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On a new species of the genus *Cyprinotus* (Crustacea, Ostracoda) from a temporary wetland in New Caledonia (Pacific Ocean), with a reappraisal of the genus

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Abstract. The New Caledonia archipelago is known for its high level of endemism in both faunal and floral groups. Thus far, only 12 species of non-marine ostracods have been reported. After three expeditions to the main island of the archipelago (Grande Terre), about four times as many species were found, about half of which are probably new. Here, we describe a new species, *Cyprinotus drubea* sp. nov., which is characterised mainly by the hyper-developed dorsal hump on the right valve, much larger than in any other known Recent species in this genus. After a literature study of the other presumed species in *Cyprinotus* Brady, 1886, we retain seven Recent species in the genus, including the present new species. *Cyprinotus crenatus* (Turner, 1893), *C. dentatus* (Sharpe, 1910), *C. flavescens* Brady, 1898, *C. inconstans* Furtos, 1936, *C. newmexicoensis* Ferguson, 1967, *C. ohanopecoshensis* Ferguson, 1966, *C. pellucidus* (Sharpe, 1897), *C. scytodus* (Dobbin, 1941) and *C. sulphurous* Blake, 1931 are here all referred to the genus *Heterocypris* s. lat. Claus, 1892. *Cyprinotus unispinifera* Furtos, 1936 is assigned to the genus *Cypricercus* Sars, 1895. *Cyprinotus tenuis* Henry, 1923, *C. fuscus* Henry, 1919 and *C. carinatus* (King, 1855) are here classified as doubtful species. A checklist of the 14 non-marine ostracods, now including *Cyprinotus drubea* sp. nov. and *Cypris granulata* (Daday, 1910), thus far reported from New Caledonia, is provided. *Herpetocypris caledonica* Méhes, 1939 and *H. caledonica* var. *minor* Méhes, 1939 are synonymised with *Candonocypris novaezelandiae* (Baird, 1843).

Keywords. Living non-marine Ostracoda, *Heterocypris*, taxonomy, morphology, new combinations, doubtful species.

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Introduction

Owing to the geological history of New Caledonia, situated in the Pacific Ocean, to the east of Australia, the flora and fauna of the archipelago has a high proportion of endemism, which has attracted the attention of botanists, zoologists and biogeographers (Grandcolas 2017). The taxonomy and ecology of larger organisms, such as higher plants (Morat 1993), birds (Dutson 2011) and even freshwater molluscs (Haase & Bouchet 1998) and Trichoptera (Johanson & Ward 2009; Johanson 2017), are relatively well known. Smaller organisms, such as ostracods, on the other hand, were largely overlooked in the past. Only 12 species of non-marine ostracods have thus far been reported from this archipelago (Table 1).

During the past 3 years (2016–2018), the Muséum national d'Histoire naturelle (Paris, France) organised the New Caledonia Hydrobiological expeditions under the 'Our Planet Reviewed / La Planète revisitée' programme. Two of the present authors, Janet Higuti (JH) and Koen Martens (KM), participated in these expeditions and collected more than 350 samples from a variety of water bodies and have found close to 50 species of living non-marine Ostracoda of which about half are expected to be new to science. Here, we describe a new species of the circumtropical genus *Cyprinotus* Brady, 1886. The other (new) species found during these expeditions will be reported on elsewhere.

The genus *Cyprinotus* has a complex history (Purper & Würdig-Maciel 1974; Malz 1976; Neale 1979), as many species that are now assigned to the genus *Heterocypris* Claus, 1892 were originally described in *Cyprinotus*. The only difference between the two genera is that in *Cyprinotus* species, the right valve overlaps the left valve with a dorsal expansion (hump), which is absent in species of *Heterocypris*. Other features, e.g., the presence of marginal tubercles on the right valve and the fact that the larger left valve overlaps the right valve on all other sides, are also present in *Heterocypris*. The confusion between the two genera is largely owing to the fact that the original description of the type species, *C. cingalensis* by Brady (1886) from the South Asian island Ceylon (now Sri Lanka) was very brief, and the illustrations so minuscule that the dorsal overlap was hardly visible, leading many authors to see *Heterocypris* as a younger synonym of *Cyprinotus*. In his *Index and Bibliography of nonmarine Ostracoda*, Kempf (1980, 1997) listed 200 and 89 species of *Cyprinotus*, respectively (both living and fossil species included). The recent global checklist by Meisch *et al.* (2019) retained 17 living species of *Cyprinotus*. After a literature review, the present paper proposes to retain only seven living species in this genus, including the new species here described (Table 2).

Material and methods

New Caledonia is an archipelago in the southwest Pacific. It is located 1500 km to the north of New Zealand and 1500 km to the east of Australia. It comprises the main island of Grande Terre, the Loyalty Islands (Maré, Lifou, Tiga and Ouvéa) and other smaller islands, such as Ile des Pins and Ile Belep. Grande Terre, from which the samples for the current study were obtained, represents the emergent parts of the Norfolk Ridge. New Caledonia lies just north of the Tropic of Capricorn within latitudes 18° and 23° south and longitudes 158° and 172° east (Rawling 2009).

The present material was collected by JH and KM during the 2018 expedition to New Caledonia, organised by the Muséum national d'Histoire naturelle (Paris, France – see Acknowledgements). Ostracods were collected by moving a rectangular hand net (28 cm × 14 cm, mesh size ~160 µm) either over sediment (to whirl up the top layers with living biota) or amidst aquatic vegetation. We measured

Table 1. Non-marine ostracod species known from New Caledonia.

Species	Locality	Reference
Darwinulidae		
Penthesilenula brasiliensis (Pinto & Kotzian, 1961)	Hienghène, Mt. Panié	Martens & Rossetti 2002
Vestalenula marmonieri Rossetti & Martens, 1999	River Diahot, Ouegoa	Rossetti & Martens 1999
Cytherideidae		
? *Cyprideis australiensis* Hartmann, 1978	Grande Terre	Hoibian *et al.* 2000, 2002
Cyprideis consobrina (Brady, 1890)	Noumea	Brady 1890
Notodromadidae		
Kennethia major (Méhes, 1939)	Canala	De Deckker 1979; Maddocks 2007; this paper
As *Notodromas major* Méhes, 1939		Méhes 1939
Cyprididae		
? *Cyprinotus cingalensis* Brady, 1886	Loyalty Isl., Ovéa	Neale 1979
Cyprinotus drubea sp. nov.	Poindimié	this paper
Cypris granulata (Daday, 1910)	comm. Paita	this paper
Eucypris wolfhügeli Méhes, 1914	Loyalty Isl., Ovéa	Méhes 1939
Strandesia rouxi Méhes, 1939	Koné, Canala, La Foa	Méhes 1939
Candonocypris novaezelandiae (Baird, 1843)	La Foa	this paper
Syn. nov.: *Candonopsis caledonica*		Meisch *et al.* 2007
Syn. nov.: *Herpetocypris caledonica* Méhes, 1939		Méhes 1939
Syn. nov.: *Candonocypris caledonica* (Méhes, 1939)		De Deckker 1981
Syn. nov.: *Herpetocypris caledonica* var. *minor* Méhes, 1939		Méhes 1939
Stenocypris major (Baird, 1859)	Canala, Koné	this paper
As *Stenocypris malcolmsoni* Brady, 1886		Méhes 1939
Stenocypris marginata Daday, 1910	Koné, Canala, La Foa	Méhes 1939
Cypridopsis sarasini Méhes, 1939	Loyalty Isl., Ovéa	Méhes 1939

Table 2. Species retained in *Cyprinotus* s. str. (* = type species). AT: Afrotropical; AU: Australasian; OL: Oriental; PA: Palaeartic; PAC: Pacific Oceanic Islands.

* *Cyprinotus cingalensis* Brady, 1886	AT, OL, PAC?
Cyprinotus dahli Sars, 1896	AU
Cyprinotus edwardi McKenzie, 1978	AU
Cyprinotus indicus Battish, 1981	OL
Cyprinotus kimberleyensis McKenzie, 1966	AU, OL, PA
Syn.: *Cyprinotus setoensis* Okubo, 1990 (*fide* Okubo 2004)	
Cyprinotus drubea sp. nov.	PAC
Cyprinotus uenoi Brehm, 1936	OL, PA

pH (VWR pH 1100H) and electrical conductivity / water temperature (VWR CO 3100H) *in situ*. The position of the type locality is illustrated in Fig. 1.

