African Zoology 2015, 50(2): 147–163
Printed in South Africa

Open Access article distributed under the terms of the
Creative Commons Attribution License [CC BY 4.0]
(http://creativecommons.org/licenses/by/4.0)

Copyright © The Authors
AFRICAN ZOOLOGY
ISSN 1562-7020 EISSN 2224-073X
http://dx.doi.org/10.1080/15627020.2015.1043943

Review of *Mothocya* Costa, in Hope, 1851 (Crustacea: Isopoda: Cymothoidae) from southern Africa, with the description of a new species

Kerry A Hadfield[1]*, Niel L Bruce[1,2] and Nico J Smit[1]

[1] Water Research Group (Ecology), Unit for Environmental Sciences and Management, Potchefstroom Campus, North-West University, Potchefstroom, South Africa
[2] Museum of Tropical Queensland, Queensland Museum and School of Marine and Tropical Biology, James Cook University, Townsville, Queensland, Australia
** Corresponding author, email: kerryh26@yahoo.com*

Three species of *Mothocya* are reported from the east coast of southern Africa: *Mothocya plagulophora* (Haller, 1880) from Maputo, Mozambique, from the gills of *Hemiramphus far* (Forsskål, 1775); *Mothocya renardi* (Bleeker, 1857) from diverse localities in South Africa and Mozambique, from the hosts *Strongylura leiura* (Bleeker, 1850) and *Tylosurus choram* (Rüppell, 1837); and *Mothocya affinis* sp. nov. from Sodwana Bay, South Africa, from the gills of *Hyporamphus affinis* (Günther, 1866). *Mothocya affinis* sp. nov. is characterised by relatively small size (maximum 16 mm); large, wide coxae on pereonite 7 that overlap the pleon; uropods that do not extend past the pleotelson posterior margin; produced anterolateral margins on pereonite 1; and a twisted pleon and pleotelson. *Mothocya katoi* Nunomura, 1992 and *Mothocya toyamaensis* Nunomura, 1993 are both transferred to the genus *Ceratothoa*, with *M. katoi* being placed into junior synonymy with *Ceratothoa guttata* (Richardson, 1910). *Irona ogcocephalus* Avdeev & Avdeev, 1974 and *I. callionymus* Avdeev & Avdeev, 1974 are both transferred to *Elthusa*, and *Irona trillesi* Rokicki, 1986 is synonymised with *Mothocya longicopa* Bruce, 1986. A key to the south-western Indian Ocean species of *Mothocya* is given, and a table summarising recent and new nomenclatural acts in the genus is provided.

http://zoobank.org/urn:lsid:zoobank.org:pub:1ECACB83-F8E3-400B-9B12-0F6CC7F1C047

Keywords: cymothoid, gill chamber, isopod, marine fish parasite, Mozambique, South Africa

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

Introduction

Cymothoid isopods are readily recognised as a family, but genera and species are often misidentified and misplaced. In many instances, existing species records are unable to be verified or rejected, making much of the information available on the biodiversity, distribution and host records of this family seem unreliable (Smit et al. 2014). Despite recent studies (Hadfield et al. 2013, 2014a, 2014b), a large number of cymothoid species still require revision to ensure that accurate information is available for future research on this economically and ecologically important group of fish parasites.

One attachment site used by fish parasitic isopods is within the gill chamber of the host. Most of these gill-inhabiting species are recognised by the laterally twisted body shape of the female caused by the shape of the gill arches and operculum (Kensley and Schotte 1989). Many species cause severe damage to the gills (Kroger and Guthrie 1972; Colorni et al. 1997), which could affect the fish's development and survival.

Mothocya Costa, in Hope, 1851 is one of the more widespread gill parasitic genera. Bruce (1986) revised *Mothocya*, synonymising *Irona* Schioedte & Meinert, 1884 with *Mothocya*, redescribing seven species and adding 18 new species. Since that review a further five new species have been described, namely *M. katoi* Nunomura, 1992; *M. toyamaensis* Nunomura, 1993; *M. komatsui* Yamauchi, 2009; *Irona trillesi* Rokicki, 1986 (= *Mothocya longicopa* Bruce, 1986); and *M. bertlucy* Hadfield, Sikkel & Smit, 2014. Martin et al. (2015) recently transferred *Ceratothoa lineata* Miers, 1876 into *Mothocya*, at the same time placing *Mothocya ihi* Bruce, 1986 into junior synonymy. A further two species and one subspecies (Avdeev and Avdeev 1974), and three unidentified species are transferred to the appropriate genus or placed in synonymy (Table 1).

Two species of *Mothocya* are known from southern Africa, namely *M. plagulophora* (Haller, 1880) and *M. renardi* (Bleeker, 1857). *Mothocya plagulophora* is known from the western Indian Ocean including Mauritius, Zanzibar and Madagascar (Haller 1880; Pfeffer 1889; Monod 1971; Bruce 1986). *Mothocya renardi* is known from numerous localities across the Indian and Pacific Oceans, including Madagascar and Mozambique (Trilles 1976; Bruce 1986). A third species, *Mothocya melanosticta* (Schioedte & Meinert, 1884), was also thought to occur in this region (Barnard 1914; Nierstrasz 1931; Barnard 1955; Kensley 1978) but was a misidentification of *M. renardi.*

Methods

All isopods labelled as *Irona* from the Iziko South African Museum (SAM), Cape Town, were borrowed. New material was collected from the Maputo Fish Market in Mozambique,

Table 1: Taxonomic and nomenclatural changes in *Mothocya* since 1986 in chronological order

Original combination	Present status	Reference
Ceratothoa lineata Miers, 1876	= *Mothocya lineata* (Miers, 1876)	Martin et al. (2015)
Iroha [sic] *melanosticta japonensis* Avdeev & Avdeev, 1974	*Mothocya* sp.; identity uncertain	Present study
Irona callionymus Avdeev & Avdeev, 1974	*Elthusa callionymus* (Avdeev & Avdeev 1974) comb. nov.	Present study
Irona ogcocephalus Avdeev & Avdeev, 1974	*Elthusa ogcocephalus* (Avdeev & Avdeev 1974) comb. nov.	Present study
Irona sp. 1, Trilles, 1979	= *Mothocya longicopa* Bruce, 1986	Rokicki (1986), present study
Irona trillesi Rokicki, 1986	= *Mothocya longicopa* Bruce, 1986	Present study
Mothocya ihi Bruce, 1986	= *Mothocya lineata* (Miers, 1876)	Martin et al. (2015)
Mothocya sp. (Bruce 1986)	*Mothocya affinis* sp. n.	Present study
Mothocya katoi Nunomura, 1992	= *Ceratothoa guttata* (Richardson, 1910)	Present study
Mothocya toyamaensis Nunomura, 1993	*Ceratothoa toyamaensis* (Nunomura, 1993) comb. nov.	Present study
Mothocya sp. Nunomura (2005)	*Cymothoa* sp.	Present study
Mothocya komatsui Yamauchi, 2009	Unchanged	Yamauchi (2009)
Mothocya sp. Yamauchi and Nunomura (2010)	Aegathoid (i.e. juvenile, generic identity unknown)	Present study
Mothocya bertlucy Hadfield, Sikkel & Smit, 2014	Unchanged	Hadfield et al. (2014b)

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

as well as Sodwana Bay, St Lucia and Mhlathuze estuaries in South Africa. Isopods were preserved in 70% ethanol and processed according to techniques described in Hadfield et al. (2010, 2011). The species descriptions were prepared in DELTA (Descriptive Language for Taxonomy) using a general Cymothoidae character set (as in Hadfield et al. 2013, 2014b) and full references are provided for all isopod authorities. Ratios and measurements of appendages were rounded off to one decimal place and were made using maximum values of the specific measured article. Classification follows Brandt and Poore (2003) and host nomenclature, species authorities (not included in the reference list) and distribution are from FishBase (Froese and Pauly 2014) and Eschmeyer (2015).

Abbreviations: MNHG—Muséum d'Histoire naturelle, Genève, Switzerland; RMNH—Rijksmuseum van Natuurlijke Historie (Naturalis Biodiversity Center), Leiden, The Netherlands ; TL—total length; USNM—National Museum of Natural History, Smithsonian Institution, Washington, DC, USA; W—width.

Taxonomy

Family Cymothoidae Leach, 1814

Genus *Mothocya* Costa, in Hope, 1851

Mothocya Costa, in Hope, 1851: 48.— Trilles, 1968: 168.— Monod, 1971: 174.— Bruce, 1986: 1092–1095.— Trilles, 1994: 197.— Hadfield, Sikkel & Smit, 2014: 111.

Irona Schioedte & Meinert, 1884: 381.— Stebbing, 1905: 27.— Richardson, 1905: 265.— Hale, 1926: 218.— Monod, 1971: 174.— Kussakin, 1979: 307.— Trilles, 1994: 166.

Type species

Mothocya epimerica Costa, in Hope, 1851; by subsequent designation (Bruce 1986).

Remarks

This genus was revised by Bruce (1986) and a revised diagnosis was given by Hadfield et al. (2014b). The genus can be distinguished from other gill-attaching genera in the Indian Ocean, such as *Elthusa* Schioedte & Meinert, 1884 and *Ichthyoxenus* Herklots, 1870, by the antennula being longer than the antenna, long pereopod dactyli and no enlarged carina on the basis of pereopods 5–7, maxilliped article 3 with 3–5 recurved robust setae, as well as simple laminar pleopods (Hadfield et al. 2014b).

***Mothocya plagulophora* (Haller, 1880)** Figures 1–2

Livoneca plagulophora Haller, 1880: 380, pl. 18, figs. 8–9.— Nierstrasz, 1931: 144.

Irona vatia Schioedte & Meinert, 1884: 386–388, Pl. XVII (Cym. XXXV), figs. 1–2.— Nierstrasz, 1915: 104–105; 1931: 145.— Monod, 1971: 169–176, figs. 18–42; 1976: 863, fig. 33.— Trilles, 1976: 784–785, pl. 1, fig. 9; 1994: 171.

Irona vatica [lapsus].— Pfeffer, 1889: 36.

Irona melanosticta.— Nierstrasz, 1915: 103–104 [non *Mothocya melanosticta* (Schioedte & Meinert, 1884)].

Irona far Nair, 1950: 70–74, pl. 2, figs. 13–23; 1956: 2–33.— Pillai, 1954: 17.— Abraham, 1966: 23–51, figs. 1–27.— Monod, 1971: 173.— Thampy & John, 1974: 574–583, figs. 1–18.

Mothocya plagulophora.— Bruce, 1986: 1134–1139, figs. 25–27, 54.— Trilles, 2008: 26.— Gopalakrishnan, Rajkumar, Jun & Trilles, 2010: 832–835.— Ravichandran, Rameshkumar & Trilles, 2011: 232–234.— Trilles, Ravichandran & Rameshkumar, 2011: 446–459.— Sethi, Jithendran & Kannappan, 2013: 357–360.— Rameshkumar, Ramesh, Ravichandran, Trilles & Subbiah, 2014: 1–4.— Vijayakumar, Raja, Velvizhi, Sinduja & Gopalakrishnan, 2014: 331–333.

Syntypes

Three syntypes ♀♀ (25.7–32.0 mm TL) from Mauritius ('Isles Maurice') (Haller 1880), no other data (MHNG uncatalogued) (Bruce 1986). Not examined. The whereabouts of the type material for *Irona far* Nair, 1950 remains unknown. The two syntypes for *Irona vatia* Schioedte & Meintert, 1884 were stated to be at 'Semper capta, in Museo Gotingensi asservantur' but are most likely lost as they could not be located in the Göttingen Museum material examined by Trilles (2008).

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

Material examined

Four ♀♀ (29.0–30.5 mm TL; 12.0–13.0 mm W), 1 ♂ (16.5 mm TL; 6.0 mm W), Maputo Fish Market (25.98° S, 32.62° E), Mozambique, from gills of black-barred halfbeak, *Hemiramphus far*, November 2013, coll. Wynand Vlok (SAM A78915).

