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## A new species of *Opecarcinus* Kropp & Manning, 1987 (Crustacea: Brachyura: Cryptochiridae) associated with the stony corals *Pavona clavus* (Dana, 1846) and *P. bipartita* Nemenzo, 1980 (Scleractinia: Agariciidae)

SANCIA E.T. VAN DER MEIJ

Department of Marine Zoology, Naturalis Biodiversity Center, Darwinweg 2, 2333 CR Leiden, The Netherlands.

E-mail: [Sancia.vanderMeij@naturalis.nl](mailto:Sancia.vanderMeij@naturalis.nl)

### Abstract

A new species of *Opecarcinus* Kropp & Manning, 1987, is described from Indonesia and Malaysia. *Opecarcinus cathyae* sp. nov. is associated with the scleractinian corals *Pavona clavus* (Dana, 1846) and *P. bipartita* Nemenzo, 1980, inhabiting crescent-shaped cavities or tunnels on the coral surface. The new species is the ninth assigned to the genus. It can be separated from congeners by the anterolateral orientation of the cornea, the carapace with shallow transverse depressions, lacking longitudinal depressions, and the smooth dorsal margin of the fifth female pereopod carpus. The distinctive colour pattern can be used as a diagnostic character in live specimens.

**Key words:** DNA barcoding, gall crabs, host-specificity, Indonesia, Malaysia, taxonomy

### Introduction

Colonies of the scleractinian coral *Pavona clavus* (Dana, 1846), belonging to the Agariciidae, can occur in huge monospecific stands, covering large areas of reef flats and slopes (Veron & Pichon 1980). Gall crabs belonging to the genus *Opecarcinus* Kropp & Manning, 1987, have been found to inhabit these large colonies in high densities (Hoeksema & van der Meij 2013) and eight species are now recognised in the genus (cf. Ng *et al.* 2008). *Opecarcinus* was established by Kropp & Manning (1987) to accommodate the Atlantic *Pseudocryptochirus hypostegus* Shaw & Hopkins, 1977, and *Cryptochirus crescentus* Edmonson, 1925, from the Pacific. An additional five species of *Opecarcinus* were described by Kropp (1989), who also removed *O. granulatus* from the synonymy of *O. crescentus*.

The Indo-Pacific species of *Opecarcinus* occur from the Red Sea to the Pacific coast of Central America (Kropp 1989; pers. obs.), and have been recorded from corals belonging to several genera of the scleractinian family Agariciidae (Kropp 1989). In the western Atlantic, Scott (1985, 1987) and Johnsson *et al.* (2006) recorded *O. hypostegus* from the genera *Agaricia* (family Agariciidae) and *Siderastrea* (family Siderastreidae), in contrast to Kropp & Manning (1987) and Van der Meij (2014) who recorded *O. hypostegus* only from *Agaricia*.

Based on the observations by Hoeksema & van der Meij (2013), gall crabs collected from the Indo-Pacific agariciid *P. clavus* were studied in more detail, resulting in the identification of the present new species. This species, described herein, is the ninth assigned to the genus.

### Methodology

Gall crabs were collected in eastern Indonesia (Lembah Strait, northern Sulawesi; Gura Ici, Halmahera) and Malaysian Borneo (Kudat, north Sabah; Semporna, east Sabah) from 2009 to 2012. Corals were searched for galls, cavities and pits, photographed, and subsequently split with hammer and chisel. Crab specimens were preserved in 80% ethanol after being photographed with a digital SLR camera equipped with a 50 mm macro-lens. All material is deposited in the collections of Naturalis Biodiversity Center in Leiden (formerly Rijksmuseum van Natuurlijke

Historie, collection coded as RMNH.Crus.D). The identification of host corals was based on Veron & Pichon (1980) and Veron (2000). Drawings were made with a stereo microscope with camera lucida. Carapace lengths and widths were measured to the nearest 0.1 mm using an eyepiece micrometre, with the crabs positioned on a level surface.

Abbreviations used: CL, carapace length; CW, carapace width (at widest point); MXP, maxilliped; ovig., ovigerous; P, pereopod; G1, male gonopod 1; G2, male gonopod 2. Carapace measurements are given as CL × CW, in mm.