Soft parts were separated from the valves using dissection needles and were then put in a drop of glycerine for the dissection of the appendages. The dissection was covered with a cover-slip and sealed with transparent nail polish. Valves were stored dry in micropalaeontological slides. Drawings of soft

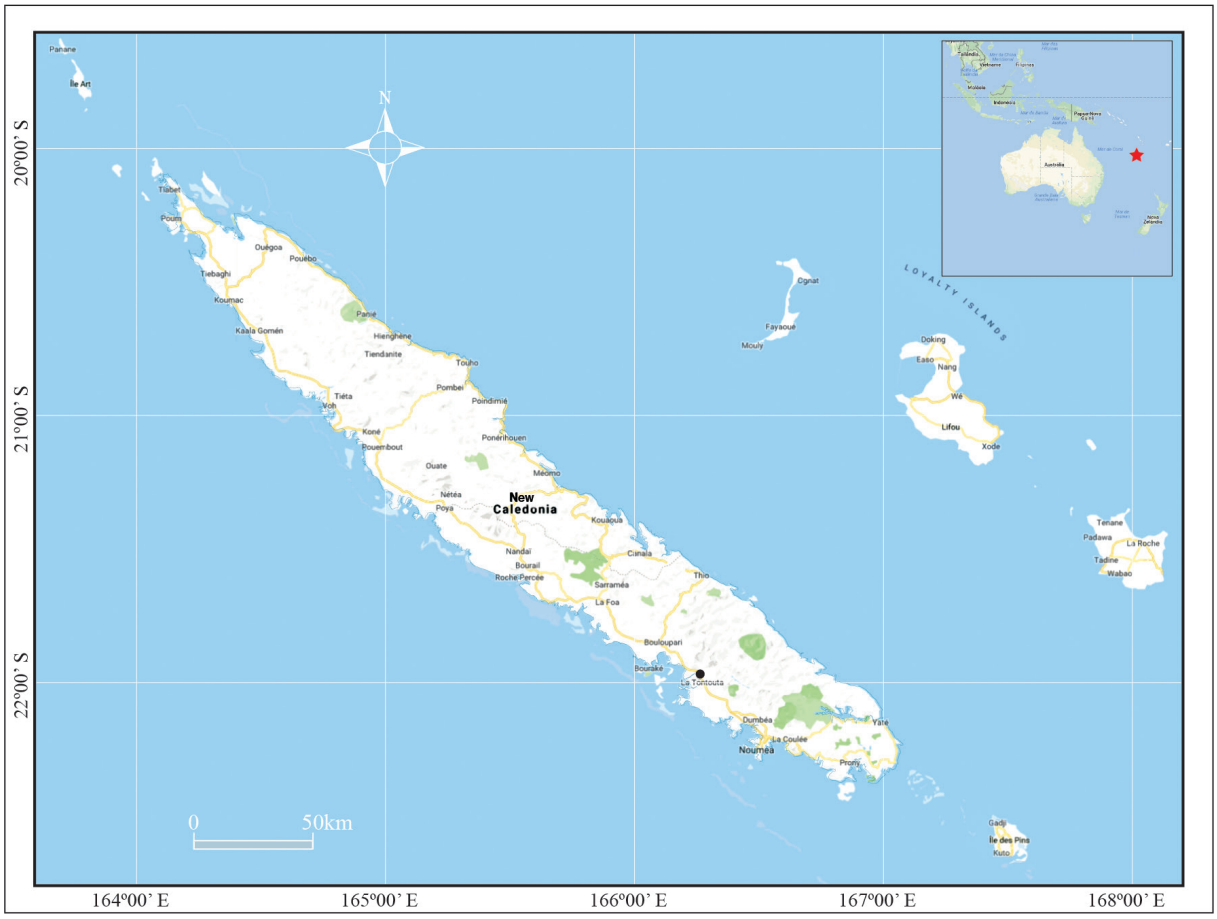

Fig. 1. Map of New Caledonia, showing type locality on Grande Terre, near La Tontouta.

parts were made using a camera lucida (Olympus U-DA) attached to the microscope (Olympus CX-41). Carapace and valves were illustrated and measured using Scanning Electron Microscopy (SEM; Fei Qanta 200 ESEM, in the Royal Belgian Institute of Natural Sciences, Brussels, Belgium) in different views and details.

Type material is lodged in the Muséum national d'Histoire naturelle (Paris, France) and in the Royal Belgian Institute of Natural Sciences (Brussels, Belgium).

Repositories

MNHN = Muséum national d'Histoire naturelle, Paris, France.
RBINS = Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

Abbreviations used in text and figures

Valves and carapaces

Cp = carapace
CpD = carapace in dorsal view
CpLL = carapace in left lateral view
CpRL = carapace in right lateral view
CpV = carapace in ventral view
H = height of valves
L = length of valves
LV = left valve
LVi = left valve in internal view
RV = right valve
RVi = right valve in internal view
W = width of valves

Limbs

A1 = antennula
A2 = antenna
CR = caudal ramus
Md = mandibula
Md-palp = mandibular palp
Mx1 = maxillula
T1 = first thoracopod
T2 = second thoracopod
T3 = third thoracopod

The nomenclature of the limb chaetotaxy follows Broodbakker & Danielopol (1982), for the second antenna the revised model proposed by Martens (1987), and for the second and third thoracopods Meisch's nomenclature (2000). Higher taxonomy of the Ostracoda follows the synopsis by Horne *et al*. (2002).

Results

Class Ostracoda Latreille, 1802
Subclass Podocopa G.O. Sars, 1866
Order Podocopida G.O. Sars, 1866
Suborder Cypridocopina G.O. Sars, 1866
Superfamily Cypridoidea Baird, 1845
Family Cyprididae Baird, 1845
Subfamily Cyprinotinae Bronstein, 1947

Genus ***Cyprinotus*** Brady, 1886

Type species

Cyprinotus cingalensis Brady, 1886.

Cyprinotus drubea sp. nov.
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Figs 2–7

Diagnosis

A species typical of the genus, with the larger LV overlapping the RV along the anterior, ventral and posterior margins and with anterior and posterior margins of the RV set with row of strong tubercles. RV dorsally overlapping LV with a very large, rounded hump, which is dorsally skewed to the right and posterior sides and is lined by a ridge. LV rather elongated (L / H ratio = 1.79).

Etymology

The species is named after the Drubea Kapone customary area.

Material examined

Holotype

NEW CALEDONIA • ♀, with soft parts dissected in glycerine in a sealed slide and with valves stored dry in a micropaleontological slide; Grande Terre, Province Sud, north of Tontouta airport, commune de Paita; approx. coordinates 21°59′18.5″ S, 66°12′25.4″ E; ca 9 m a.s.l.; 7 Jun. 2018; J. Higuti and K. Martens leg.; sample HYNC 3065; pH = 7.56; electrical conductivity = 831 µS / cm; water temperature = 22.3°C; accompanying ostracod fauna – *Stenocypris major* (Baird, 1859), *Cypris granulata* (Daday, 1910), *Kennethia major* (Méhes, 1939) and several as yet unidentified species in *Cypretta*, *Candona* s. lat., *Stenocypris* and '*Gomphocythere*'; MNHN-IU-2019-784.

Paratypes

NEW CALEDONIA • 2 ♀♀, with soft parts dissected as the holotype but with valves lost; same collecting data as for holotype; MNHN-IU-2019-2541, MNHN-IU-2019-2542 • 2 ♀♀; same collecting data as for holotype; MNHN-IU-2019-782, MNHN-IU-2019-783 • 2 ♀♀; same collecting data as for holotype; RBINS-INV.156000/OC.3400, RBINS-INV.15600/OC.3401 • 3 A-1 ♀♀, with valves and carapaces stored dry after use for SEM illustrations; same collecting data as for holotype; MNHN-IU-2019-779, MNHN-IU-2019-780, MNHN-IU-2019-781 • 1 A-1 ♀, with valves and carapace stored dry after use for SEM illustrations; same collecting data as for holotype; RBINS-INV.156002/OC.3402 • ca 10 ♀♀ and 10 A-1 ♀♀ *in toto* in EtOH; same collecting data as for holotype; MNHN-IU-2019-2313 • ca 10 ♀♀ and 10 A-1 ♀♀ *in toto* in EtOH; same collecting data as for holotype; RBINS-INV.156003/OC.3403.

Measurements (all in µm)

Holotype (adult female)
MNHN-IU-2019-784: RVi / L = 1.079; H = 782; LVi / L = 1.153; H = 671.

Paratypes (adult females)
MNHN-IU-2019-783: CpRL / L = 1.144; H = 756.
RBINS-INV.156000/OC.3400: CpLL / L = 1.128; H = 796.
MNHN-IU-2019-782: CpD / L = 1.171; W = 521.
RBINS-INV.156001/OC.3401: CpV / L = 1.203; W = 525.