Ovigerous female

Body weakly twisted, 2.4 times as long as greatest width, dorsal surfaces smooth, widest at pereonite 4 and 5, most narrow at pereonite 1, lateral margins slightly convex. Cephalon 0.7 times longer than wide, visible from dorsal view, trapezoid shaped. Eyes oval with distinct margins, moderate to large; eye 0.2 times width of cephalon, 0.3 times length of cephalon. Pereonite 1 smooth, anterior border indented, anterolateral angle narrowly rounded, posterior margins of pereonites smooth and straight. Coxae 2 and 3 narrow; 4–7 produced and with rounded point, not extending past pereonite margin. Pereonites 1–3 increasing in length and width; 5–7 decreasing in length and width. Pleon with pleonite 1 largely concealed by pereonite 7, slightly visible in dorsal view; pleonites posterior margin smooth, mostly concave; pleonite 2 partially overlapped by pereonite 7; pleonite 5 widest, with posterolateral angles narrowly rounded, posterior margin straight. Pleotelson 0.7 times as long as anterior width, dorsal surface smooth, lateral margins weakly convex, posterior margin evenly rounded.

Antennula with 7 articles; peduncle articles 1 and 2 distinct; article 2 1.2 times as long as article 1; article 3 1.2 times as long as wide, 0.5 times as long as combined lengths of articles 1 and 2; flagellum with 4 articles, extending to posterior margin of eye, with tufts of simple setae on articles 4–6. Antenna with 8 articles; peduncle article 3 1.3 times as long as article 2, 0.9 times as long as wide; article 4 1.4 times as long as wide, 1.2 times as long as article 3; article 5 0.9 times as long as article 4, 1.6 times as long as wide; flagellum with 3 articles, terminal article terminating in 6 or 7 short simple setae.

Molar process present, mandible palp without setae. Maxillula with 4 terminal robust setae. Maxilla lateral lobe with 2 recurved robust setae; mesial lobe with 2 large recurved robust setae. Maxilliped article 3 with 6 recurved robust setae.

Pereopod 1 basis 1.5 times as long as greatest width; ischium 0.8 times as long as basis; merus proximal margin with slight bulbous protrusion; carpus with straight proximal margin; propodus 1.3 times as long as wide; dactylus moderately slender, 0.9 times as long as propodus, 2.2 times as long as basal width. Pereopod 7 basis 2.5 times as long as greatest width; ischium 0.7 as long as basis; merus proximal margin with slight bulbous protrusion, 0.4 as long as ischium, 0.6 times as long as wide; carpus 1.3 as long as ischium, 0.8 times as long as wide; propodus 0.7 as long as ischium, 1.5 times as long as wide; dactylus moderately slender, 1.1 as long as propodus, 2.3 times as long as basal width.

Pleopod 1 exopod 0.8 times as long as wide, lateral margin strongly convex, distally broadly rounded, mesial margin strongly convex; endopod 1.2 times as long as wide, lateral margin convex, distally narrowly rounded, mesial margin straight; peduncle 3 times as wide as long. Pleopods 2–5 similar to pleopod 1. Pleopods 3–5 endopods proximal borders extending below exopod to peduncle. Proximomedial lobes present and increasing in size from pleopod 1 to 5. Peduncle lobes increasing in size from pleopod 2 to 5.

Uropod half length of pleotelson, peduncle 0.7 times longer than rami, peduncle lateral margin without setae; rami not extending beyond pleotelson. Endopod apically slightly pointed, 4.3 times as long as greatest width, lateral margin distally straight, mesial margin straight, terminating without setae. Exopod extending beyond end of endopod, 1.4 times longer than endopod, 4.8 times as long as greatest width, apically rounded, lateral margin weakly convex, mesial margin straight, terminating without setae.

Distribution

From the Indian Ocean: Mauritius (Haller 1880; Bruce 1986); Zanzibar (Pfeffer 1889; Bruce 1986); Indonesia (Nierstrasz 1915; Bruce 1986); India (Nair 1950; Pillai 1954; Gopalakrishnan et al. 2010); Madagascar (Monod 1971); Djibouti (Trilles 1976); Comoro Islands, Kenya, Somalia, Sri Lanka, Australia (Bruce 1986); and Mozambique (present study).

Schioedte and Meinert (1884) mentioned a possible occurrence in the Philippines (Mariveles, Luzon Island) but the identity was not confirmed.

Hosts

Known only from the black-barred halfbeak, *Hemiramphus far* (Forsskål, 1775), with one record from the yellowtip halfbeak, *Hemiramphus marginatus* (Forsskål, 1775) (Sethi et al. 2013). There are also unconfirmed records from a *Sardinella* species (Bruce 1986) and from a belonid host (Monod 1971).

Remarks

Mothocya plagulophora can be distinguished from other *Mothocya* species by the characteristically large and extremely wide pleon and pleotelson. Furthermore, the unique colour pattern in Indian and central Indo-West Pacific specimens is characteristic for the species, showing dark bands along the pereonite and pleonite posterior margins. Specimens from East Africa lack these bands and are uniform in colour (Bruce 1986). *Mothocya plagulophora* also has short uropods, pleonite 5 wider than the other pleonites, and is the only *Mothocya* species known to infect *Hemiramphus far*.

Comparison of numerous drawings of the Mozambique specimen in this study with the drawings and description by Bruce (1986) reveal only minor variations that can be considered as within the range of intraspecific variation shown by species of *Mothocya*. These isopods are known to be highly variable, as can be seen in the study by Hadfield et al. (2014c) where one species, *Ceratothoa retusa* (Schioedte & Meinert, 1883), showed many morphological differences depending on its geographical locality. The two most noticeable variations include the number of maxilliped recurved robust setae and the size of females. Bruce (1986) reported four recurved robust setae on article

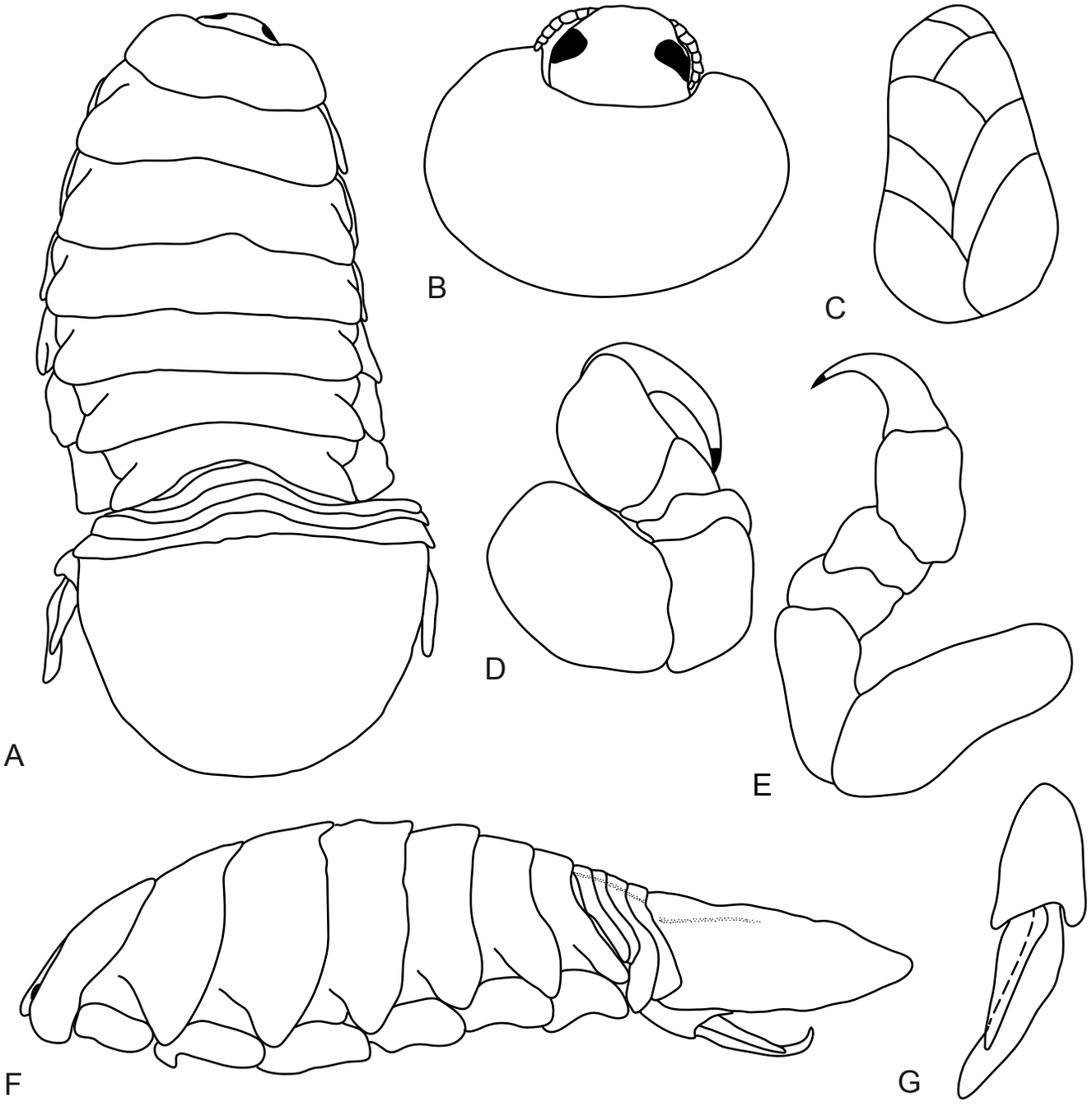

Figure 1: *Mothocya plagulophora* (Haller, 1880) (30.5 mm) (SAM A78915): (A) dorsal view, (B) dorsal view of cephalon, (C) oostegites, (D) pereopod 1, (E) pereopod 7, (F) lateral view, (G) uropod

3 of the maxilliped and females ranging from 17 to 26 mm in length, whereas six recurved robust setae and females measuring 29–30.5 mm are reported in the present study.

Mothocya plagulophora was thought to be specific to a single host species, *H. far*, but recently *H. marginatus* was identified as a new host from India (Sethi et al. 2013). It has also often been collected together with *Lernaeenicus hemiramphi* Kirtisinghe, 1932 from the same host fish (Gopalakrishnan et al. 2010; Vijayakumar et al. 2014).

***Mothocya renardi* (Bleeker, 1857)** Figures 3–4

Livoneca Renardi Bleeker, 1857: 28–29, pl. 1, fig. 8.

Irona Renardi.— Schioedte & Meinert, 1884: 383–386, pl. XIV (Cym. XXXIV), figs. 10–15.

Livoneca Renardi.— Gerstaecker, 1881: 261.

Irona melanosticta.— Barnard, 1914: 373–374; 1955: 6.— Kensley, 1978: 80, fig. 33A (non *I. melanosticta* Schioedte & Meinert, 1884.)

