dactylus 3.5–5.7 times as long as wide, 1.2–1.9 times length of palm; carpus 4.1–6.2 times as long as wide.

Third pereopod (Fig. 7C, D): dactylus 3.2–4.3 times as long as wide, terminal spine included, with 6–9 spines on flexor margin in addition to the terminal one; propodus 12.4–19.8 times as long as wide, 3.9–5.8 times as long as dactylus.

Fifth pereopod (Fig. 7E, F): dactylus 4.4–6.6 times as long as wide with 42–58 spiniform setae on flexor margin; propodus 15.3–22.7 times as long as wide, 3.2–5.3 times as long as dactylus.

Telson (Fig. 7M): variable, mostly rounded without a median process, rarely triangular with a median process; 3–4 pairs of distal simple setae, intermediate setae slightly shorter or slightly longer than the lateral setae.

Pre-anal carina (Fig. 7I): armed with a spine.

First male pleopod (Fig. 7K): leaf-like endopod with well-developed appendix interna.

Second male pleopod (Fig. 7L): appendix masculina on second pleopod reaching 0.56 times length of endopod; appendix interna reaching 0.85 times length of appendix masculina.

Uropodal diaeresis (Fig. 7H): with 7–13 spinules.

Eggs (Fig. 7J): size 0.34–0.75 × 0.24–0.48 mm.

Colour pattern

Colour varies in live specimens and tends to match their background. The colour of the body is hyaline with many red dots. The colouration is lost on preserved material (Fig. 8G, H).

Distribution

Caridina meridionalis is endemic to New Caledonia (Roux 1926a; present study) (Fig. 2).

Habitat

All specimens were collected in rivers, from the estuary in brackish water to the upper middle course in freshwater.

Remarks

Our specimens of *C. meridionalis* agree with those of Richard and Clark (2014) in accordance with the slender rostrum, length 0.8–2.1 times length of the carapace (vs 0.75–1 by Richard and Clark 2014); with 16–26 dorsal teeth (vs 11–27 by Richard and Clark 2014) and 5–33 ventral teeth (vs 4–17 by Richard & Clark 2014); P1 carpus 2.3–3.5 (vs 1.8–2.4 by Richard and Clark 2014); P2 carpus 4.1–6.2 (vs 4.5–5.5 by Richard and Clark 2014); P3 propodus 3.9–5.8 times as long as dactylus (vs 5.0–7.0 by Richard and Clark 2014); P5 dactylus 4.4–6.6 times long as wide (vs 2–4.2 by Richard and Clark 2014) with 42–62 spiniform setae (vs 45–60 by Richard and Clark 2014); larger eggs 0.34–0.75 × 0.24–0.48 mm (vs 0.60–0.65 × 0.35–0.43 mm by Richard and Clark 2014); pre-anal carina with a spine and diaeresis with 7–13 spinules (vs 9–14 by Richard and Clark 2014).

Jean Roux (1926b) described *C. meridionalis* from Australia. Agreeing with Richard and Clark (2014), these Australian specimens differ from the type specimens of *C. meridionalis* with respect to the following characters, short P1 carpus, 2.1–2.4 (vs 2.3–3.5 for types); short P3 dactylus, 3.1–3.4 (vs 3.2–4.3 for types); smaller eggs, $0.40\text{--}0.43 \times 0.18\text{--}0.27$ mm (vs $0.34\text{--}0.75 \times 0.24\text{--}0.48$ mm for types) and its triangular posterior margin with median process, bearing one pair of long lateral simple setae and two pairs of intermediate simple setae that are shorter than the laterals (vs mostly rounded without a median process rarely triangular with a median process; 3–4 pairs of distal spiniform setae, intermediate spiniform setae slightly shorter or slightly longer than the lateral spiniform setae). Contrary to Richard and Clark (2014), who considered them to be *C. brachydactyla*, we identified them as *C. gracilipes* because of their short P1 chela, 2–2.1 (vs 2.1–2.3 in *C. brachydactyla*); short P2 chela 2.4–2.9 (vs 2.7–3.2 in *C. brachydactyla*); P3 dactylus with 8–9 spines on the flexor margin in addition to the terminal one (vs 5–7 in *C. brachydactyla*) and P5 dactylus with 50–67 spiniform setae on the flexor margin (vs 32–42 in *C. brachydactyla*).