Paratypes (A-1 juvenile females)
MNHN-IU-2019-781: CPRL / L = 915; H = 519.
MNHN-IU-2019-780: CpD / L = 898; W = 374.
MNHN-IU-2019-779: CpLL / L = 888; H = 508.
RBINS-INV.156002/OC.3402: RVi / L = 867; H = 511; LVi / L = 894; H = 526.

Description

Adult female
LVI (Fig. 2A). With evenly rounded anterior and bluntly pointed posterior margin. Dorsal margin bluntly pointed and with greatest height situated well in front of the middle. Calcified inner lamellae narrow on anterior and posterior sides; these margins with a tuberculated selvage (Fig. 2G–H). Posterior part of valve slightly protruding beyond postero-ventral valve margin (Fig. 2H).

RVI (Fig. 2B). With evenly rounded anterior margin and almost straight, sloping posterior margin. Dorsally with a very large and rounded hump, slightly leaning backwards. Calcified inner lamellae narrow on anterior and posterior sides; these margins set with a row of strong tubercles (Fig. 3A–B). Anterior margin furthermore with a sub-marginal selvage, marginal tubercles caught between this selvage and the valve margin (Fig. 3A). Posterior margin with clearly inwardly displaced selvage, the latter leaving the tubercles largely free (Fig. 3B).

CP. CpRL (Fig. 2C) clearly showing larger LV overlapping RV along anterior and posterior margin, and to a lesser extend along ventral margin. CpLL (Fig. 2D) showing extend to which dorsal hump on RV overlaps LV. External surface of both valves densely pitted and set with short setae in rimmed pores (Fig. 3C). CpD (Fig. 2E) showing the rostrum-like anterior part of the Cp and the shape of the hump-like expansion of the RV; the latter leaning toward the right side and the dorsal edge being set with a ridge (Fig. 3D). CpV (Fig. 2F) also showing anterior rostrum (Fig. 3E) and weakly developed flap-like expansion of LV overlapping RV (Fig. 3F).

A1 (Fig. 4A). 7-segmented. First segment large, with two long ventral and one short dorsal setae; Wouters organ not seen. Second segment with one apical seta on the dorsal side, reaching beyond middle of third segment: Rome organ very small and indistinguishable. Third segment ca twice as long as second segment, carrying one shorter ventral and one longer dorsal apical setae. Fourth and fifth segments all with four long apical natatory setae, two ventral and two dorsal, but dorsal ones much longer than ventral ones. Sixth segment with four long and one shorter setae. Final segment with two long natatory setae, one shorter seta and an aesthetasc Ya, the latter ca half the length of the shorter apical seta.

A2 (Fig. 4B–C). Typical of the subfamily. First segment with three basal setae on the ventral side and with one long ventro-apical seta, the latter reaching beyond tip of terminal segment. Endopodite consisting of a small plate with one long and two unequal short setae. First endopodal segment with basally inserted aesthetasc, distally with five long and one short natatory setae, long setae reaching

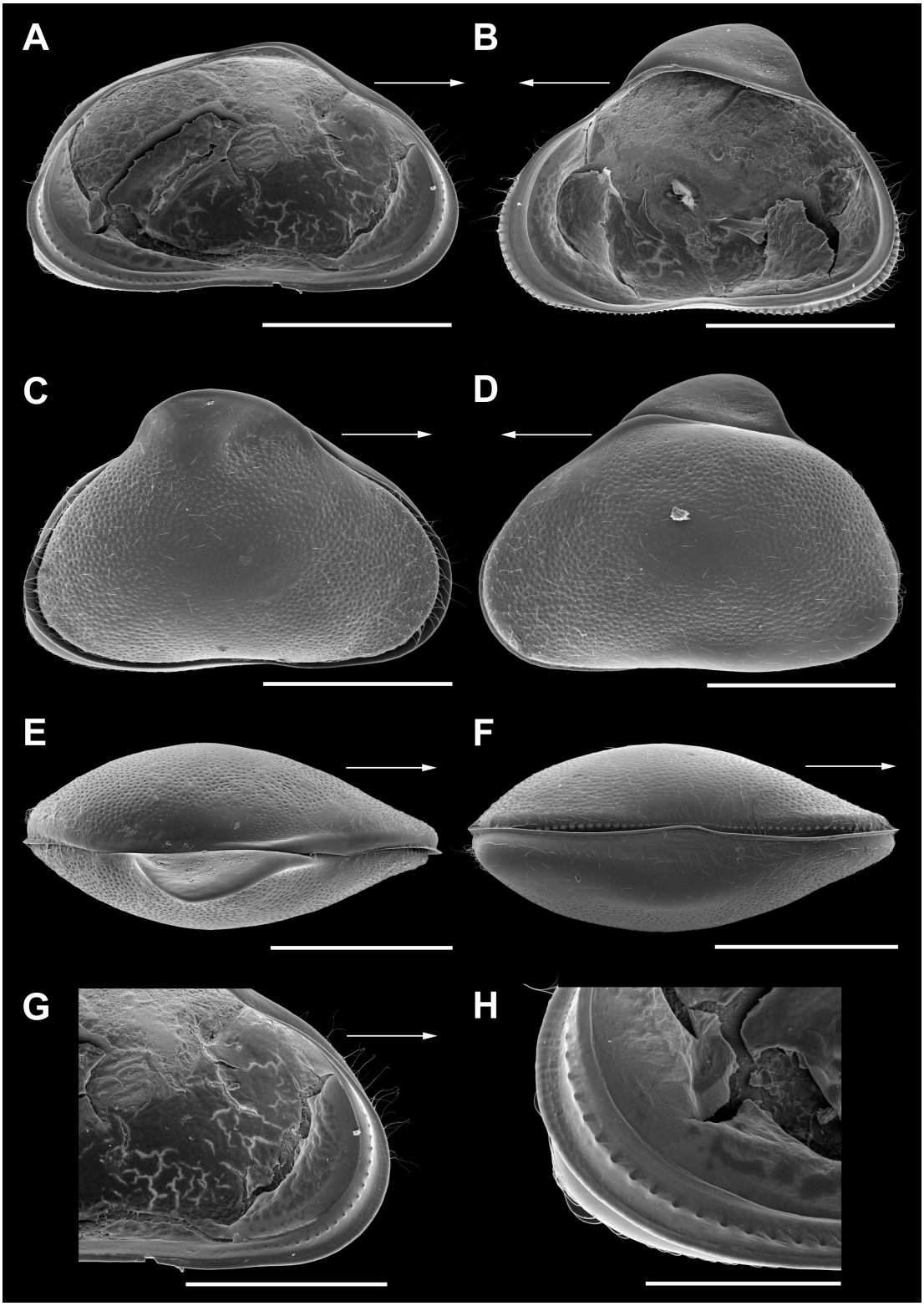

Fig. 2. Scanning Electron Microscope images of *Cyprinotus drubea* sp. nov., ♀♀. **A**. LVi (MNHN-IU-2019-784). **B**. RVi (MNHN-IU-2019-784). **C**. CpRL (MNHN-IU-2019-783). **D**. CpLL (RBINS-INV.156000/OC.3400). **E**. CpD (MNHN-IU-2019-782). **F**. CpV (RBINS-INV.156001/OC.3401). **G**. LVi, detail of anterior part (MNHN-IU-2019-784). **H**. LVi, detail of posterior part (MNHN-IU-2019-784). Arrows indicate anterior side. Scale bars: A–F = 500 μm; G = 400 μm; H = 200 μm.