Irona renardi.— Nierstrasz, 1915: 104; 1931: 145.— Hale, 1926: 218–220, fig. 12; 1929: 258, fig. 255.— Holthuis,

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

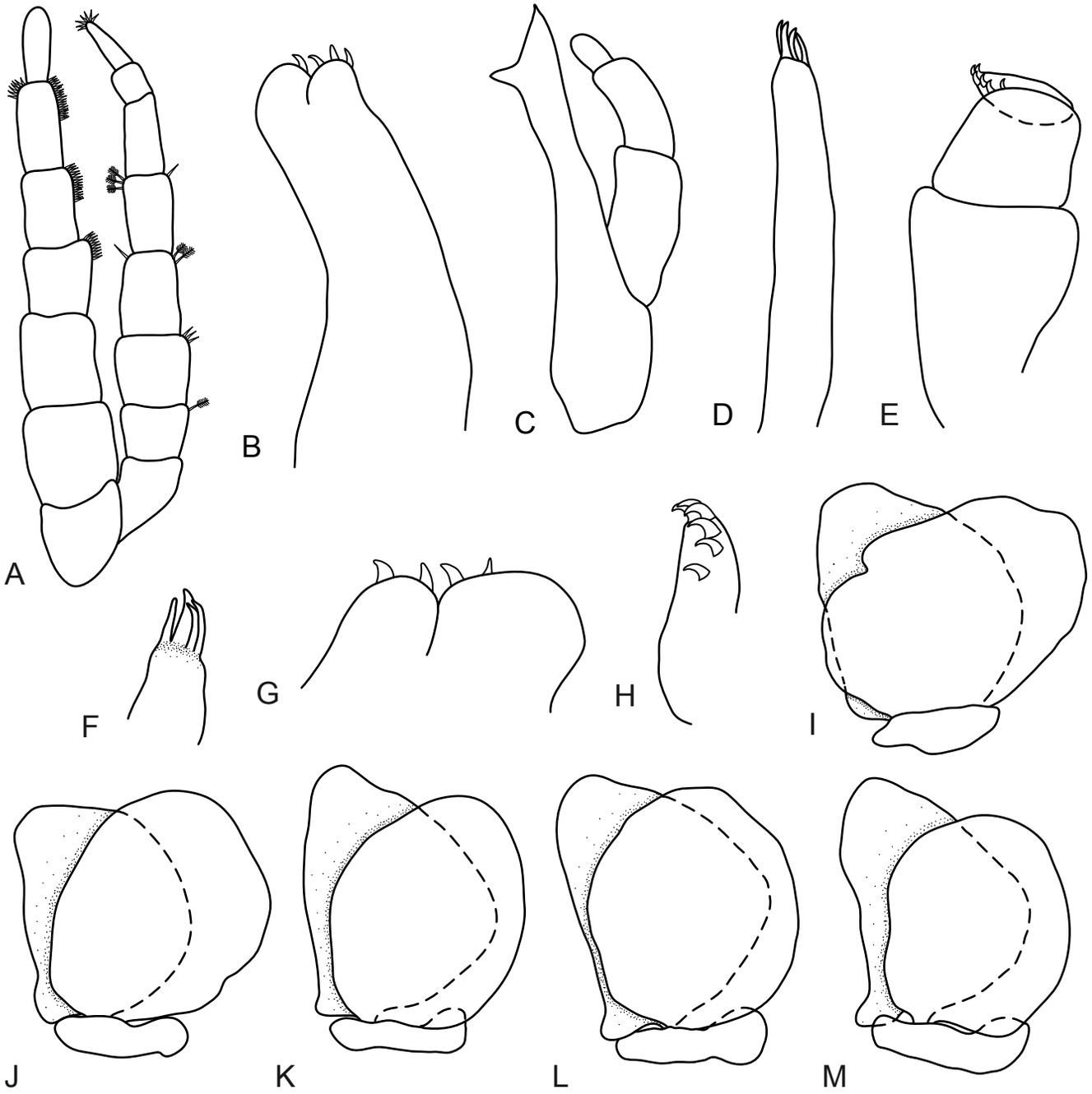

Figure 2: *Mothocya plagulophora* (Haller, 1880) (30.5 mm) (SAM A78915): (A) antennula and antenna, (B) maxilla, (C) mandible, (D) maxillula, (E) maxilliped, (F) tip of maxillula, (G) maxilla tip, (H) tip of maxilliped article 3, (I–M) pleopod 1–5, respectively

1959: 97, photo. 11, figs. 4–9.— Monod, 1971: 173–174; 1976: 863, figs. 30, 32.— Trilles, 1976: 785–786, Pl. 11, fig. 10; 1979: 266.— Beumer, Ashburner, Burbury, Jette & Latham, 1982: 32.

Irona robusta Nair, 1950: 66–70, figs. 1–12; 1956: 2.— Abraham, 1966: 23–42, figs. 28–54, photos 5–6; 1967: 10–16, figs. 1–25.— Monod, 1971: 174.

Mothocya species.— Bowman & Tareen, 1983: 25, fig. 19.

Mothocya renardi.— Bruce, 1986: 1169–1177, figs. 49–52, 55.— Williams & Williams, 1986: 215.— Yu & Li, 2003: 230–232, fig. 6.— Jones, Miller, Grutter & Cribb, 2008: 477–491.— Aneesh, Sudha, Helna, Arshad, Anilkumar & Trilles, 2013: 1–9.— Trilles, Ravichandran & Rameshkumar, 2011: 446–459.— Rameshkumar, Ravichandran & Allayie, 2013: 127–132.

Lironeca puhi.— Ravichandran, 2007: 87–93, fig. 3 [misidentification].

Non *Lironeca Renardi*.— Miers, 1880: 465–466.

Non *Irona renardii*.— Lanzing & O'Connor, 1975: 355–361, fig. 1 c–d [= *Mothocya halei*].

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

Syntypes

Two presumed syntypes ♀♀ (19.5–21.5 mm TL) from Jakarta Bay ('mer de Batavia'), Java, Indonesia, coll: P. Bleeker (RMNH 4611) (Bruce 1986). Not examined; redescribed by Bruce (1986).

Material examined

Two ovig. ♀♀ (21.0 mm TL; 10.0–11.0 mm W), 1 ♂ (14.0 mm TL; 5.0 mm W), St Lucia, South Africa, 28.384531° S, 32.424744° E, from gills of banded needlefish, *Strongylura leiura*, January 1997, coll. Nico Smit (SAM A78916). 1 ovig. ♀ (21.0 mm TL; 10.0 mm W), Chinde, Mozambique, 18.577841° S, 36.470958° E, from gills of Red Sea houndfish, *Tylosurus choram*, November 1912, coll. K.H. Barnard (SAM A2675). 2 ♀♀ (23.0–24.0 mm TL; 12.0–13.0 mm W), 1 ♂ (18.0 mm TL; 7.0 mm W), Salisbury channel, Durban harbour, South Africa, 29.873019° S, 31.054119° E, from gills of banded needlefish, *Strongylura leiura* (labelled as *Tylosurus leiurus*), April 1952 (SAM A44855 – previously labelled as *Irona melanosticta*, see Barnard 1955). 1 ♀ (19.0 mm TL; 8.0 mm W), 1 ♂ (9.0 mm TL; 4.0 mm W), Mhlathuze estuary, South Africa, 28.814073° S, 32.035436° E, from gills of banded needlefish, *Strongylura leiura*, July 2000 (SAM A78917).

Ovigerous female

Body oval and weakly twisted, 1.8 times as long as greatest width, widest at pereonite 3, most narrow at pereonite 7, lateral margins slightly convex. Cephalon 0.7 times longer than wide, visible from dorsal view, ovate. Eyes oval with distinct margins; eye 0.3 times width of cephalon, 0.4 times length of cephalon. Pereonite 1 smooth, anterior border deeply indented to surround cephalon, anterolateral angle wide with inwardly produced point; posterior margins of pereonites smooth and straight. Coxae 2 and 3 narrow with posteroventral angles rounded; 4–7 produced with rounded point, most not extending past pereonite margin. Pereonites 1–3 increasing in length and width; 4–7 decreasing in length and width; becoming more progressively rounded posteriorly. Pleon with pleonite 1 completely concealed by pereonite 7; pleonites 2 and 3 partially overlapped by pereonite 7; posterolateral angles of pleonite 2 forming acute point; pleonites posterior margin smooth. Pleonites 3–5 similar to pleonite 2. Pleonite 5 posterolateral angles forming acute point, posterior margin straight. Pleotelson 0.9 times as long as anterior width, dorsal surface smooth, lateral margins widen slightly then curve inwards, posterior margin evenly rounded, without median point.

Antennula with 8 articles; peduncle articles 1 and 2 distinct and articulated; article 2 0.5 times as long as article 1; article 3 1.3 times as long as wide, 0.5 times as long as combined lengths of articles 1 and 2; flagellum with tufts of setae on articles 4–7, extending to middle of eye, terminal article terminating in 5–10 short simple setae. Antenna with 9 articles; peduncle article 3 0.8 times as long as article 2, 0.7 times as long as wide; article 4 1.5 times as long as wide, 1.9 times as long as article 3; article 5 0.9 times as long as article 4, 1.5 times as long as wide; flagellum with 4 articles, last article terminating in 6 or 7 short simple setae.

Molar process present, mandible palp without setae. Maxillula with 4 terminal robust setae. Maxilla lateral lobe with 2 recurved robust setae; mesial lobe with 2 large recurved robust setae. Maxilliped article 3 with four recurved robust setae.

Pereopod 1 basis 1.6 times as long as greatest width; ischium 0.6 times as long as basis; merus proximal margin; carpus with straight proximal margin; propodus 1.4 times as long as wide; dactylus slender, as long as propodus, 2.4 times as long as basal width. Pereopods all without robust or simple setae. Pereopod 7 basis 1.9 times as long as greatest width; ischium 0.9 as long as basis; merus proximal margin, 0.5 as long as ischium, 1.2 times as long as wide; carpus 0.6 as long as ischium, 0.7 times as long as wide; propodus 0.8 as long as ischium, 1.4 times as long as wide; dactylus slender, 1.3 as long as propodus, 2.7 times as long as basal width.

Pleopods extending past posterior margin of pleotelson. Pleopod 1 exopod 1.5 times as long as wide, lateral margin weakly convex, distally broadly rounded, mesial margin strongly convex; endopod 1.6 times as long as wide, lateral margin weakly convex, distally subtruncate, mesial margin mostly straight, peduncle 3.2 times as wide as long. Pleopods 2–5 similar to pleopod 1. Proximomedial lobes present and increasing in size from pleopod 1 to 5. Peduncle lobes increasing in size from pleopod 2 to 5.

Uropod longer than pleotelson, peduncle 0.6 times longer than rami, peduncle lateral margin without setae; rami extending beyond pleotelson, marginal setae absent. Endopod apically rounded, 4.4 times as long as greatest width, lateral margin straight, mesial margin straight, terminating without setae. Exopod extending beyond end of endopod, 1.4 times longer than endopod, 5.2 times as long as greatest width, apically narrowly rounded, lateral margin straight, mesial margin straight, terminating without setae.

Distribution

Known from the Indian Ocean and Indo-West Pacific: Indonesia (Bleeker 1857; Nierstrasz 1915; Bruce 1986); Australia (Hale 1926; Bruce 1986); Philippines (Schioedte and Meinert 1884; Bruce 1986); India (Nair 1950; Bruce 1986; Trilles et al. 2011); Madagascar (Trilles 1976); Kuwait (Bowman and Tareen 1983); Japan, Kenya, Mozambique and Papua New Guinea (Bruce 1986); Thailand (Williams and Williams 1986); China (Yu and Li 2003); and South Africa (present study).

Hosts

The most frequently recorded host is *Strongylura leiura* (Bleeker, 1850) (sometimes cited as *Tylosurus leiurus* or *Belone ciconia*). Hale (1926) recorded it from *Strongylura leiura* (cited as *Tylosurus ferox*, presumably *Belone ferox*, which is a junior synonym of *S. leiura*) and *Tylosurus gavialoides* (Castelnau, 1873) (cited as *Tylosurus macleayana*, presumably *Belone macleayana*, which is a junior synonym for *T. gavialoides*). Other host species are *Strongylura anastomella* (Valenciennes, 1846), *S. incisa* (Valenciennes, 1846), *S. strongylura* (van Hasselt, 1823) and *Tylosurus crocodilus* (Péron & Lesueur, 1821) (Bruce 1986). Bruce (1986) reported *M. renardi* from '*Strongylura crocodilis* (recorded as *S. choram*)' (Bruce 1986: 1174) as the host from the Zambezi River estuary (SAM A2675); however, the original label records the host as *Tylosurus*