## Taxonomy

### Family Cryptochiridae Paul'son, 1875

#### *Opecarcinus* Kropp & Manning, 1987

##### *Opecarcinus cathyae* sp. nov.

(Figs 1A–E, 2A–E, 3A–F, 4A–E, 5A–D)

**Type locality.** Creach Reef, Semporna district, Sabah, Malaysia (04°18'58.8"N, 118°36'17.3"E)

**Type material.** Holotype (female) and allotype (male). RMNH.Crus.D.53648a, 10–14 m, host *Pavona clavus* (Dana, 1846), 05.xii.2010, ovig. female (5.5 × 3.8), male (3.3 × 2.6), leg. Z Waheed. Paratypes. RMNH.Crus.D.53648b, from the same lot as holotype and allotype, 1 ovig. female (3.7 × 3.0), 1 juvenile male (1.6 × 1.1). A damaged male from this lot was used for DNA barcoding.

**DNA barcoding.** A COI sequence (partially, Folmer *et al.* 1994) of one of the paratypes (damaged male) has been deposited in GenBank under accession number KM396420.

**Additional material. Indonesia.** RMNH.Crus.D.53923, S Lela, Gura Ici, Halmahera (00°01'51.2"S 127°15'03.1"E), 10.xi.2009, 3 males, one with epicaridean parasite (*Carcinione platypleura* Bourdon, 1983) under carapace, host *Pavona clavus*, leg. SET van der Meij.—RMNH.Crus.D.53916, 3 ovig. females, 1 male, host *Pavona clavus*, leg. SET van der Meij (same lot as RMNH.Crus.D.53923); RMNH.Crus.D.54202, Baturiri, Lembah Strait (01°27'34.7"N 125°14'23.1"E), 10 m, 6.ii.2012, 1 male, host *Pavona bipartita*, leg. SET van der Meij.—RMNH.Crus.D.54214, Teluk Walemetodo, Lembah Strait (01°24'11.3"N 125°10'20.3"E), 6 m, 15.ii.2012, 1 ovig. female, 1 male, host *Pavona bipartita*, leg. SET van der Meij. **Malaysia (Borneo).** RMNH.Crus.D.53656, Matakang I., Semporna district (04°34'57.6"N 118°56'46.5"E), 8.xii.2010, 1 ovig. female, 1 non-ovig. female, host *Pavona clavus*, leg. BW Hoeksema.—RMNH.Crus.D.53768, Hanging Gardens, Sipadan I., Semporna district (04°06'45.3"N 118°37'29.3"E), 18.xii.2010, 2 ovig. females, host *Pavona clavus*, leg. Z Waheed.—RMNH.Crus.D.54297, SW Mangsee Great Reef, Kudat (07°27'24.8"N 117°13'21.6"E), 9 m, 22.ix.2012, 1 ovig. female, 1 male, host *Pavona clavus*, leg. SET van der Meij.—RMNH.Crus.D.54275, Paliuk, Kudat (07°03'17.4"N 117°22'32.6"E), 10.ix.2012, 2 ovig. females, 2 non-ovig. females, 2 males, host *Pavona clavus*, leg. SET van der Meij.