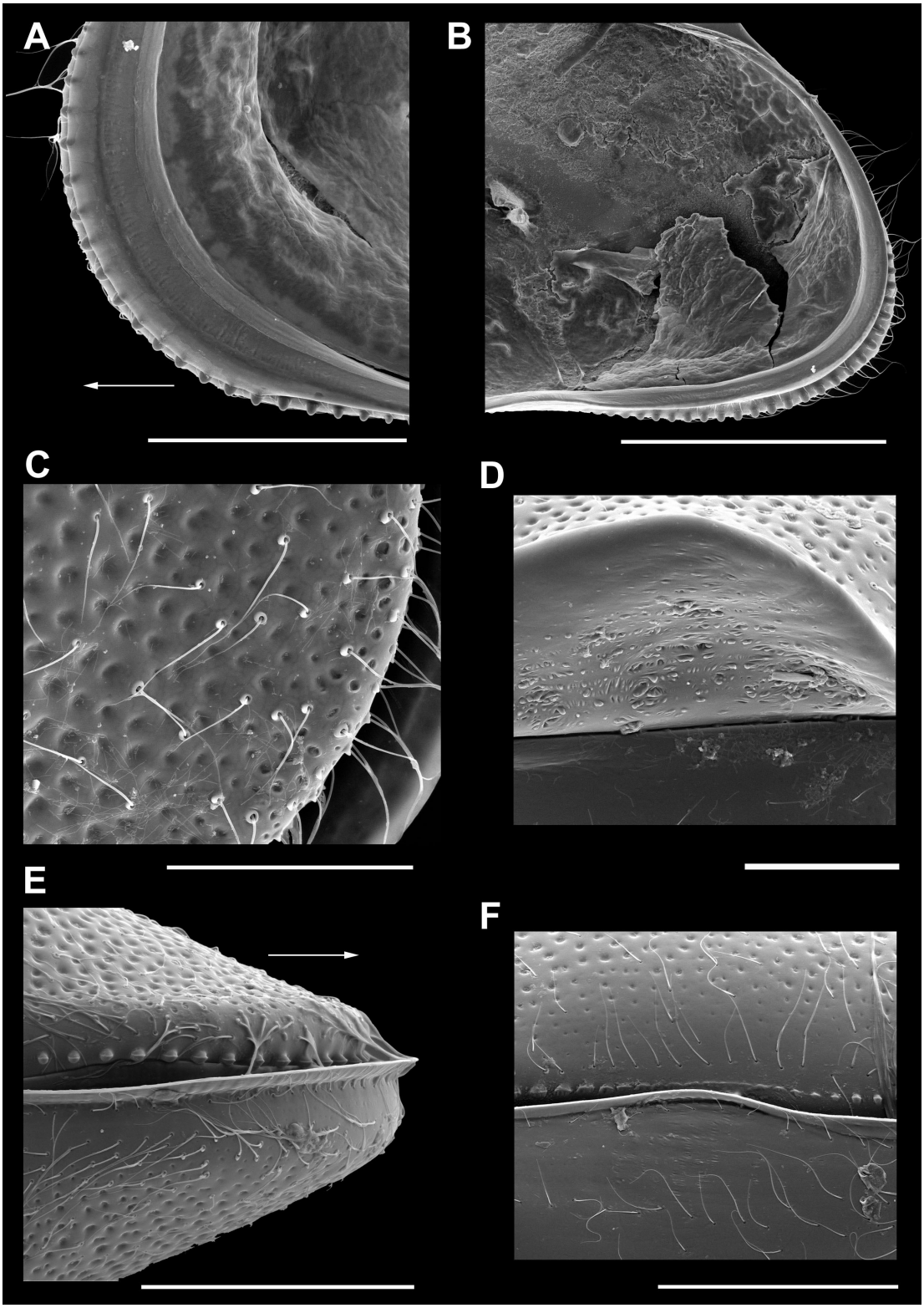

Fig. 3. Scanning Electron Microscope images of *Cyprinotus drubea* sp. nov., ♀♀. **A**. RVi, detail of anterior part (MNHN-IU-2019-784). **B**. RVi, detail of posterior part (MNHN-IU-2019-784). **C**. CpRL, detail of carapace surface (MNHN-IU-2019-783). **D**. CpD, detail of hump (MNHN-IU-2019-782). **E**. CpV, detail of anterior part (RBINS-INV.156001/OC.3401). **F**. CpV, detail of central overlap (RBINS-INV.156001/OC.3401). Arrows indicate anterior side. Scale bars: A, D–E = 200 µm; B = 400 µm; C, F = 100 µm.

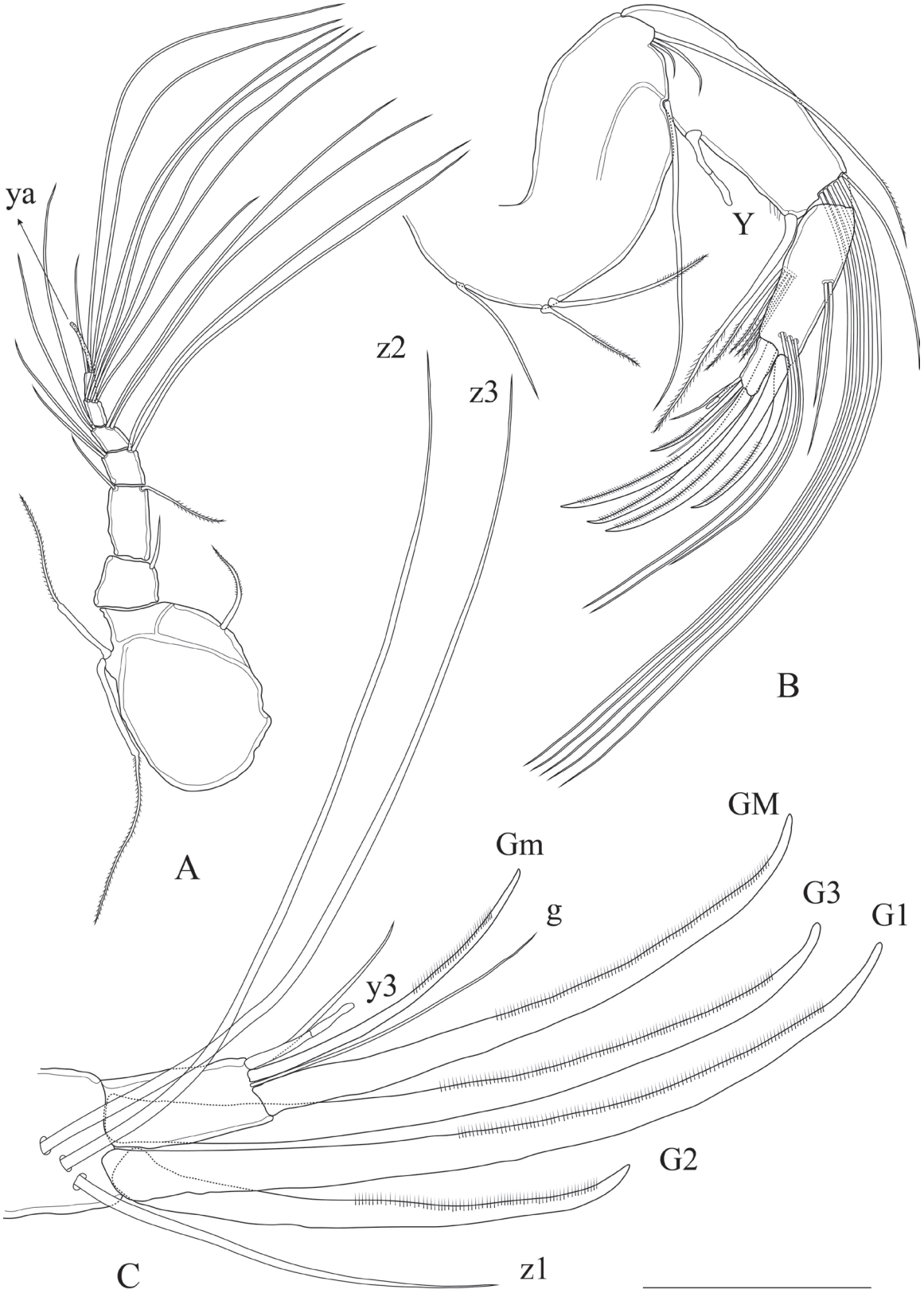

Fig. 4. *Cyprinotus drubea* sp. nov., ♀♀. **A**. A1 (MNHN-IU-2019-2542). **B**. A2 (MNHN-IU-2019-2541). **C**. Detail of apical chaetotaxy of A2 (MNHN-IU-2019-2542). Scale bar: A = 344 µm; B = 135 µm; C = 46 µm.

with about ⅕ of their length beyond the tips of the endclaws, and one stout and long ventro-apical seta, reaching till the middle of the endclaws. Second endopodal segment with two unequal setae inserted mid-dorsally and four unequal setae, inserted mid-ventrally, apically with three long z-setae (reaching beyond tips of endclaws) and claws G1, G2 and G3, G2 being the shortest. Terminal segment with one large claw GM, one shorter claw Gm (ca half the length of GM), seta g almost as long as claw Gm and an aesthetasc y3, fused with an accompanying seta over a short distance, the accompanying seta being ca twice the length of the aesthetasc and ¾ of the length of seta g.

Md. Md-palp (Fig. 5A) with four segments. First segment large, with a respiratory plate bearing five long and one short setae; ventro-distally with one long smooth seta, a long, thin and smooth α-seta and two setose s-setae. Second segment with a group of three long setae, inserted mid-dorsally and a group of five ventral setae: three thin and relatively long setae, setose in their distal third, one stout, shorter seta and one short, but stout β-seta. Third segment with a dorso-subapical group of four setae; a row of four apical setae, three thin and relatively short setae and one stout and claw-like γ-seta, dorsally inserted; and two ventro-subapical setae, one long and one very short. Terminal segment about as long as basal width, tapering, set with four apical claws and one seta. Md coxa (Fig. 5B) elongated, distally with ca 10 teeth, interspaces with small setae, and one short subapical seta.