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

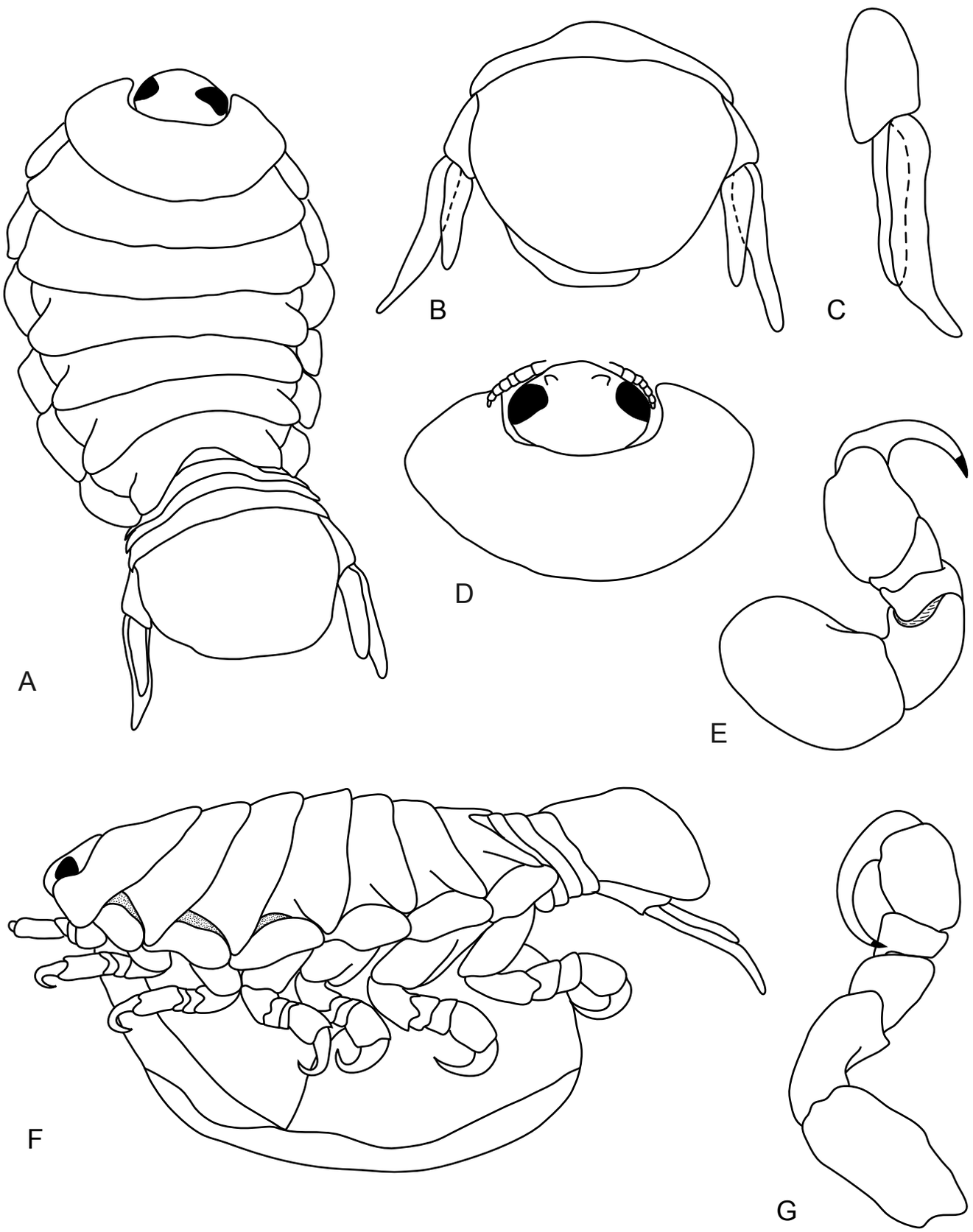

Figure 3: *Mothocya renardi* (Bleeker, 1857) (21 mm) (SAM A78916): **(**A) dorsal view, (B) dorsal view of pleotelson, (C) uropod, (D) anterodorsal view of pereonite 1 and cephalon, (E) pereopod 1, (F) lateral view, (G) pereopod 7

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

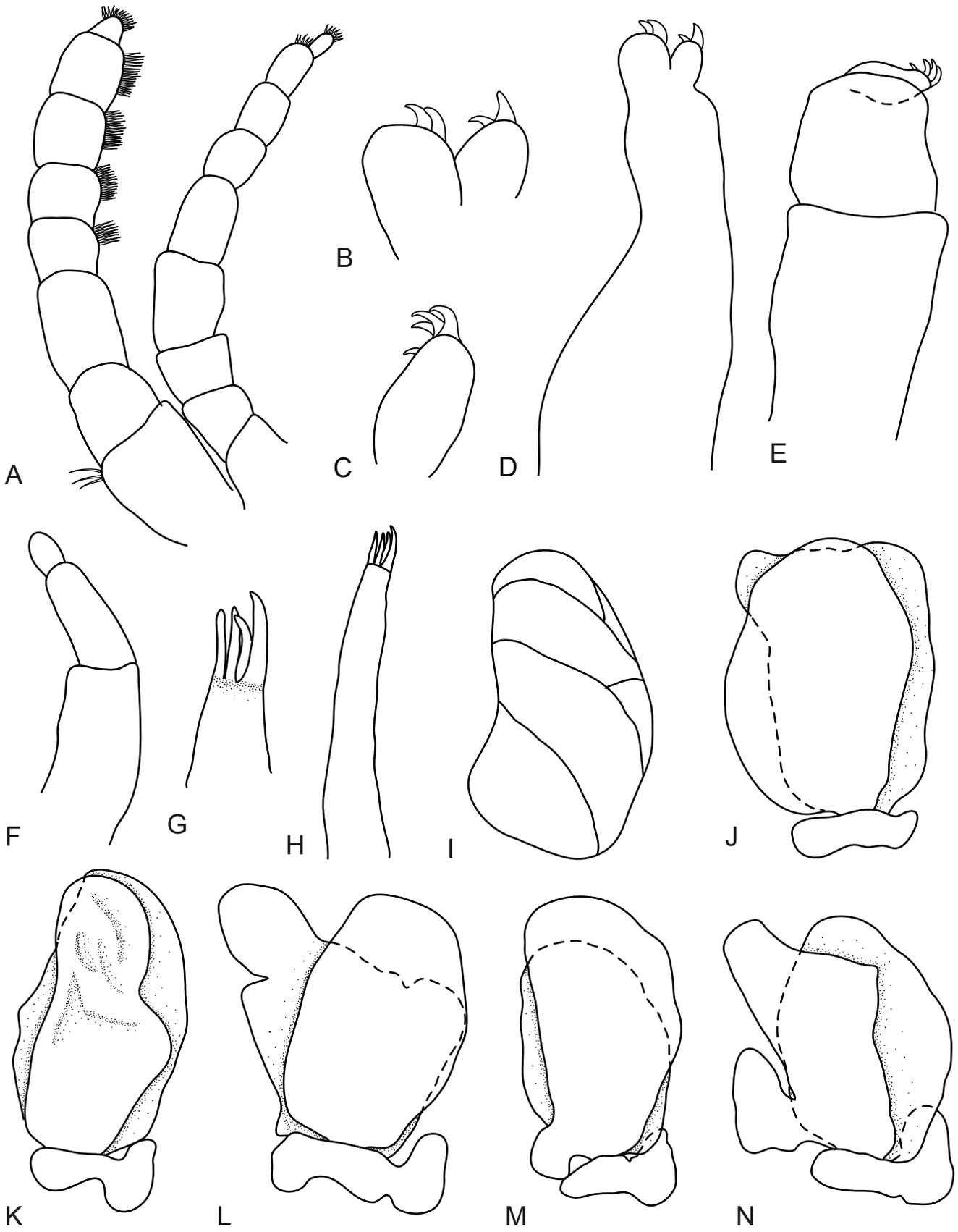

Figure 4: *Mothocya renardi* (Bleeker, 1857) (21 mm) (SAM A78916): (A) antennula and antenna, (B) maxilla tip, (C) tip of maxilliped article 3, (D) maxilla, (E) maxilliped, (F) molar process, (G) tip of maxillula, (H) maxillula, (I) oostegites, (J–N) pleopod 1–5, respectively

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

choram (Rüppell, 1837), adding another host record for this species.

Remarks

Mothocya renardi can be distinguished by the large size (24–36 mm in length), narrow pleon and long narrow uropods, which extend well past the posterior margin of the pleotelson.

Variation is seen among *M. renardi* specimens from different regions (as is known for other cymothoid species; see Hadfield et al. 2014c). Those specimens from the Indian Ocean average 24 mm (the specimens from the present study correspond with this size range), those from the Indo-Malaysian and northern Pacific regions average 27 mm, and those from Australia average 29 mm in total length (Bruce 1986). Specimens also differ in body shape, widest pereonite, shape of pleotelson and pereopod 7 propodus.

When compared with the description of the syntypes given by Bruce (1986), specimens from South Africa are broader with a moderately twisted pleon in relation to the plane of the pereon. Furthermore, the maxilla lateral lobe has two rather than three recurved robust setae, the propodal palm on pereopod 7 does not form a shallow lobe, and the exopod is 1.4 rather than 1.6 times longer than endopod.

Bruce (1986) examined the specimens and confirmed the identity of many previous records and was able to confidently synonymise *M. robusta* with *M. renardi*. Miers (1880) reported on a single female in the museum collection from a *Mugil* species inhabiting Indian waters. This report seems doubtful and is here removed from the synonymy.

This is the first record of *M. renardi* from South Africa and conforms to the known distribution of *M. renardi* within the Indian and Pacific oceans. Barnard (1914, 1955) incorrectly identified *M. renardi* as *Irona melanosticta* Schioedte & Meinert, 1884; those records later repeated by Kensley (1978: fig. 33A) are now here corrected. The host species record of *Tylosurus choram* is also confirmed.

***Mothocya affinis* sp. n.** Figures 5–8

Mothocya sp.— Bruce, 1986: 1178.

Material examined

All material from the gills of the tropical halfbeak, *Hyporamphus affinis*.

Holotype. 1 ovig. ♀ (16.0 mm TL; 8.0 mm W), Sodwana Bay, South Africa (27.540202° S, 32.678191° E), March 2010, coll. Kerry Hadfield, Nico Smit and Niel Bruce (SAM A78918).

Paratypes. 5 ♀♀ (10.0–16.0 mm TL; 5.0–8.5 mm W), 5 ♂♂ (8.0–10.0 mm TL; 4.0–5.0 mm W), 2 juveniles (7 mm TL; 3 mm W), Sodwana Bay, South Africa (27.540202° S, 32.678191° E), March 2010, coll. Kerry Hadfield, Nico Smit and Niel Bruce (SAM A78919).

Other material. 3 ♀♀, 8 ♂♂, Dog Point (27.1° S, 32.84° E), between Sodwana Bay and Kosi Bay, Natal, March 1981 (USNM 216412).

Ovigerous female holotype

Body oval and weakly twisted, twice as long as greatest width, widest at pereonite 3, most narrow at pereonite 7, lateral margins slightly convex. Cephalon 0.6 times longer than wide, visible from dorsal view, roughly semi-circular. Eyes oval with distinct margins; eye 0.2–0.3 times width of cephalon, 0.6 times length of cephalon. Pereonite 1 smooth, anterior border deeply indented, anterolateral angle wide, with inwardly produced point and produced to frontal margin of cephalon; posterior margins of pereonites smooth and straight. Coxae 2–3 wide with small produced point; 4–7 large, rounded and produced, coxae of pereonite 7 may be produced to pereonite 5, coxae of pereonite 7 0.9 to 1.2 times longer than wide; same length as pereonite or produced past pereonite margin. Pereonites 1–3 increasing in length and width; 4–7 decreasing in length and width; becoming more progressively rounded posteriorly. Pleon with pleonite 1 concealed by pereonite 7; pleonites 2–5 partially overlapped by pereonite 7 and coxae; pleonites posterior margin smooth. Pleonite 5 with posterolateral angles narrowly rounded, posterior margin straight. Pleotelson 0.8 times as long as anterior width, dorsal surface smooth, lateral margins widen slightly then curve inwards, posterior margin subtruncate.

Antennula with 8 articles; peduncle articles 1 and 2 distinct; article 2 0.9 times as long as article 1; article 3 1.1 times as long as wide, 0.6 times as long as combined lengths of articles 1 and 2; flagellum extending to middle of eye, last article terminating in 4–7 short simple setae. Antenna with 9 articles; peduncle article 3 1.1 times as long as article 2, 1.2 times as long as wide; article 4 1.6 times as long as wide, 1.2 times as long as article 3; article 5 0.8 times as long as article 4, 1.4 times as long as wide; flagellum with last article terminating in 6–7 short simple setae.

Molar process present, without setae; mandible palp without setae. Maxillula with 4 terminal robust setae. Maxilla lateral lobe with 2 recurved robust setae; mesial lobe with 1 large recurved robust seta. Maxilliped article 3 with 3 recurved robust setae, and no simple setae.