We observed a great variation in egg size (Table 2), with the specimens with the biggest eggs collected at the higher altitudes. This phenomenon has been shown in *Paratya australiensis* (Hancock 1998) and is supposed to have appeared to maintain the population at higher altitudes, preventing the drift of the larvae down to the sea.

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Fig. 1. Bayesian 16S rRNA phylogenetic tree showing the relationships of some of the species discussed in this study. Numbers above branches indicate Bayesian posterior probabilities; numbers under branches indicate maximum likelihood bootstrap values.

Fig. 2. Distribution map of the five species re-described in this study. Shapes marked with a dot indicate type localities. For *Caridina longirostris* H. Milne Edwards, 1837, the dashed star indicates the previously accepted type locality; the full star indicates the new proposed type locality.

Fig. 3. *Caridina longirostris* H. Milne Edwards, 1837: (A) first pereopod; (B) second pereopod; (C) third pereopod; (D) dactylus of third pereopod; (E) fifth pereopod; (F) dactylus of fifth pereopod; (G) anterior region of cephalothorax; (H) uropodal diaeresis; (I) pre-anal carina; (J) eggs; (K) first male pleopod; (L) second male pleopod; (M) telson.

Fig. 4. *Caridina appendiculata* Jaliha & Shenoy, 1998: (A) first pereopod; (B) second pereopod; (C) third pereopod; (D) dactylus of third pereopod; (E) fifth pereopod; (F) dactylus of fifth pereopod; (G) anterior region of cephalothorax; (H) uropodal diaeresis; (I) pre-anal carina; (J) eggs; (K) first male pleopod; (L) second male pleopod; (M) telson; (N, O) rostrum variations.

Fig. 5. *Caridina brevidactyla* Roux, 1920: (A) first pereopod; (B) second pereopod; (C) third pereopod; (D) dactylus of third pereopod; (E) fifth pereopod; (F) dactylus of fifth pereopod; (G) anterior region of cephalothorax; (H) uropodal diaeresis; (I) pre-anal carina; (J) eggs; (K) first male pleopod; (L) second male pleopod; (M) telson; (N, O) rostrum variations.

Fig. 6. *Caridina gracilipes* De Man, 1892: (A) first pereopod; (B) second pereopod; (C) third pereopod; (D) dactylus of third pereopod; (E) fifth pereopod; (F) dactylus of fifth pereopod; (G) anterior region of cephalothorax; (H) uropodal diaeresis; (I) pre-anal carina; (J) eggs; (K) first male pleopod; (L) second male pleopod; (M) telson; (N, O) rostrum variations.

Fig. 7. *Caridina meridionalis* Roux, 1926: (A) first pereopod; (B) second pereopod; (C) third pereopod; (D) dactylus of third pereopod; (E) fifth pereopod; (F) dactylus of fifth pereopod; (G) anterior region of cephalothorax; (H) uropodal diaeresis; (I) pre-anal carina; (J) eggs; (K) first male pleopod; (L) second male pleopod; (M) telson; (N, O) rostrum variations.

Fig. 8. Views of live specimens showing their colouration: (A, B) *Caridina appendiculata* Jaliha & Shenoy, 1998; (C, D) *C. brevidactyla* Roux, 1920; (E, F) *C. gracilipes* De Man, 1892; (G, H) *C. meridionalis* Roux, 1926. Credits: Philippe Keith (A, B, C); Valentin de Mazancourt (D, G, H); Werner Klotz (E, F).