Mx1 (Fig. 5C–D). Consisting of a two-segmented palp, three endites and a vibratory plate for respiration. First palp segment with five apical setae, one of which plumose, one long and one short subapical setae. Second palp segment rectangular, ca twice as long as basal width, apically carrying three claws and three setae. Third endite with two large, distally serrated setae ("Zahnbürsten"). First endite with one apical side-ways directed bristle and two basal setae. Vibratory plate with ca 12 distal rays and an additional six basal setae.

T1 (Fig. 6A). With an elongated palp, carrying three apical setae, the middle one (h2) being the longest. Respiratory plate with five long and one short rays. Protopodite with two short but unequal a-setae, a short b-seta, a longer d-seta, almost twice as long as b-seta and distally with 11 (sub-) apical setae of unequal length.

T2 (Fig. 6B). A walking leg. First segment with short seta d1. Second segment (knee-segment) without seta d2. Third segment long, ca three times as long as wide, carrying a distal e-seta, reaching just to tip of segment 4a. Fourth segment divided in two parts. Segment 4a with apical f-seta reaching tip of segment 4b. Segment 4b with apically inserted seta g and a very short second seta. Terminal segment with curved claw h2 and two flanking setae, seta h1 longer than seta h3, the latter subapical.

T3 (Fig. 6C–D). A cleaning leg. First segment with three long setae (d1, d2 and dp). Second segment elongated, about five times as long as wide, distally with a long e-seta, reaching beyond tip of limb. Third segment shorter, with medially inserted f-seta, also reaching beyond tip of limb. Distal part of third segment fused with fourth segment, forming a pincer, with a long seta h3, a curved hook-like seta h2 and a minuscule seta h1 (not shown).

Cr (Fig. 6E). Elongated, with broad basal part. Proximal claw Gp ca ½ the length of distal claw Ga; proximal seta Sp almost as long as distal seta Sa. Attachment of caudal ramus (Fig. 6F) a single narrow and curved ramus.

Rake-like organ (Fig. 6G). With narrow rod and distally with eight blunt teeth.

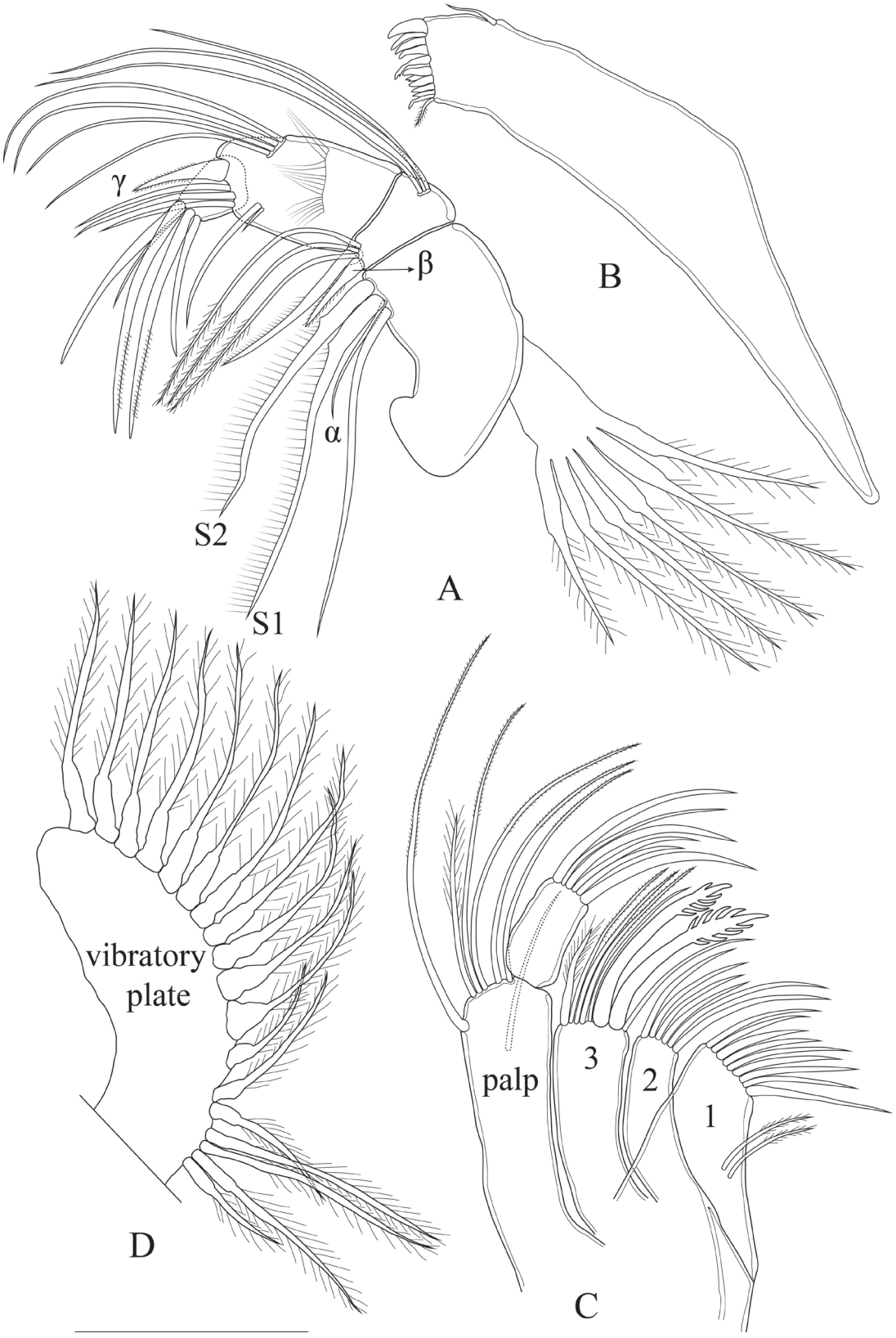

Fig. 5. *Cyprinotus drubea* sp. nov., ♀♀. **A**. Md-palp (MNHN-IU-2019-2541). **B**. Md-coxa (MNHN-IU-2019-2541). **C**. Palp and endites of Mx1 (chaetotaxy of endites not complete) (MNHN-IU-2019-2541). **D**. Vibratory plate of Mx1 (MNHN-IU-2019-2542). Scale bar: A = 101 µm; B, D = 139 µm; C = 84 µm.