Pereopod 1 basis 1.6 times as long as greatest width; ischium 0.7 times as long as basis; merus proximal margin with slight bulbous protrusion; carpus with straight proximal margin; propodus 1.3 times as long as wide; dactylus moderately slender, 1.4 times as long as propodus, 3 times as long as basal width. Pereopod 2 propodus 1.2 as long as wide; dactylus 1.4 as long as propodus. Pereopods all without robust or simple setae. Pereopod 6 basis 1.6 times as long as greatest width, ischium 0.9 times as long as basis, propodus 1.4 as long as wide, dactylus 1.5 as long as propodus. Pereopod 7 basis 2.2 times as long as greatest width; ischium 0.8 as long as basis; merus proximal margin, 0.4 as long as ischium, 0.8 times as long as wide; carpus 0.4 as long as ischium, 0.8 times as long as wide; propodus 0.7 as long as ischium, 1.4 times as long as wide; dactylus moderately slender, 1.6 as long as propodus, 2.7 times as long as basal width.

Pleopod 1 exopod 1.1 times as long as wide, lateral margin weakly convex, distally narrowly rounded with strongly oblique medial margin; endopod 1.5 times as long as wide, lateral margin weakly convex, distally subtruncate, mesial margin straight, peduncle 2.9 times as wide as long. Pleopods 3–5 endopods proximal borders extending below exopod to peduncle. Proximomedial lobes present

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

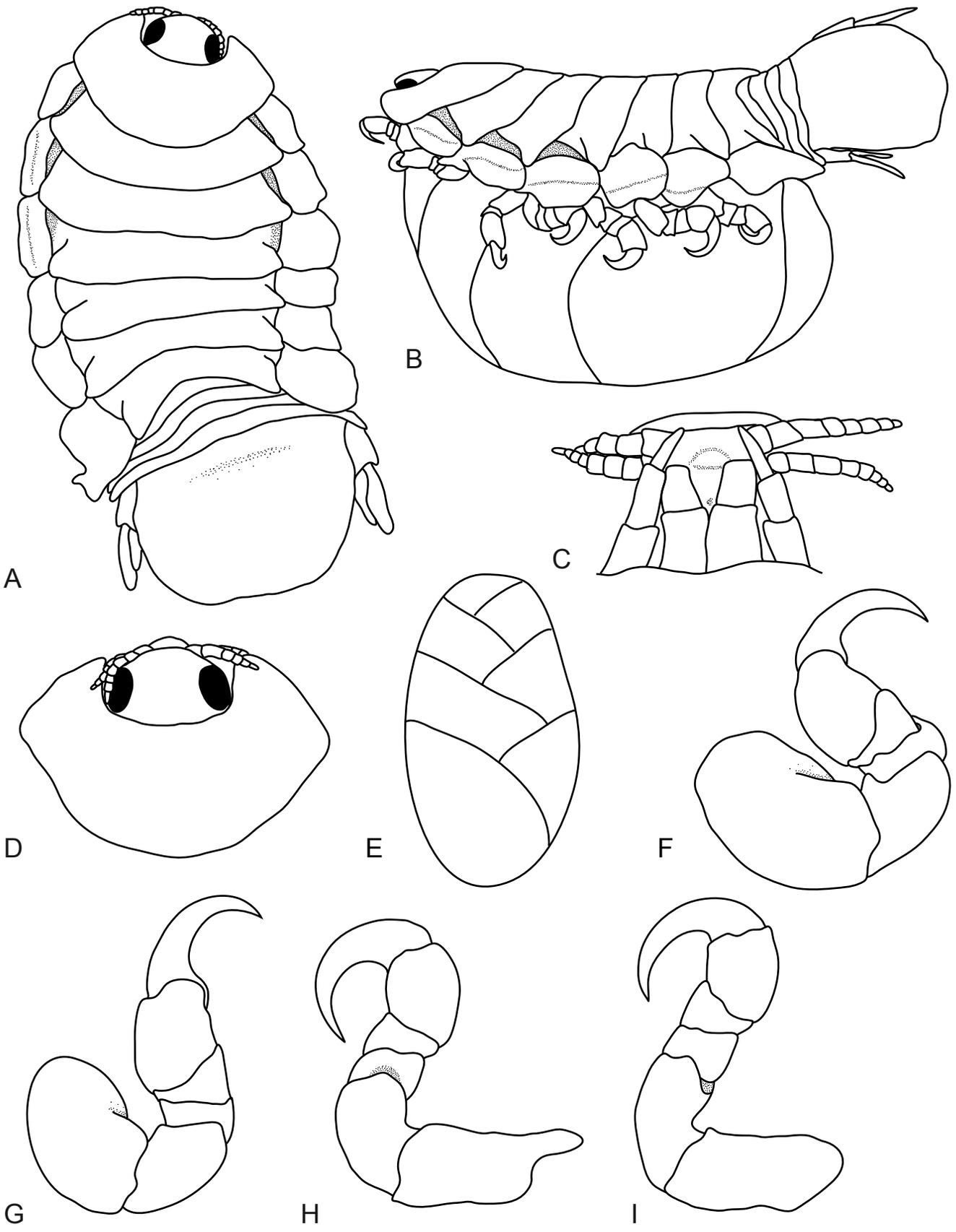

Figure 5: *Mothocya affinis* sp. n. female holotype (16 mm) (SAM A78918): (A) dorsal view, (B) lateral view, (C) ventral view of cephalon, (D) dorsal view of pereonite 1 and cephalon, (E) oostegites, (F) pereopod 1, (G) pereopod 2, (H) pereopod 6, (I) pereopod 7

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

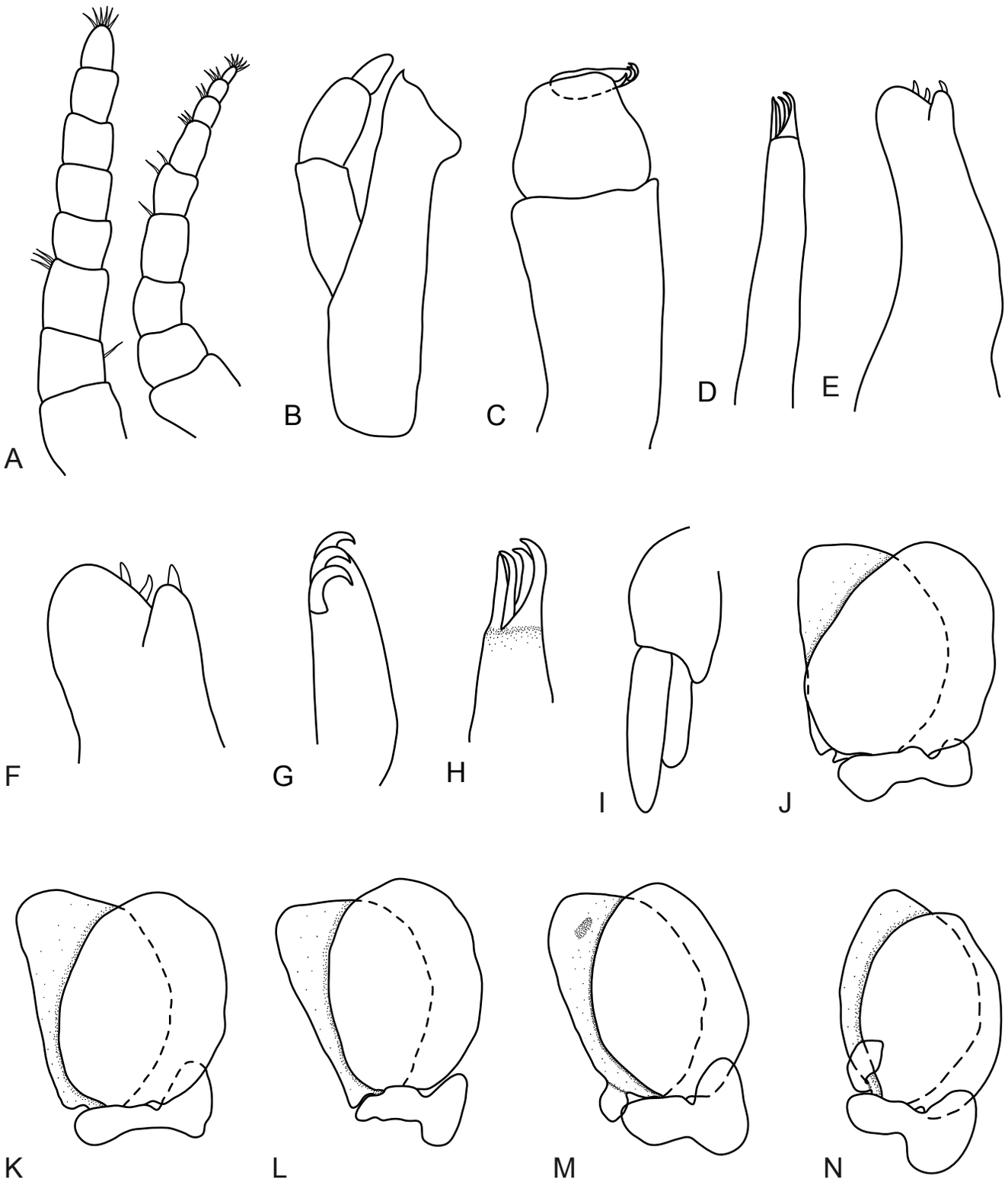

Figure 6: *Mothocya affinis* sp. n. female paratype (15 mm) (SAM A78919): (A) antennula and antenna, (B) mandible, (C) maxilliped, (D) maxillula, (E) maxilla, (F) maxilla tip, (G) tip of maxilliped article 3, (H) tip of maxillula, (I) uropod, (J–N) pleopod 1–5, respectively

and increasing in size from pleopod 1 to 5. Peduncle lobes increasing in size from pleopod 2 to 5.

Uropod more than half length of pleotelson, peduncle 0.9 times longer than rami, peduncle lateral margin without setae; rami not extending beyond pleotelson, marginal setae absent, apices broadly rounded. Endopod apically rounded, 4.2 times as long as greatest width, lateral margin straight, mesial margin straight, terminating with no setae. Exopod extending beyond end of endopod, 1.4 times longer than endopod, 4.3 times as long as greatest width, apically rounded, lateral margin straight, mesial margin straight, terminating without setae.

Male

Males similar to females but smaller. Body more oval than female, not twisted, 2.2 times as long as wide. Maxilla and maxilliped article 3 each with 4 robust setae. Penes prominent, set apart, 1.3 times as long as basal width, shallow indent between tubercules. Pleopod 2 appendix masculina narrow, basally swollen, 0.8 times as long as endopod, distally bluntly rounded. Uropods extend past posterior margin of pleotelson, exopod longer than endopod, exopod 1.4 times as long as endopod. Pleotelson subtriangular.