Table 1. List of the *Caridina* specimens used in the genetic study

Species	Locality	Previous ID	DNA voucher	Museum no.	Type status	GenBank no.	Reference
<i>C. appendiculata</i>	Australia	<i>C. sp. indistincta</i> E	CA1708	MNHN-IU-2018-126		MH497543	This study
			GU0170			AY795051	Page <i>et al.</i> 2005
			CA1665	MNHN-IU-2018-121		MH497530	This study
			CA1667	MNHN-IU-2018-118		MH497531	This study

<i>C. sp. indistincta E</i>	Micronesia		CA1668	MNHN-IU-2018-117	MH497532	This study
			GUC186		DQ478526	Page <i>et al.</i> 2007
			CA1669	MNHN-IU-2018-125	MH497533	This study
			CA1670	MNHN-IU-2018-124	MH497534	This study
			CA1333	MNHN-IU-2018-129	MH497517	This study
			CA1330	MNHN-IU-2018-130	MH497516	This study
			CA1021	MNHN-IU-2018-127	MH497499	This study
			CA1494	MNHN-IU-2018-135	MH497525	This study
			CA1493	MNHN-IU-2018-133	MH497524	This study
			CA1216	MNHN-IU-2018-151	MH497504	This study
			CA1139	MNHN-IU-2018-152	MH497503	This study
			CA1218	MNHN-IU-2018-153	MH497505	This study
			CA1219	MNHN-IU-2018-154	MH497506	This study
			CA1220	MNHN-IU-2018-155	MH497507	This study
			CA1264	MNHN-IU-2018-143	MH497511	This study
			CA1268	MNHN-IU-2018-144	MH497512	This study
			CA1489	MNHN-IU-2018-140	MH497523	This study
			CA1378	MNHN-IU-2018-142	MH497521	This study
			CA1259	MNHN-IU-2018-156	MH497509	This study
			CA1261	MNHN-IU-2018-157	MH497510	This study
<i>C. brachydactyla</i>	Bali Sulawesi	Topotypical	CA037	NMB 1054a	MH497490	This study
			CA1129	WK 63-10	MH497500	This study
		Topotypical	CA1130	WK 63-10-1	MH497501	This study
		Topotypical	CA1131	WK 63-10-3	MH497502	This study
<i>C. brevidactyla</i>	Fiji	<i>C. longirostris</i>	CA017	RMNH.CRU S.D.54674	MH497484	This study
			CA1426	MNHN-IU-2018-159	MH497522	This study
	New Caledonia		CA1785	MNHN-IU-2018-166	MH497546	This study
			CA1788	MNHN-IU-2018-167	MH497547	This study
			CA1007	MNHN-IU-2018-161	MH497498	This study
	Papua New Guinea	<i>C. nilotica brevidactyla</i>	GUC358		DQ478539	Page <i>et al.</i> 2007
		<i>C. nilotica brevidactyla</i>	GUC529		DQ478540	Page <i>et al.</i> 2007