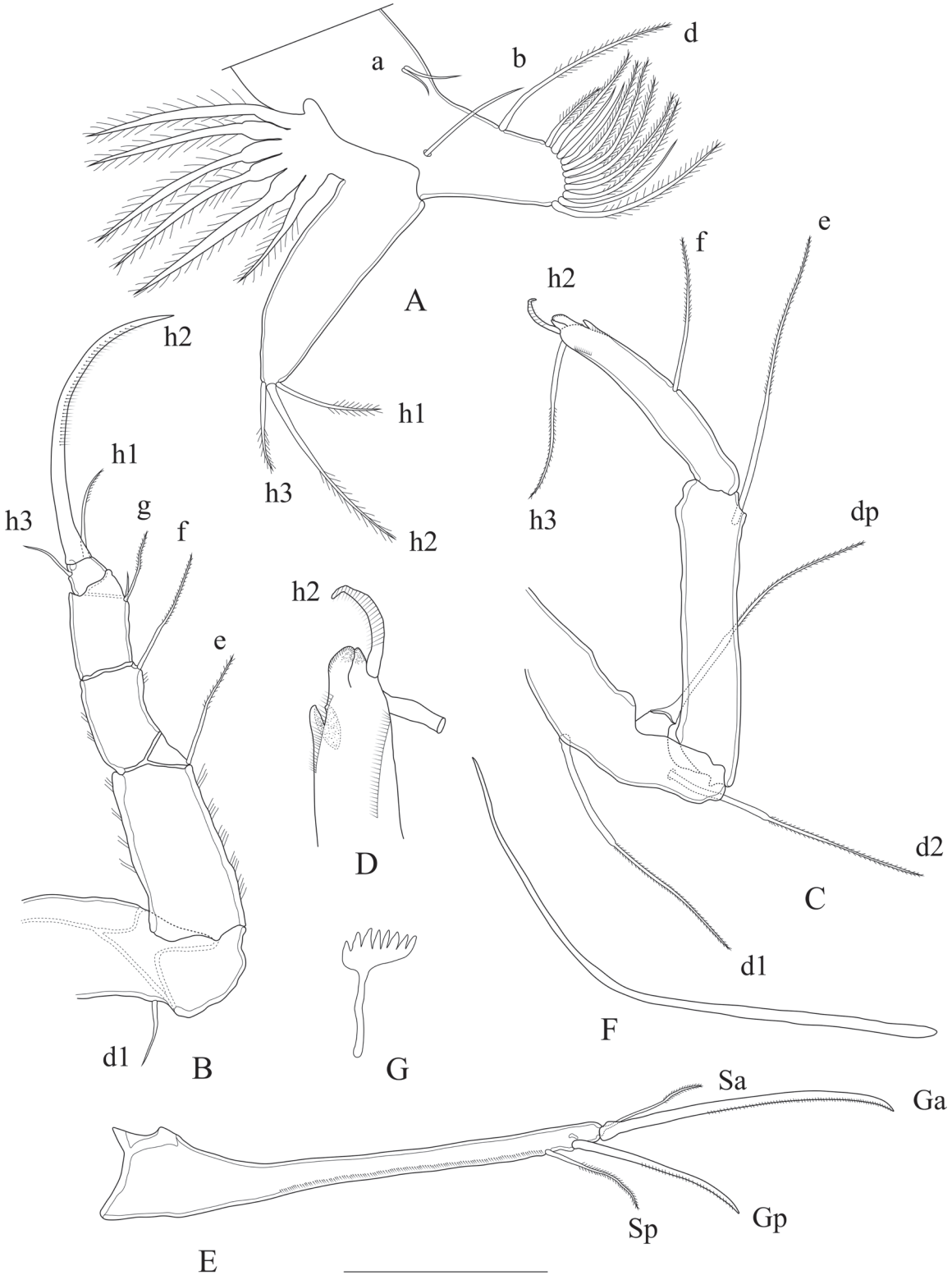

Fig. 6. *Cyprinotus drubea* sp. nov., ♀♀. **A**. T1 (MNHN-IU-2019-2542). **B**. T2 (MNHN-IU-2019-2541). **C**. T3 (MNHN-IU-2019-2541). **D**. Detail of apical pincer of T3 (MNHN-IU-2019-2541). **E**. CR (MNHN-IU-2019-2542). **F**. Attachment of CR (MNHN-IU-2019-2542). **G**. Rake-like organ (MNHN-IU-2019-2542). Scale bar: A = 111 µm; B = 93 µm; C = 106 µm; D = 42 µm; E–F = 127 µm; G = 104 µm.

A-1 juvenile female

LV (Fig. 7A). With shape similar to that in adults, greatest height situated well in front of the middle; both posteriorly (Fig. 7H) and anteriorly (Fig. 7I) with large selvage; calcified inner lamella narrow.

RV (Fig. 7B). With similar outline, but with much smaller postero-dorsal hump than in the adult. Anterior (Fig. 7F) and posterior margins with narrow calcified inner lamella; no inwardly displaced selvages. Marginal tubercles absent, or very small.

CpD (Fig. 7E). Rather narrow, with LV overlapping RV anteriorly and posteriorly; greatest width situated in the middle.

CpRL (Fig. 7C). With LV overlapping RV anteriorly and posteriorly; along dorsal margin RV extending beyond LV in posterior part, LV extending beyond RV in anterior part. External surface of Cp strongly ornamented, with tightly intertwined ridges, resulting pits and rimmed pores with long setae (Fig. 7G).

CpLL (Fig. 7D). With RV only slightly extending past LV in posterior part of the dorsal margin.

A2. With five long natatory setae and without the shorter seta. Remark: this is typical of the A-1 juveniles in Cyprididae; the accompanying short seta only forms in the last moult to the adult stage (not illustrated).

Differential diagnosis

The new species can at once be distinguished from all other extant species in the genus by the large and rounded dorsal hump on the RV; this hump is much smaller in most other species of *Cyprinotus*. Some specimens of *Cyprinotus* with a large dorsal hump from wells in the Pilbara region (northern Western Australia) were illustrated and erroneously identified as *C. cingalensis* by Karanovic (2008). However, the hump in the latter species is wider, less high and distally less rounded. Also, the ventro-caudal side of the LV in the specimens from the Pilbara is more rounded, while the LV as such is less elongated (L/H ratio in Pilbara specimens = 1.70; L/H ratio in *C. drubea* sp. nov. = 1.79). The dorsal helmet of the new species is also larger than in the fossil *C. scholiosus* (Sohn & Morris, 1963) and the LV of the former is also slightly more elongated (L/H ratio in Sohn & Morris (1963) = 1.62, in Malz (1976) = 1.71; L/H ratio in *C. drubea* sp. nov. = 1.79).

Ecology and distribution

All species in this genus are typical of temporary habitats and *C. drubea* sp. nov. is no exception. The species was found in a shallow temporary marsh, covering several hectares, which was densely covered with grasses and species of *Juncus* L.

Discussion

Taxonomy of the genus *Cyprinotus*

Meisch *et al.* (2019) retained 17 species in the genus *Cyprinotus*. However, a literature survey conducted in the present paper showed that actually only seven species, including *Cyprinotus drubea* sp. nov., really belong in the genus (Table 2). Based on the illustrations in the original descriptions, several of the other species could be allocated to other genera (Table 3). *Cyprinotus crenatus* (Turner, 1893), *C. flavescens* Brady, 1898, *C. ohanopecoshensis* Ferguson, 1966 and *C. sulphurous* Blake, 1931 belong in the genus *Heterocypris*, because of a clear lack of a dorsal hump on the RV. *Cyprinotus scytodus* (Dobbin, 1941) most likely also belongs in the genus *Heterocypris*.

For *C. pellucidus* (Sharpe, 1897), it is impossible to see to which genus it belongs based on the original illustrations in Sharpe (1897). However, Sharpe (1918) provided new illustrations which indicate that