Size

Ovigerous females (n = 3): TL 15.0–16.0 mm (mean = 15.7 mm), W 7.0–8.0 mm (7.5 mm); non-ovigerous females (n = 3): TL 10.0–14.5 mm (mean = 12.8 mm), W 5.0–8.5 mm (6.8 mm); mature males (n = 5): TL 8.0–10.0 mm (mean =

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

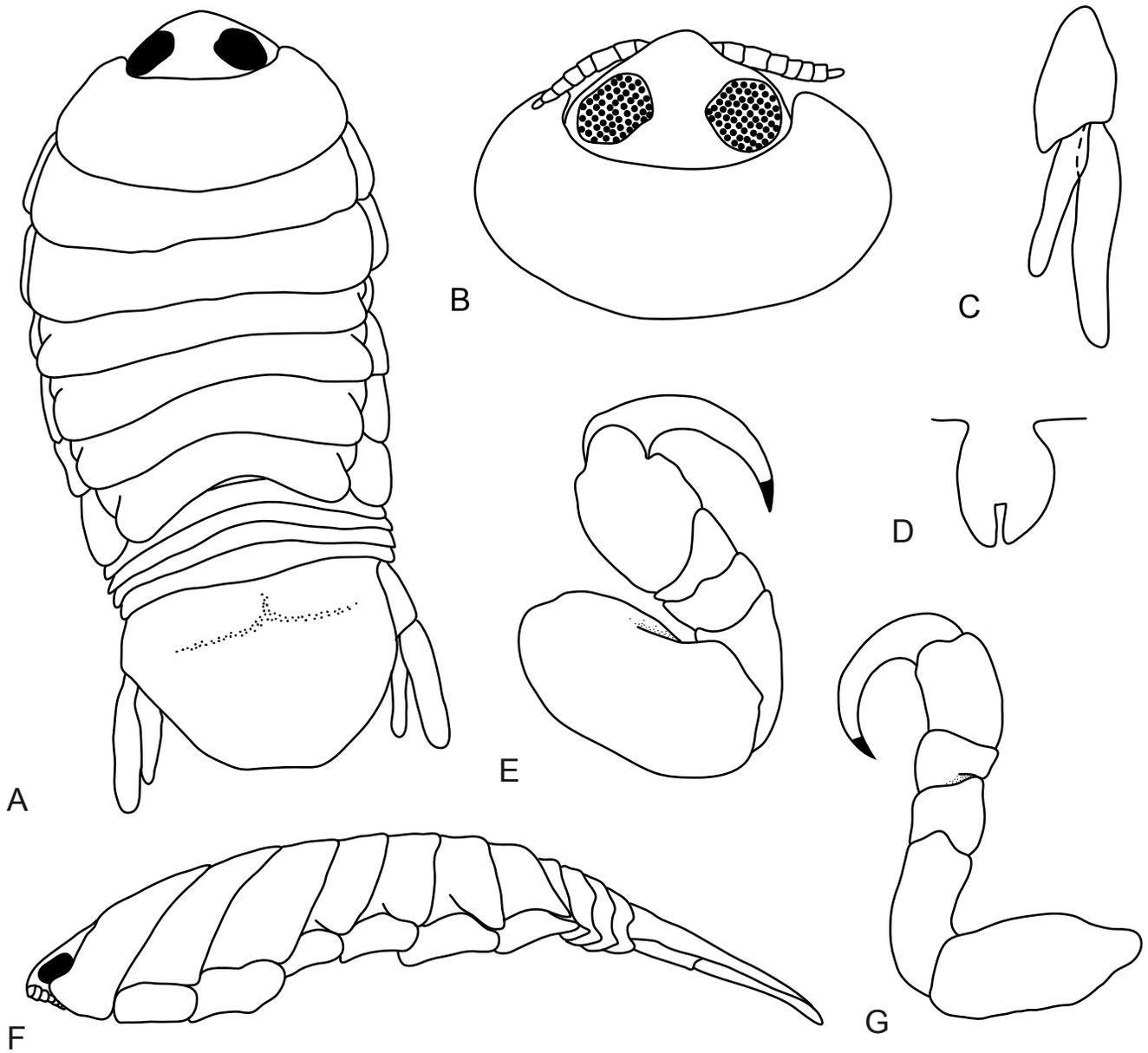

Figure 7: *Mothocya affinis* sp. n. male paratype (10 mm) (SAM A78919): **(**A) dorsal view, (B) ventral view of cephalon, (C) uropod, (D) penes, (E) pereopod 1, (F) lateral view, (G) pereopod 7

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

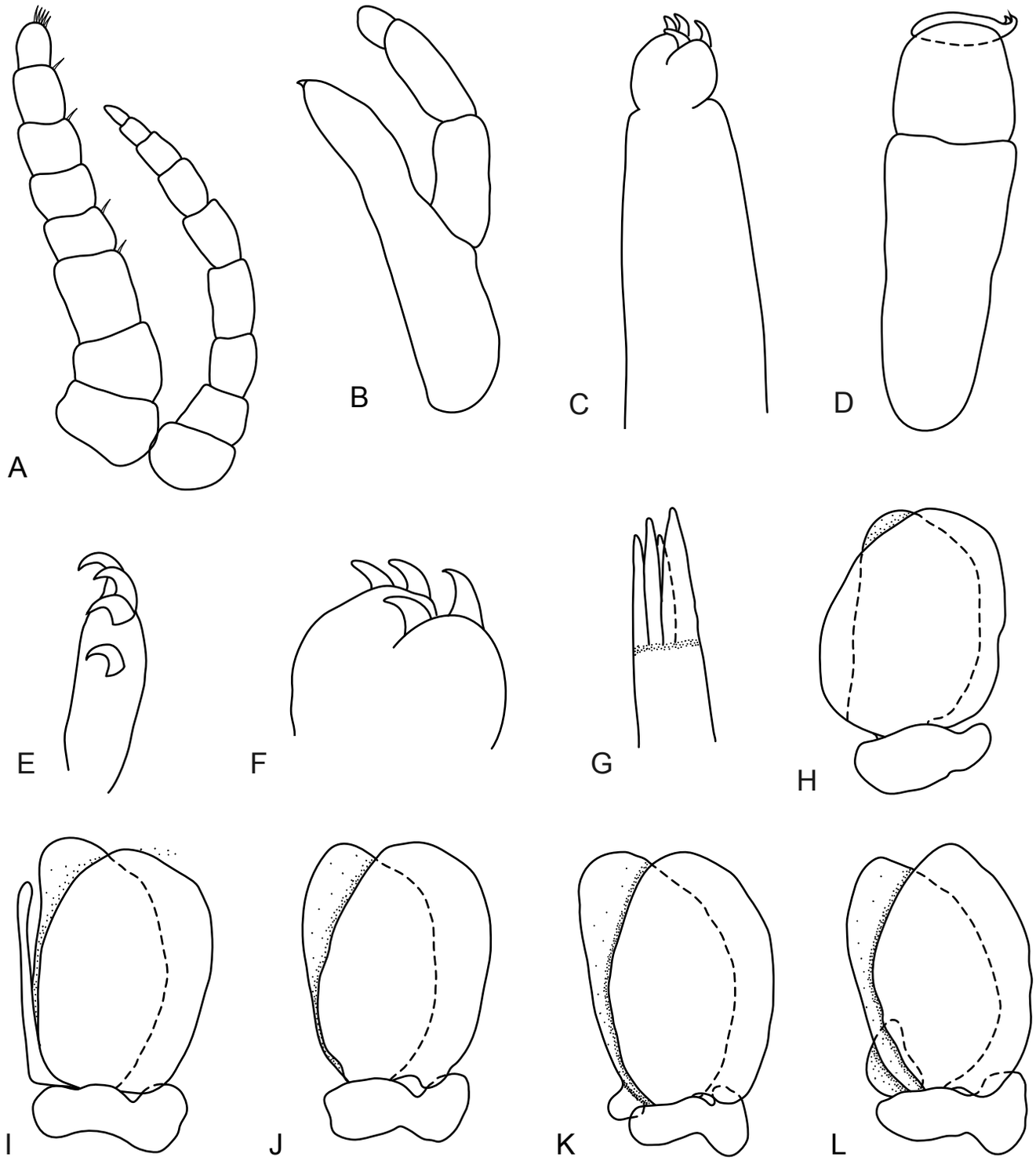

Figure 8: *Mothocya affinis* sp. n. male paratype (10 mm) (SAM A78919): (A) antennula and antenna, (B) mandible, (C) maxilla, (D) maxilliped, (E) tip of maxilliped article 3, (F) tip of maxilla, (G) tip of maxillula, (H–L) pleopod 1–5, respectively

8.8 mm), W 4.0–5.0 mm (4.6 mm); immature males (n = 2): TL 7.0 mm; W 3.0 mm.

Etymology
Named after the only known host species, *Hyporamphus affinis*; noun in apposition.

Distribution
Known only from Sodwana Bay, north-eastern South Africa.

Hosts
Known only from the tropical halfbeak, *Hyporamphus affinis* (Günther, 1866).

Remarks
The most distinctive character for *Mothocya affinis* sp. n. is the large, wide coxae, especially those of pereonite 7, which extend over the pleon. Other distinguishing characters include the short uropods, which do not extend past the pleotelson posterior margin, pereonite 1 anterolateral margins extend to the anterior margin of the eye, subtriangular cephalon, and a twisted pleon and pleotelson.

Some intraspecific variation is seen among specimens of *M. affinis* sp. n. The pleotelson is narrowly rounded and the uropods extend to the posterior margin of the pleotelson in younger females. Some specimens appear more twisted than others with the pleon and pleotelson twisting to approximately 45° to the plane of the pereon.

Mothocya affinis sp. n. is similar to *M. collettei* Bruce, 1986 but is smaller in size (average 15.7 mm compared with 20.5 mm in *M. collettei*), has a different host, has a more twisted and convex body shape, has one recurved seta on the medial maxilla lobe (vs two in *M. collettei*), three recurved setae on maxilliped article 3 (four in *M. collettei*), the shape of the coxae is less wide and longer laterally than *M. collettei*, shorter uropods, and the pleotelson is not as wide and round as *M. collettei*.

The other southern African *Mothocya* species, *M. renardi* and *M. plagulophora*, are easily distinguished from *M. affinis* (Figure 9). *Mothocya affinis* sp. n. has shorter uropods, a wider pleon, larger coxae, and shorter pleopods than *M. renardi*. It also has larger coxae, a much narrower pleon and pleotelson, longer uropods, and larger peduncle and posteromedial lobes on the pleopods than *M. plagulophora*.

Status of records of *Mothocya* since 1986
Irona ogcocephalus Avdeev and Avdeev, 1974, *I. callionymus* Avdeev and Avdeev, 1974, and the subspecies *Irona melanosticta japonensis* Avdeev and Avdeev, 1974 have largely been overlooked since their description. *Irona ogcocephalus* was collected from an *Ogcocephalus* sp. (batfish) and *I. callionymus* was collected from a *Callionymus* sp. (dragonet). However, the antennula is shorter than the slender antenna in both these species, indicating that they belong to the genus *Elthusa* and not *Mothocya*. These two species are here transferred to

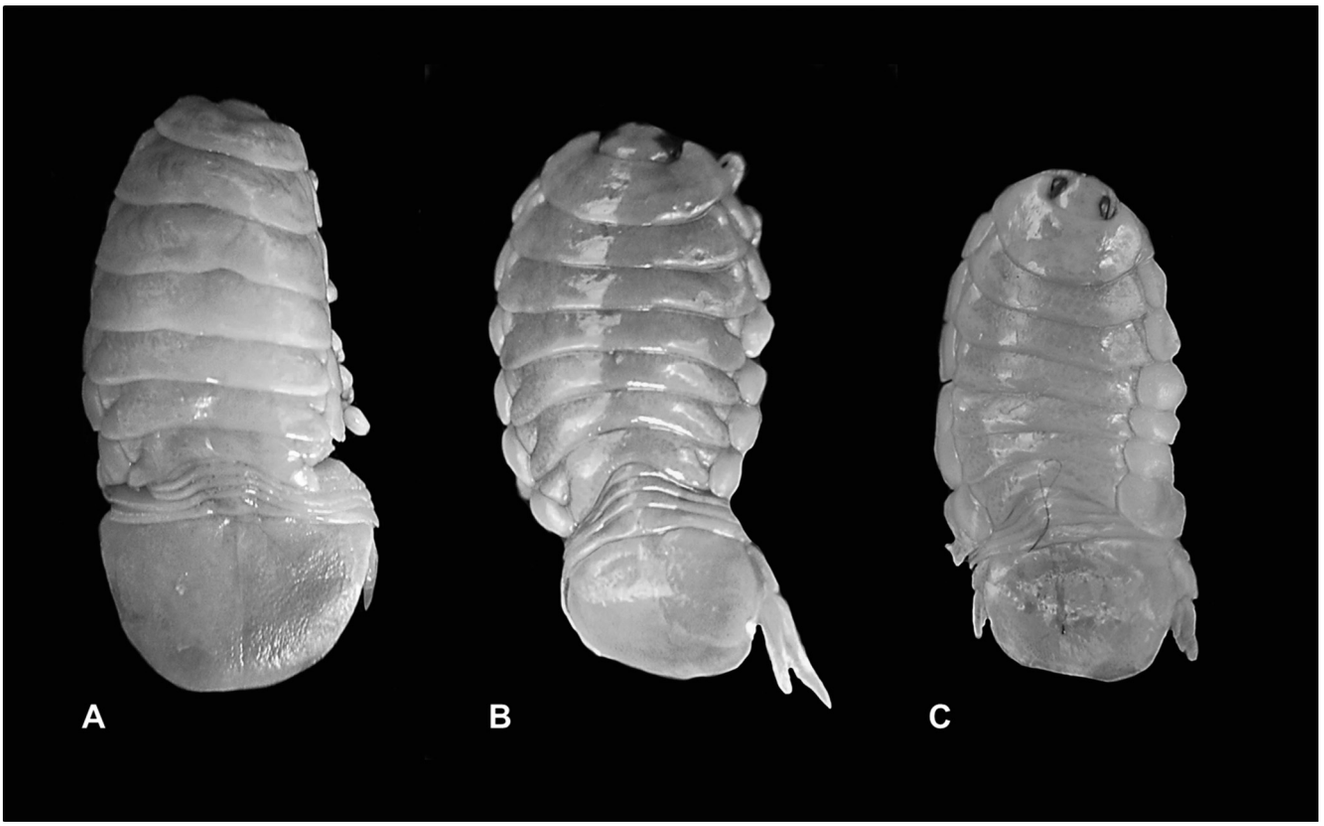

Figure 9: (A) *Mothocya plagulophora* (Haller, 1880) female, 30.5 mm (SAM A78915). (B) *Mothocya renardi* (Bleeker, 1857) female, 21 mm (SAM A78916). (C) *Mothocya affinis* sp. n. female holotype, 16 mm (SAM A78918)