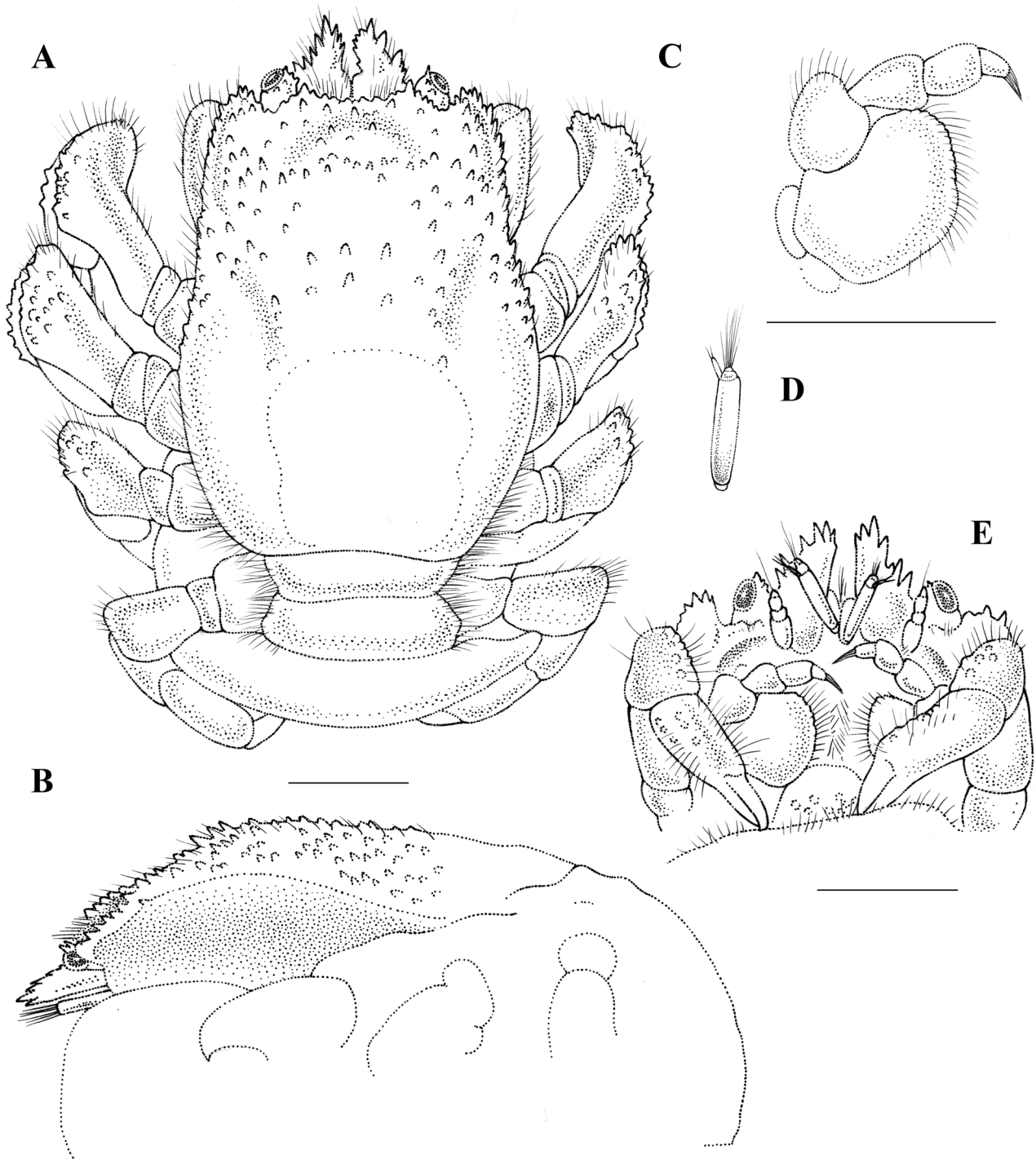
**Description female holotype** Carapace vase-shaped, CL 1.4 CW; widest posterior to midlength; anterior third of carapace deflected by about 40°, not sharply set off from posterior carapace, with shallow transverse depression across protogastric region; dorsal surface convex in lateral view, median third concave with scattered small conical tubercles. Mesogastric region slightly inflated with tubercles, cardiointestinal region outlined. Carapace surface ornamented with rounded, conical tubercles; posterior carapace smooth, tubercles most numerous at anterior, lateral carapace; anterolateral margins of carapace granular; anterolateral angle without prominent tubercle; margin inner orbital angle with tubercle. Front slightly concave with small tubercles, width about half of carapace at anterolateral angle. Orbit broadly V-shaped. Pterygostomial region fused to carapace (Fig. 1A–B). Brood pouch swollen (ovigerous), many short setae on distal margin (ventral view) (Fig. 1E). Posterior carapace, brood pouch margins fringed with many setae (Fig. 1A, E).

Antennular peduncle dorsal surface with small tubercles, slightly inflated distally, scarcely inflated mesially; apex of distal projection slightly extending beyond tip of eyestalk; spines on distal margin larger than those on mesial margin. Basal segment strongly tapering anteriorly in ventral view, length 1.5 times width; ventral surface relatively smooth (Fig. 1E).