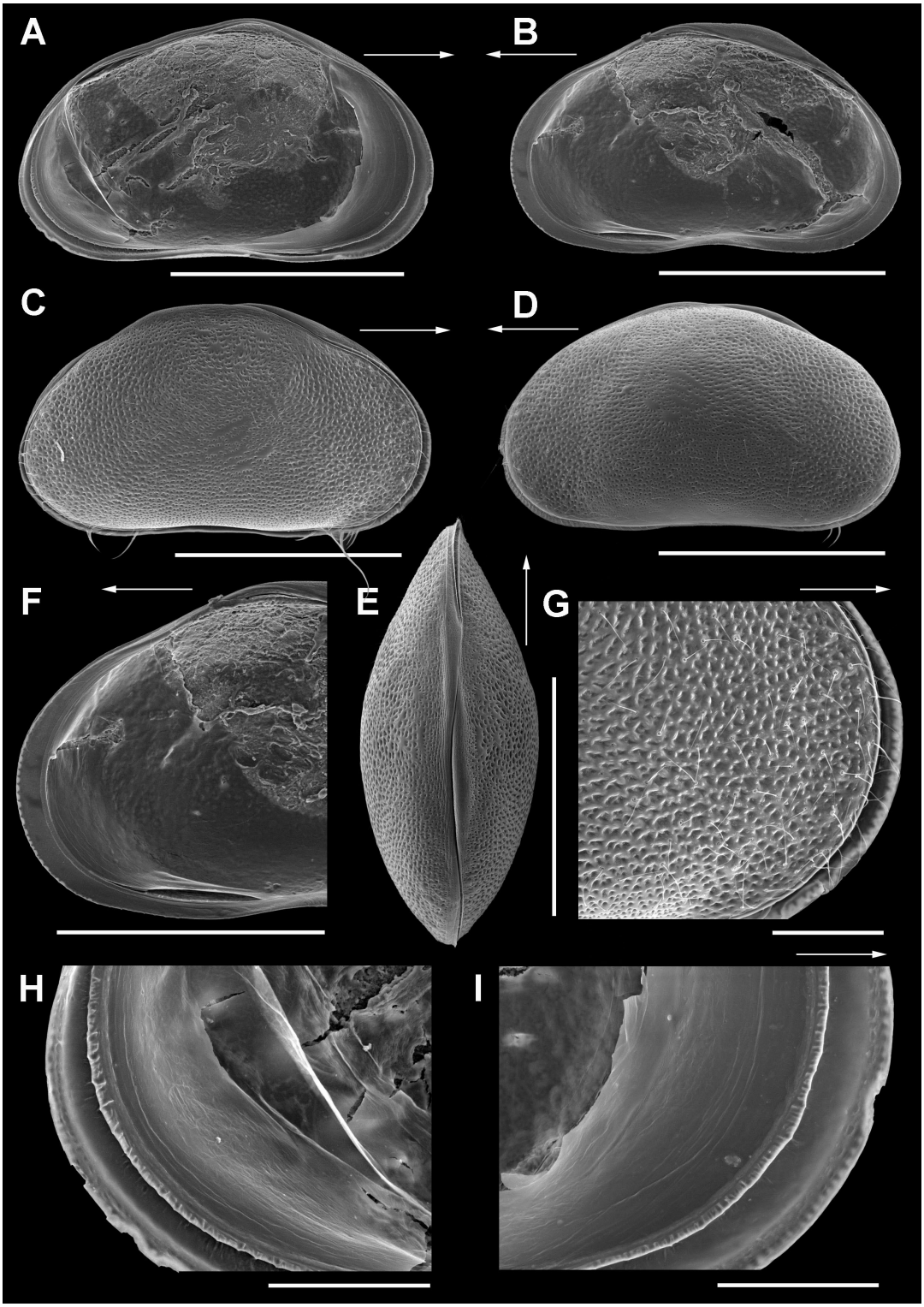

Fig. 7. *Cyprinotus drubea* sp. nov., ♀♀ A-1 juveniles. **A**. LVi (INV.156002/OC.3402). **B**. RVi (RBINS-INV.156002/OC.3402. **C**. CpRL (MNHN-UI-2019-781). **D**. CpLL (MNHN-UI-2019-779). **E**. CpD (MNHN-UI-2019-780). **F**. RVi, detail of anterior part (RBINS-INV.156002/OC.3402). **G**. CpRL, detail anterior (MNHN-UI-2019-781). **H**. LVi, detail of posterior part (RBINS-INV.156002/OC.3402). **I**. LVi, detail of anterior part (RBINS-INV.156002/OC.3402). Arrows indicate anterior side. Scale bars: A–E = 500 µm, F = 400 µm, G–I= 100 µm.

Table 3. Re-assignment of species assigned to *Cyprinotus* by Meisch *et al.* (2019), based on the original descriptions.

Original assignment	Correct assignment / comments
Cyprinotus crenatus (Turner, 1893) Turner, 1895	*Heterocypris crenata fide* Purper & Würdig-Maciel 1974.
Cyprinotus dentatus (Sharpe, 1910) Blake, 1931	*Heterocypris dentata* comb. nov. (several species)
Cyprinotus flavescens Brady, 1898	*Heterocypris flavescens* comb. nov.
Cyprinotus inconstans Furtos, 1936	*Heterocypris inconstans* (Furtos, 1936) comb. nov.
Cyprinotus newmexicoensis Ferguson, 1967	*Heterocypris newmexicoensis* comb. nov. (possibly juvenile)
Cyprinotus ohanopecoshensis Ferguson, 1966	*Heterocypris ohanopecoshensis* comb. nov.
Cyprinotus pellucidus (Sharpe, 1897) Sharpe, 1918	*Heterocypris pellucida* comb. nov.
Cyprinotus scytodus (Dobbin, 1941) Tressler, 1947	*Heterocypris scytoda* comb. nov.
Cyprinotus sulphureus Blake, 1931	*Heterocypris sulphuras* comb. nov.
Cyprinotus unispinifera Furtos, 1936	*Cypricercus unispinifera* comb. nov.
Cyprinotus tenuis Henry, 1923	Not Cyprinotinae, doubtful species
Cyprinotus fuscus Henry, 1919	Not *Cyprinotus*, doubtful species
Cyprinotus carinatus (King, 1855)	Doubtful species in Müller (1912)

these specimens belong to *Heterocypris*. However, it is uncertain if both sets of specimens, those of Sharpe (1897) and those of Sharpe (1918) really belong to the same species.

Cyprinutus dentatus (Sharpe, 1910) certainly refers to several species. The species described by Sharpe (1910) certainly belongs to *Heterocypris*, even to the '*rostrata*' type, but it is clear that males of two different species are figured here (compare Sharpe, 1910: figs 2b and 2c, the latter could be *Heterocypris incongruens* (Ramdohr, 1808)). The illustrations in Sharpe (1918: 816, fig. 1271a–c) refer most likely to the species figured by Sharpe (1910: fig. 2b). *Cyprinotus newmexicoensis* Ferguson, 1967 certainly belongs in *Heterocyrpis*, but the specimens might be juvenile.

Cyprinotus unispinifera Furtos, 1936 clearly belongs in the genus *Cypricercus* Sars, 1895. *Cyprinotus tenuis* Henry, 1923, *C. fuscus* Henry, 1919 and *C. carinatus* (King, 1855) do not belong in *Cyprinotus*, maybe not even in the Cyprinotinae. Müller (1912) already ranked *C. carinatus* as "doubtful species" and we here propose to consider all three species as 'doubtful' and to exclude them from further consideration. They would thus belong in the list of "excluded species" in Meisch *et al.* (2019: 110), using the "taxonomic filter" of Müller (1912).

The new species can be distinguished from most of the *Cyprinotus* s. str. species by the size and shape of the dorsal hump, which is much smaller and more elongated in *C. cingalensis* (Fig. 8A), *C. edwardi* McKenzie, 1978 (Fig. 8B), *C. indica* Battish, 1981 (Fig. 8C), *C. dahli* Sars, 1896 (Fig. 8D) and *C. uenoi* Brehm, 1936 (Fig. 8G, H). In *C. kimberleyensis* McKenzie, 1966 (Fig. 8E), the hump is also large but of a more rectangular shape. The most closely related species is the fossil *Cyprinotus scholiosus* (Fig. 8F), originally described by Sohn & Morris (1963) as *Cheikella scholiosa* from the Pliocene of Saudi Arabia, and later also reported from the Pleistocene of Yemen by Malz (1976).

Cyprinotus drubea sp. nov. closely resembles *C. scholiosus* (see above, differential diagnosis). However, to us it is not entirely clear what the identity of *C. scholiosus* really is, as various illustrations in Sohn & Morris (1963) and in Malz (1976) show a variety of shapes and sizes of the dorsal hump. For example,