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

Elthusa: *Elthusa ogcocephalus* (Avdeev and Avdeev 1974) comb. nov. and *Elthusa callionymus* (Avdeev and Avdeev 1974) comb. nov. The subspecies, *Irona melanosticta japonensis*, is confirmed to be a species of *Mothocya*. The host was the Pacific saury, *Cololabis saira*, but the lack of a detailed description and drawings prohibits an accurate assessment of the specimen and neither the identity nor validity of the subspecies can be confirmed.

Mothocya longicopa Bruce, 1986 and *Irona trillesi* Rokicki, 1986 are from the same region (West Africa) and share the same host (*Ablennes hians*) and the two descriptions show many similarities (including body shape, cephalon, coxae size and uropod rami lengths) and appear to be the same species. There is some variation in the number of recurved setae on the maxilla and maxillped article 3, as well as the shape of the uropod rami. Furthermore, the size of the two species differs, with *M. trillesi* measuring 18.3–23.0 mm in length, whereas the *M. longicopa* specimens measured only 11.0–12.0 mm. However, these slight variations are within known species variation and therefore the two species are synonymised. *Mothocya longicopa* Bruce, 1986 has the publication date of 1 September 1986 (Anon. 1986: 1282), and thus has priority over *Irona trillesi* Rokicki, 1986, which has a publication date of 30 September 1986 (Rokicki 1986: title page). Therefore, *Irona trillesi* Rokicki, 1986 is here placed into junior synonymy with *Mothocya longicopa* Bruce, 1986.

Mothocya katoi Nunomura, 1992, from the Bonin Islands, Japan, was collected from the mouth of the sailfin flyingfish, *Parexocoetus brachypterus* (Nunomura 1992). This species lacks the diagnostic characters of *Mothocya* but does show the diagnostic characteristics of *Ceratothoa* (see Hadfield et al. 2014a). Comparison to known *Ceratothoa* species showed that *M. katoi* scarcely differs from *Ceratothoa guttata* (Richardson, 1910), which is only found on *Parexocoetus brachypterus* and is known to occur in the north-western Pacific (Taiwan). Both species have similar pereopod and mouthpart structures, differing only in the body shape (widest as pereonite 4 in *M. katoi* and pereonite 5 in *C. guttata*), antenna articles (7 on *M. katoi* and 8 on *C. guttata*), number of recurved robust setae on the maxilla (5–7 on *M. katoi* and 8 on *C. guttata*), and pleon shape in the male. Some of these differences may be attributable to errors in observation or the specimen may have been damaged (the *M. katoi* female pereonite 7 appears damaged in the habitus drawing). The ovigerous female of *C. guttata* drawn by Bruce and Bowman (1989) shows large coxae, but this is only observed in females ready to release mancas and this could account for the lack of strongly produced coxae in the drawings of *M. katoi* by Nunomura (1992). There is no information regarding the distance between antennae, pleopod morphology or brood pouch morphology, but based on the above evidence, we hereby place *M. katoi* into junior synonymy with *Ceratothoa guttata*.

Mothocya toyamaensis Nunomura, 1993 was recorded from 20 m depth in the Sea of Japan (off Toyama City), without a host identity (Nunomura 1993). The description and drawings, based on a single 22.1 mm female, are limited in detail, but clearly show a species of *Ceratothoa,* with the illustrations all agreeing with the antennular, antenna, pereopodal and general body morphology for that genus (see Hadfield et al. 2014a). We make no judgement as to the validity of *Ceratothoa toyamaensis* (Nunomura, 1993) comb. nov., as the figures do not allow for comparison to the other species of the genus.

Mothocya sp. of Nunomura (2005) was collected from the mouth of the cornetfish, *Fistularia commersonii*, and was also incorrectly identified as a species of *Mothocya*. The description was based on a male specimen and the drawings and description are brief but appear most similar to the genus *Cymothoa*. Without more detailed drawings and information, the identity of the species cannot be confirmed.

Mothocya sp. of Yamauchi and Nunomura (2010) collected 'from the head of *Pterogobius zonolecus*' is an aegathoid-stage specimen of entirely uncertain identity. The authors provided no data to support its inclusion in *Mothocya*.

Key to the *Mothocya* species from the south-western Indian Ocean

Mothocya melanosticta is also included in the key as it is a widespread species parasitising pelagic flyingfishes (Bruce 1986), with one record from the Red Sea (Avdeev 1978). We regard it as probably occurring in the western Indian Ocean region.

1 Occurring on Exocoetidae ..... ***M. melanosticta***
Not occurring on Exocoetidae 2

2 Occurring on Belonidae 3
Occurring on Hemiramphidae 4

3 Uropod extending beyond posterior margin of pleotelson ..... ***M. renardi***
Uropod more than half the length of the pleotelson but not extending beyond posterior margin of pleotelson ..... ***M. collettei***

4 Pleotelson subtruncate and wide, coxae on pereonite 7 largely produced (as long as wide) ..... ***M. affinis***
Pleotelson large (as wide or wider than pleon) and evenly rounded, coxae on pereonite 7 less produced laterally (longer than wide) 5

5 Body almost straight, pleon 0.6 times as long as pereon, pereon more narrow than the pleotelson ..... ***M. plagulophora***
Body moderately twisted, pleon 0.4 times as long as pereon, pereon as wide as pleotelson ..... ***M. arrosor***

Acknowledgements — The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged (NRF project IFR2011040100022, NJ Smit, PI and SFP12091012541, KA Hadfield, PI). Opinions expressed and conclusions arrived at, are those of the authors and are not necessarily to be attributed to the NRF. Special thanks to Wynand Vlok for collecting the isopods from Mozambique and Liz Hoenson from the South African Museum, Cape Town (SAM) for the loans of the South African material used. The Museum of Tropical Queensland (Queensland Museum) is gratefully acknowledged for giving NLB travel permissions to pursue the writing of this work.

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016

References

Abraham JG. 1966. On a re-description of two species of *Irona, Irona far* and *I. robusta*. *Madras Journal of Fisheries* 2: 23–42.

Abraham JG. 1967. On the larval stages of *Irona robusta*. *Madras Journal of Fisheries* 3: 10–16.

Aneesh PT, Sudha K, Helna AK, Arshad K, Anilkumar G, Trilles J-P. 2013. Simultaneous multiple parasitic crustacean infestation on Banded Needlefish, *Strongylura leiura* (Belonidae) from the Malabar coast, India. *International Journal of Scientific and Research Publications* 3: 1–9.

Anon. 1986. *Journal of Natural History* 20: 1282.

Avdeev VV. 1978. Parasitic isopods of the family Cymothoidae (Crustacea, Flabellifera) from the Red Sea. *Biologiya Morya* (*Vladivostok*) 4: 30–35 [in Russian].

Avdeev VV, Avdeev GV. 1974. Description of new species and some questions of the biology of parasitic isopods of the genus *Irona* (Cymothoidae). *Transactions of the Pacific Research Institute of Fisheries and Oceanography* 88: 15–26, figs 11–19 [in Russian].

Barnard KH. 1914. Contributions to the crustacean fauna of South Africa. 3. Additions to the Marine Isopoda, with notes on some previously incompletely known species. *Annals of the South African Museum* 10: 325–440.

Barnard KH. 1955. Additions to the fauna list of South African Crustacea and Pycnogonidae. *Annals of the South African Museum* 43: 1–107, figs 1–53.

Beumer JP, Ashburner ME, Burbery ME, Jette E, Latham DJ. 1982. *A checklist of the parasites of fishes from Australia and its adjacent Antarctic Territories*. Technical Communication no. 48. Farnham Royal: Commonwealth Agricultural Bureaux, Institute of Parasitology.

Bleeker P. 1857. Recherches sur les Crustacés de L'Inde Archipelagique. II. Sur les Isopodes Cymothoadiens de L'Archipel Indien. *Verhandelingen der Natuurkundige Vereeniging in Nederlandsch Indië* 2: 20–40.

Bowman TE, Tareen IU. 1983. Cymothoidae from fishes of Kuwait (Arabian Gulf) (Crustacea: Isopoda). *Smithsonian Contributions to Zoology* 382: 1–30.

Brandt A, Poore GCB. 2003. Higher classification of the flabelliferan and related Isopoda based on a reappraisal of relationships. *Invertebrate Systematics* 17: 893–923.

Bruce NL. 1986. Revision of the isopod crustacean genus *Mothocya* Costa, in Hope, 1851 (Cymothoidae: Flabellifera), parasitic on marine fishes. *Journal of Natural History* 20: 1089–1192.

Bruce NL, Bowman TE. 1989. Species of the parasitic isopod genera *Ceratothoa* and *Glossobius* (Crustacea: Cymothoidae) from the mouths of flying fishes and halfbeaks (Beloniformes). *Smithsonian Contributions to Zoology* 489: 1–28.

Colorni A, Trilles J-P, Golani D. 1997. *Livoneca* sp. (Flabellifera: Cymothoidae), an isopod parasite in the oral and branchial cavities of the Red Sea silverside *Atherinomorus lacunosus* (Perciformes, Atherinidae). *Diseases of Aquatic Organisms* 31: 65–71.

Costa A. 1851. Caratteri di alcuni de'generi e specie nouve segnete nel presente catalogo. In: Hope FW (ed.), *Catalogo dei crostacei Italiani e di molti altri de Mediterraneo*. Napoli: Fr. Azzolino. pp 41–48, pl 1.

Eschmeyer WN (ed.). 2015. Catalog of fishes: genera, species, references. Available at http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. [accessed 4 March 2015].

Froese R, Pauly D (eds). 2014. FishBase. World Wide Web electronic publication, version (11/2014). Available at http://www.fishbase.org [accessed 25 November 2014].

Gerstaecker A. 1881. Sechste Ordnung. Isopoda. –Asseln [part]. In: *Dr H. G. Bronn's Die Klassen und Ordnungen des Thier-Reichs, wissenschaftlich dargestellt in Wort und Bild*. Fünfter Band. II. Abteilung. Gleiderfussler: Arthropoda. Crustacea (Zweite Halfte: Malacostraca). 1, 2, und 3, Lieferung. Leipzig: CF Winter'sche Verlagshandlung. pp 8–278.

Gopalakrishnan A, Rajkumar M, Jun S, Trilles J-P. 2010. Occurrence of double parasitism on black-barred halfbeak fish from the southeast coast of India. *Chinese Journal of Oceanology and Limnology* 28: 832–835.

Hadfield KA, Bruce NL, Smit NJ. 2010. Redescription of the monotypic genus *Cinusa* Schioedte and Meinert, 1884 (Isopoda, Cymothoidae), a buccal-cavity isopod from South Africa. *Zootaxa* 2437: 51–68.