<i>C. gracilipes</i>	Solomon Islands	<i>C. nilotica gracilipes</i>	CA1305	MNHN-IU-2018–168		MH497514	This study
			CA1345	MNHN-IU-2018–172		MH497518	This study
			CA1346	MNHN-IU-2018–171		MH497519	This study
			CA1940	MNHN-IU-2018–185		MH497558	This study
			CA1302	MNHN-IU-2018–175		MH497513	This study
	Vanuatu		CA1307	MNHN-IU-2018–188		MH497515	This study
			CA1232	MNHN-IU-2018–191		MH497508	This study
	?					NC_024751	Xu <i>et al.</i> 2016
	Australia		CA1689	MNHN-IU-2018–201		MH497538	This study
			CA1690	MNHN-IU-2018–202		MH497539	This study
			CA1695	MNHN-IU-2018–205		MH497541	This study
			CA1700	MNHN-IU-2018–203		MH497542	This study
			CA1694	MNHN-IU-2018–199		MH497540	This study
	Borneo		CA1673	MNHN-IU-2018–209		MH497535	This study
	Flores		CA029	NMB 1061f 1		MH497489	This study
	Lombok		CA1348	MNHN-IU-2018–207		MH497520	This study
	Sulawesi		CA023	ZMA.CRUS .D.102635 1	Paralectotype	MH497485	This study
			CA024	ZMA.CRUS .D.102635 2	Paralectotype	MH497486	This study
			CA025	ZMA.CRUS .D.102635 3	Paralectotype	MH497487	This study
			CA027	ZMA.CRUS .D.102635 5	Paralectotype	MH497488	This study
					von Rintelen <i>et al.</i> 2012		
			ZMB 29016		FN995358		
	Sri Lanka	CA1825	MNHN-IU-2018–210		MH497549	This study	
		CA1826	MNHN-IU-2018–211		MH497550	This study	
		CA1823	MNHN-IU-2018–212		MH497548	This study	
	Taiwan	CA1674	MNHN-IU-2018–208		MH497536	This study	
<i>C. grandirostris</i>	Indonesia	GUCKZ 252			DQ478528	Page <i>et al.</i> 2007	
	Japan	CA1893	ZRC 2004.0530 1		MH497553	This study	
		CA1891	ZRC 2004.0519 3		MH497551	This study	
		CA1892	ZRC 2004.0519 4		MH497552	This study	
	Taiwan	CA1676	MNHN-IU-		MH497537	This study	

<i>C. leucosticta</i>	Japan		CA1912	2018–195 MNHN-IU- 2018–229		MH497556	This study
			CA1913	MNHN-IU- 2018–230		MH497557	This study
			CA1894	ZRC 2004.0530 2		MH497554	This study
			CA1896	ZRC 2004.0530 4		MH497555	This study
<i>C. meridionalis</i>	New Caledonia	<i>C. coulalorensis</i>	CA064	NMB 1057a 2	Holotype	MH497497	This study
			CA1572	MNHN-IU- 2018–226		MH497526	This study
			CA1573	MNHN-IU- 2018–227		MH497527	This study
			CA1575	MNHN-IU- 2018–219		MH497528	This study
		<i>C. cf. meridionalis</i>	GUC467			DQ478492	Page <i>et al.</i> 2007
			CA1726	MNHN-IU- 2018–217		MH497544	This study
			CA1772	MNHN-IU- 2018–228		MH497545	This study
			CA048	NMB 1057d 2	Paratype	MH497491	This study
		<i>C. coulalorensis</i>	CA049	NMB 1057e 1	Paratype	MH497492	This study
			CA050	NMB 1057e 2	Paratype	MH497493	This study
			CA051	NMB 1057e 3	Paratype	MH497494	This study
			CA052	NMB 1058c 1	Paratype	MH497495	This study
		<i>C. fritzi</i>	CA053	NMB 1058c 2	Paratype	MH497496	This study
			CA1610	MNHN-IU- 2018–222		MH497529	This study

Table 2. Comparison of the egg size of different specimens of *Caridina meridionalis*

Specimen	Altitude (m)	Development stage	Size (mm)
NMB 1056b lectotype of <i>C. meridionalis</i>	250	Early stage	0.57–0.60 × 0.35–0.40
NMB 1061 g 4	11	Early stage	0.39–0.42 × 0.26–0.29
CA1575	0	Early stage	0.46–0.50 × 0.26–0.27
CA1576	0	Early stage	0.46–0.50 × 0.27–0.29
CA1609	0	Eyes visible	0.45–0.49 × 0.26–0.28
CA1610	0	Early stage	0.43–0.44 × 0.26–0.27
CA1621	0	Early stage	0.35–0.40 × 0.24–0.26
CA1725	4	Eyes visible	0.40–0.45 × 0.24–0.26
NMB 1057a paratype of <i>C. coulalorensis</i>	250	Early stage	0.66–0.76 × 0.42–0.48
NMB 1057c 1 paratype of <i>C. coulalorensis</i>	250	Early stage	0.72–0.76 × 0.45–0.49