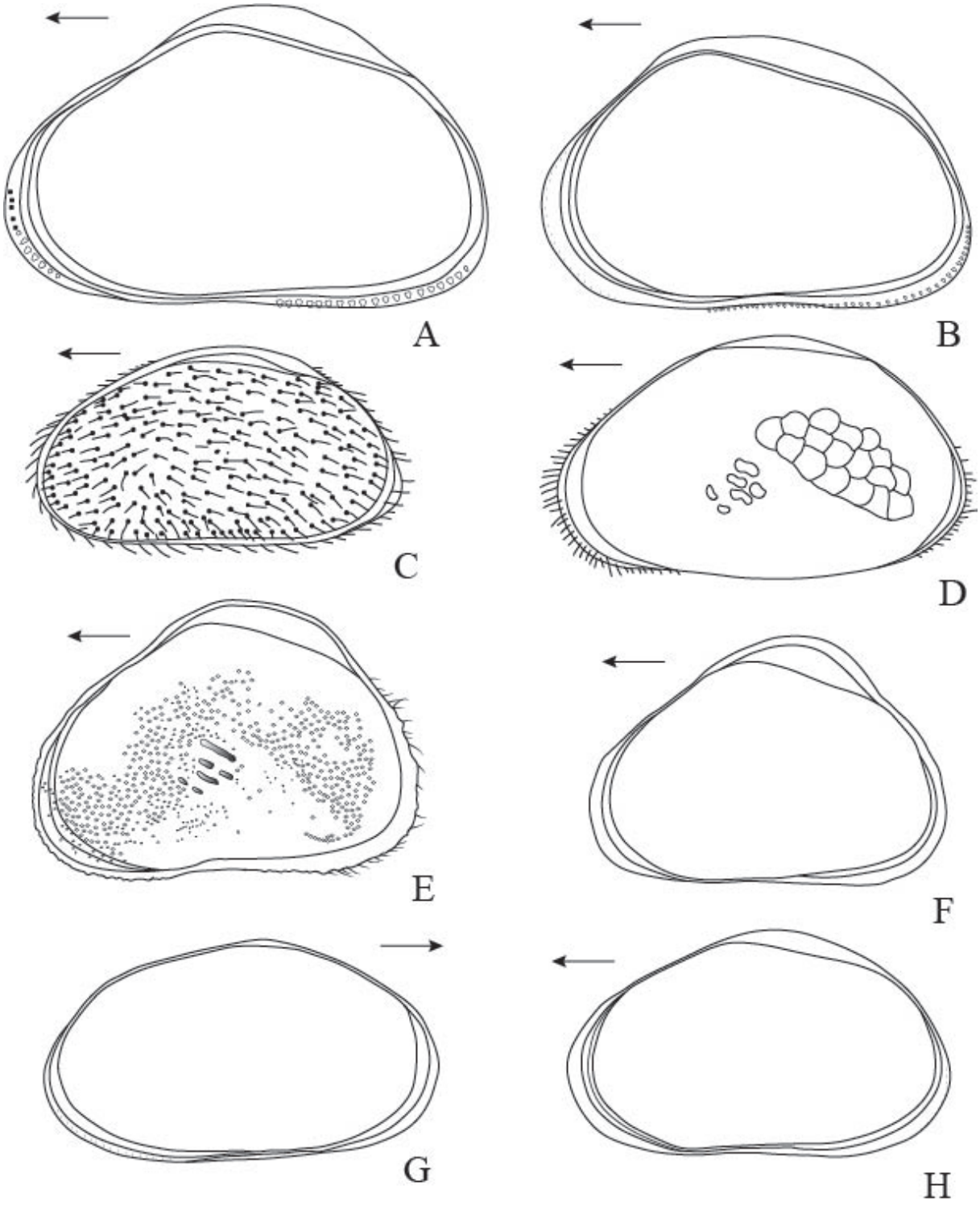

Fig. 8. Other species of *Cyprinotus* s. str. (redrawn from various sources, mostly the original descriptions, not to scale). **A**. *Cyprinotus cingalensis* Brady, 1886, RVi. **B**. *C. edwardi* McKenzie, 1978, RVi. **C**. *C. indica* Battish, 1981, CpLL. **D**. *C. dahli* Sars, 1896, CpLL. **E**. *C. kimberleyensis* McKenzie, 1966, RVi. **F**. *C. scholiosus* (Sohn & Morris, 1963), RVi. **G**. *C. uenoi* Brehm, 1936, LVi. **H**. *C. uenoi* Brehm, 1936, RVi. Arrows indicate anterior side.

fig. 1(7) in Malz (1976) shows a very different shape of the LV than fig. 1(3). The holotype of the species (nr USNM648125; Sohn & Morris 1963: 329, pl. 1, figs 7–10) has a smaller and fully symmetrical dorsal hump, while this structure in *C. drubea* sp. nov. is higher and asymmetrically curved to the posterior side, while also the posterior margin of the carapace is slightly different. We therefore decide to keep the two species separate, although they are indeed closely related. Together with the population from the Pilbara (Karanovic 2008), *C. scholiosus* and *C. drubea* sp. nov. form a clear species group within the genus.

The allocation of *C. indica* to the genus *Cyprinotus* s. str. is still doubtful, as the shape and external ornamentation with dense setae are rather aberrant and unlike any of the other species in the genus. The type materials of this species should be re-investigated.

Karanovic (2008) sank *C. dahli*, *C. uenoi*, *C. kimberleyensis* and *C. edwardi* into synonymy of *C. cingalensis*. This was most likely done, because she interpreted the variability in the size and shape of the dorsal hump on the RV in her Pilbara populations as a result of one highly variable species, i.e., *C. cingalensis*. However, there are two other possible interpretations of the difference in size and shape of the dorsal hump as illustrated by her.

Firstly, her material could have contained specimens from two species: one population of *C. cingalensis* (smaller species) and one population of a new (larger) species. In this respect, the smaller specimen in her fig. 6F–G might belong to *C. cingalensis* and the larger specimens in her figs 6A–E and 9A–E would belong to a new species.

A similar situation has occurred when Daday (1913) described *Cyprinotus inversus* Daday, 1913 from the Kalahari Desert (South Africa). His material contained two species from two genera, namely a sexual population of a species of *Heterocypris* (possibly *H. giesbrechti* Müller, 1898) and an asexual population of a species of *Hemicypris* Sars, 1903 (see Martens 1984). This description lead to decades of confusion regarding the validity of these two genera, as in *Heterocypris* the LV overlaps the RV and the RV has the marginal tubercles, while in *Hemicypris* it is just the opposite. After the description of *C. inversus,* several authors no longer accepted *Hemicypris* as a separate and valid genus.

Secondly, the smaller specimens might also simply be the A-1 juveniles (see fig. 6A, F in Karanovic: adult specimen in fig. 6A with marginal tubercles = 1.3 mm; smaller specimen in fig. 6F with fewer marginal tubercles = 1.05 mm). We here illustrate the A-1 females of *C. drubea* sp. nov. (Fig. 7), which indeed resemble the smaller species illustrated by Karanovic (2008).

If either of these hypotheses turns out to be true, then *C. cingalensis* is not so highly variable and possibly not all four synonymies proposed by Karanovic (2008) might be valid. For these reasons, we do not follow these synonymies here.

The A-1 juvenile of *Cyprinotus drubea* sp. nov.

In ostracod taxonomy, juvenile morphology is rarely illustrated, unless the juveniles are seen as a different species or even genus than the adults. Indeed, juvenile and adult morphologies can be very different and have in some cases mislead authors. For example, *Eucypris serratomarginata* Kiss, 1960 is the last juvenile stage of *Sclerocypris multiformis* Kiss, 1960 (see Martens 1986) while *Candonocypris serratomarginata* Furtos, 1935 is most likely the juvenile of *Chlamydotheca unispinosa* (Baird, 1862) (discussed in Martens & Savatenalinton 2011). Extensive examples of the differences between adult and juvenile morphologies are given for species of the Australian genus *Bennelongia* De Deckker & McKenzie, 1981 by De Deckker & Martens (2013).

Here, the clearest differences in the valves between adults and A-1 juveniles are in the much smaller dorsal helmet and the stronger external ornamentation in the juveniles. The strong selvage in the LV is also remarkable. This selvage is completely absent in the RV, which shows the narrow, calcified lamella, typical of juveniles in Cyprididae. The RV is also devoid of tubercles.

The A-1 stage in Cyprididae can be clearly identified by the number of natatory setae on the A2: the adult has five long and one shorter setae (in those species where the natatory setae are well developed). In stage A-1, the shorter seta is still missing.

Distribution

The seven Recent species presently retained in *Cyprinotus* (Table 2) occur in the Afrotropical, Oriental, Australasian and Pacific realms, and in parts of the southern Palaearctic (North America, Japan) (Meisch *et al.* 2019). The actual distribution of the genus is most likely circumtropical so that it is also expected to occur in the northern part of South America and in Central America, from which it has not yet been reported (Higuti & Martens in press). *Cyprinotus drubea* sp. nov. is possibly an endemic to the New Caledonian archipelago.

Neale (1979) indicated that the collections of the British Museum (now Natural History Museum, London) contained a female specimen, labelled as *C. cingalensis*, from St. Joseph, Uvea, Loyalty Islands. However, Neale (loc. cit.) found differences in the limb morphology between this specimen and the material from Ceylon and doubted the identification. But if these specimens from Uvea would have belonged to *C. drubea* sp. nov., then Neale (loc. cit.) would certainly have noted this. It is thus likely that a second species of *Cyprinotus* occurs in the New Caledonia archipelago.

Morphology

This is the first time that a species of *Cyprinotus* is described in such detail, especially with regard to the valves. Neale (1979) provided some SEM images of *C. cingalensis* that show that the anterior marginal tubercles of the RV are not covered by the selvage in this species, but the posterior ones are (i.e., just the opposite of the situation in *Cyprinotus drubea* sp. nov.) and that the dorsal hump on the RV is indeed also slightly leaning towards the right side. Most surprising in the description of *C. cingalensis* by Neale (1979), however, is that he drew the proximal seta on the caudal ramus in the middle of the ramus, which is highly unusual in Cyprididae. Karanovic (2008), in what she called *C. cingalensis*, drew this seta in approximately the same position as we do here in *Cyprinotus drubea* sp. nov. Surprisingly, she did not find seta d1 on the first segment of T1 and she drew two types of attachments of the caudal ramus: one with a single rod for the male and one with a distally bifurcated rod for the female; both belong to the larger species in her material. Halse & Martens (2019) already suggested that there may be an asymmetry or sexual dimorphism in this structure in this subfamily.

Conclusions

The Recent species of the genus *Cyprinotus* Brady, 1886 are re-assessed and only seven extant species are retained in the genus. A new species, *C. drubea* sp. nov. from New Caledonia is included in this list and is compared to all extant taxa as well as to the fossil *C. scholiosus*, to which it has the closest resemblance. Also, the carapaces and valves of the last juvenile stage of the new species are described and these descriptions are used to re-assess some previous records of species of *Cyprinotus*. Together with the population from the Pilbara, described by Karanovic (2008) as *C. cingalensis*, *C. drubea* sp. nov. and *C. scholiosus* form a clear species group within the genus *Cyprinotus.*

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