Hadfield KA, Bruce NL, Smit NJ. 2011. *Cymothoa hermani* sp. n. (Isopoda, Cymothoidae, Crustacea), a parasitic isopod, collected off the Zanzibar coast, Tanzania from the mouth of a parrotfish (Scaridae). *Zootaxa* 2876: 57–68.

Hadfield KA, Bruce NL, Smit NJ. 2013. Review of the fish-parasitic genus *Cymothoa* Fabricius, 1783 (Isopoda, Cymothoidae, Crustacea) from the south-western Indian Ocean, including a new species from South Africa. *Zootaxa* 3640: 152–176.

Hadfield KA, Bruce NL, Smit NJ. 2014a. Review of the fish parasitic genus *Ceratothoa* Dana, 1852 (Crustacea, Isopoda, Cymothoidae) from South Africa, including the description of two new species. *Zookeys* 400: 1–42.

Hadfield KA, Sikkel PC, Smit NJ. 2014b. New records of fish parasitic isopods of the gill-attaching genus *Mothocya* Costa (in Hope), 1851 from the Virgin Islands, Caribbean, with description of a new species. *Zookeys* 439: 109–125.

Hadfield KA, Bruce NL, Szinetár C, Smit NJ. 2014c. *Ceratothoa retusa* (Schioedte & Meinert, 1883) (Isopoda, Cymothoidae), a variable species of fish parasitic marine isopod from the Indian Ocean. *Crustaceana* 87: 448–462.

Hale HM. 1926. Review of Australian isopods of the cymothoid group. Part II. *Transactions of the Royal Society of South Australia* 50: 201–234, pls 26–27.

Hale HM. 1929. *The crustaceans of South Australia. Part 2. Handbooks of the Flora and Fauna of South Australia*. Adelaide: British Science Guild (South Australian Branch).

Haller G von. 1880. Ueber einige neue Cymothöinen. *Archiv für Naturgeschichte* 46: 375–395, pl 18.

Herklots J. 1870. Deux nouveaux genres de Crustacés vivant en parasites sur des poissons, Epichthyes et Ichthyoxenos. *Archiv Néerlandaise Sciences Exact et Naturelles* 5: 120–137, pl 5.

Holthuis LB. 1959. Notes on pre-Linnean carcinology (including the study of Xiphosura) of the Malay Archipelago. In: de Wit HCD (ed.), *Rumphius memorial volume*. Hollandia: Baarn. pp 63–125.

Jones CM, Miller TL, Grutter AS, Cribb TH. 2008. Natatory-stage cymothoid isopods: description, molecular identification and evolution of attachment. *International Journal for Parasitology* 38: 477–491.

Kensley B. 1978. *Guide to the marine isopods of southern Africa*. Cape Town: South African Museum and The Rustica Press.

Kensley B, Schotte M. 1989. *Guide to the marine isopod crustaceans of the Caribbean*. Washington, DC: Smithsonian Institution Press.

Kroger RL, Guthrie JF. 1972. Incidence of the parasitic isopod, *Olencira praegustator*, in juvenile Atlantic menhaden. *Copeia* 2: 370–374.

Kussakin OG. 1979. Marine and brackishwater likefooted Crustacea (Isopoda) from the cold and temperate waters of the Northern Hemisphere. Suborder Flabellifera. *Opredeliteli po Faune SSSR, Izdavaemye Zoologicheskim Institutom Akademii Nauk SSSR 171*, vol. III.3. St Petersburg: Nauka, Leningradskoe otd-nie [in Russian].

Lanzing WJR, O'Conner PF. 1975. Infestation of luderick (*Girella tricuspidata*) populations with parasitic isopods. *Australian*

Journal of Marine and Freshwater Research 26: 355–361.
Martin MB, Bruce NL, Nowak BF. 2015. Review of the fish-parasitic genus *Ceratothoa* Dana, 1852 (Crustacea: Isopoda: Cymothoidae) from Australia, with description of two new species. *Zootaxa* 3963: 251–294.
Miers EJ. 1876. Descriptions of some new species of Crustacea, chiefly from New Zealand. *Annals and Magazine of Natural History* 17: 218–229.
Miers EJ. 1880. On a collection of Crustacea from the Malaysian Region. Part 4. Penaeidae, Stomatopoda, Isopoda, Suctoria and Xiphosura. *Annals and Magazine of Natural History* 5: 457–467.
Monod T. 1971. Sur quelques Crustacés de Tuléar. *Tethys* Supplément 1: 165–192.
Monod T. 1976. Expédition Rumphius II (1975). Crustacés parasites, commensaux, etc. (Th. Monod et R. Serène, éd.). III. Crustacés Isopodes (première partie: Corallanidae, Anilocridae, Cymothoidae). *Bulletin du Muséum National d'Histoire Naturelle, Paris, 3 série, Zoologie* 391: 853–870.
Nair GS. 1950. Two new species of *Irona* (Isopoda) parasitic on Madras fishes. *Journal of the Madras University* 20B: 66–74.
Nair GS. 1956. On the embryology of the isopod *Irona*. *Journal of Embryology and Experimental Morphology* 4: 1–33.
Nierstrasz HF. 1915. Die Isopoden-Sammlung im Naturhistorischen Reichsmuseum zu Leiden — 1. Cymothoidae. *Zoologische Mededelingen (Leiden)* 1: 71–108, pls 3–4.
Nierstrasz HF. 1931. Isopoda genuina. II. Flabellifera. In: Weber M, de Beaufort LF (eds), *Die Isopoden der Siboga-Expedition.* Siboga Expeditie (Uitkomsten op Zoölogisch, Botanisch, Oceanographisch en Geologisch Gebied verzameld in de Oost-Indische 1899–1900 aan boord H.M. Siboga onder commando van Luitenant ter zee 1e kl. G.F. Tydeman). Leiden: EJ Brill. pp 123–233, pls 10–11.
Nunomura N. 1992. Three cymotoid [sic] isopods collected from the sea off the Bonin Islands. *Bulletin of the Toyama Science Museum* 15: 35–45.
Nunomura N. 1993. A marine cymotoid [sic] isopod crustacean collected from the sea off Mizuhasi, Toyama City. *Bulletin of the Toyama Science Museum* 16: 7–10.
Nunomura N. 2005. Sea shore isopod crustaceans from Bonin Islands. *Bulletin of the Toyama Science Museum* 28: 33–57.
Pfeffer G. 1889. Ubersicht der von Herrn Dr. Franz Stuhlmann in Agypten, auf Sansibar und dem gegenuberliegenden Festlande gessammelten Reptilien, Amphibien, Fische, Mollusken und Krebse. *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten* 6: 1–36.
Pillai NK. 1954. A preliminary note on the Tanaidacea and Isopoda of Travancore. *Bulletin of the Central Research Institute, University of Travancore, Trivandrum* 3: 1–22.
Ravichandran S, Rameshkumar G, Trilles J-P. 2011. New records of two parasitic cymothoids from Indian fishes. *Journal of Parasitic Diseases* 35: 232–234.
Rameshkumar G, Ravichandran S, Allayie SA. 2013. Study of the functional morphology of mouthparts of parasitic isopods of marine fishes. *Asian Pacific Journal of Tropical Disease* 3: 127–132.
Rameshkumar G, Ramesh M, Ravichandran S, Trilles J-P, Subbiah S. 2014. Host–parasite relationships: *Mothocya plagulophora* parasitizing *Hemiramphus* far in the Southeast coast of India. *Journal of Parasitic Diseases.* DOI 10.1007/s12639-014-0438-2.
Ravichandran S. 2007. Infestation of the isopod parasite *Lironeca puhi* in slender needle fish *Strongylura leiura*. *Research Journal of Parasitology (India)* 2: 87–93.
Richardson H. 1905. A monograph on the isopods of North America. *Bulletin of the United States National Museum* 54: 1–727.
Richardson H. 1910. Marine isopods collected in the Philippines by the U.S. fisheries steamer Albatross in 1907–1908. *Department of Commerce and Labor, Bureau of Fisheries Document* 736. Washington, DC: US Government Printing Office.
Rokicki J. 1986. Two new species of Cymothoidae (Crustacea, Isopoda) from fishes of the shelf of North-West Africa. *Acta Parasitologica Polonica* 30: 251–258.
Schioedte JC, Meinert F. 1884. Symbolæ ad monographium cymothoarum crustaceorum isopodum familiæ. IV. Cymothoidæ Trib. II. Cymothoinæ. Trib. III: Lironecinæ. *Naturhistorisk Tidsskrift, Kjøbenhavn* 14: 221–454, pls 226–213.
Sethi S, Jithendran KP, Kannappan S. 2013. Co-infection of yellowtip halfbeak fish (*Hemiramphus marginatus*) with isopod and copepod parasites from the Coromandal Coast, India. *Fishery Technology* 50: 357–360.
Smit NJ, Bruce NL, Hadfield KA. 2014. Global diversity of fish parasitic isopod crustaceans of the family Cymothoidae. *International Journal for Parasitology: Parasites and Wildlife* 3: 188–197.
Stebbing TR. 1905. Report on the Isopoda collected by Professor Herdman, at Ceylon, in 1902. Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, 1905, Supplementary Report 4. London: Royal Society of London.
Thampy DM, John PA. 1974. Sex-reversal and androgenic gland in the fish parasite *Irona far* (Cymothoidae: Isopoda: Crustacea). *International Journal for Parasitology* 4: 575–583.
Trilles J-P. 1968. Recherches sur les Isopodes. Cymothoidae de cotes Francaises. I. Systematique et faunistique. II. Bionomie et parasitisme. Thèse de Doctorat es-sciences, Académie de Montpellier, Université des sciences et techniques du Languedoc, France.
Trilles J-P. 1976. Les Cymothoidae (Isopoda, Flabellifera) des collections du Museum National d'Histoire Naturelle de Paris. IV. Les Lironecinae Schioedte et Meinert, 1884. *Bulletin du Museum National d'Histoire Naturelle, Paris, 3e serie, no. 390, Zoologie* 272: 773–800.
Trilles J-P. 1979. Les Cymothoidae (Isopoda, Flabellifera; parasites de poissons) du Rijksmuseum van Natuurlijke Histoire de Leiden II. Afrique, Ameriques er regions Indo-Ouest-Pacifiques. *Zoologische Mededelingen (Leiden)* 54: 245–275.
Trilles J-P. 1994. Les Cymothoidae (Crustacea, Isopoda) du Monde. Podrome pour une faune. *Studia Marina* 21/22: 1–288 [for 1991].
Trilles J-P, Ravichandran S, Rameshkumar G. 2011. A checklist of the Cymothoidae (Crustacea, Isopoda) recorded from Indian fishes. *Acta Parasitologica* 56: 446–459.
Vijayakumar R, Raja K, Velvizhi S, Sinduja K, Gopalakrishnan A. 2014. Occurrence of heavy copepod infestation on *Hemiramphus lutkei* and double parasitisms on *Hemiramphus far* with copepod (*Lernaeenicus hemiramphi*) and isopod (*Mothocya plagulophora*). *Journal of Parasitic Diseases* 38: 331–333.
Williams LB, Williams EH Jr. 1986. Some parasitic isopods (Crustacea: Cymothoidae) of marine fishes from Thailand. *Galaxea* 5: 213–216.
Yamauchi T. 2009. Deep-sea cymothoid isopods (Crustacea: Isopoda: Cymothoidae) of Pacific coast of northern Honshu, Japan. *National Museum of Nature and Science Monographs* 39: 467–481.
Yamauchi T, Nunomura N. 2010. Cymothoid isopods (Crustacea: Isopoda) collected by Dr. Y. Kano in Toyama Bay of the Sea of Japan. *Bulletin of the Toyama Science Museum* 33: 71–76.
Yu H, Li X. 2003. Study on the Cymothoidae from Chinese waters. *Studia Marina Sinica* 45: 223–238 [in Chinese].

Received 2 December 2014, accepted 19 April 2015
Associate Editor: Annemariè Avenant-Oldewage

Downloaded by [JAMES COOK UNIVERSITY] at 20:50 01 June 2016