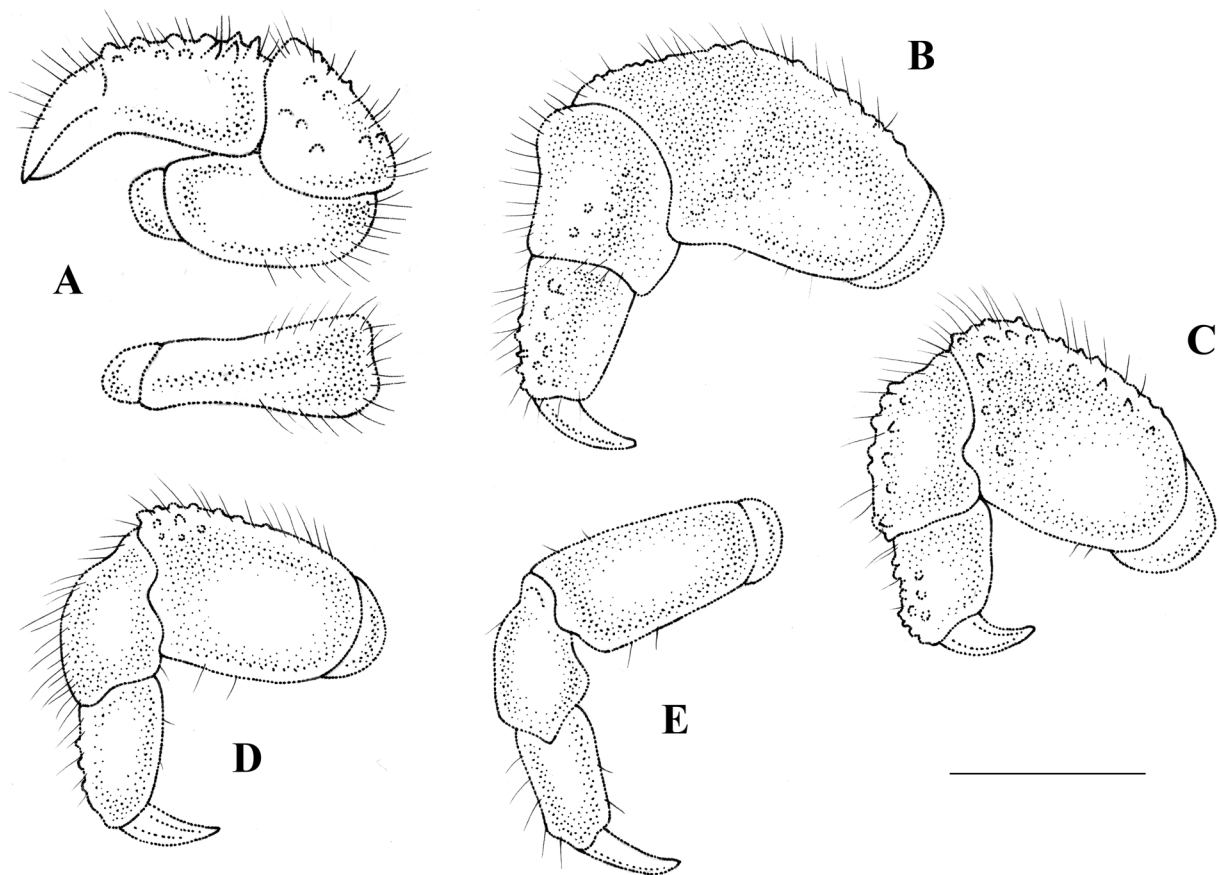
Eyestalk partly exposed dorsally, slightly granular. Cornea anterolateral. Lateral margin of stalk not extending beyond anterolateral angle; distal margin with small spines (Fig. 1A, E). Distal segment of antennules with protruding segment, visible from ventral side (Fig. 1D–E).

MXP3 with exopod; mesial margin of ischium slightly crenulated; merus with distolateral projection, carpus to dactylus decreasing in size, latter with bundle of setae (Fig. 1C).

P1 (chelipeds) slender; merus length 2.8 times height; carpus granular on dorsal margin; propodus with stronger granulation on dorsal margin than carpus; cutting edge fingers entire, tips of fingers slightly crossing when closed (Fig. 2A).



**FIGURE 1.** A–E. Holotype of *Opecarcinus cathyae* sp. nov. (RMNH.Crus.D.53648a). A, habitus, dorsal view; B, carapace, lateral view; C, MXP3 (exopod hardly visible); D, close-up of antennules; E, anterolateral margin of carapace, ventral view. Scale bars = 1.0 mm.



**FIGURE 2.** A–E. Holotype of *Opearcinus cathyae* sp. nov. (RMNH.Crus.D.53648a). A, right P1 (cheliped), merus drawn twice because of angle distortion; B, right P2; C right P3; D, right P4; E, right P5. Scale bar = 1.0 mm.

P2 stout; merus length 1.8 times height, dorsal margin evenly convex, entire length crenulated, ventral margin straight, smooth; carpus, propodus of similar length with rows of conical tubercles; dactylus smooth, sharp, curved ventrally (Fig. 2B).

P3 stout; merus length 1.6 times height, dorsal margin slightly convex, entire length with scattered conical tubercles, ventral margin straight, smooth; carpus, propodus of similar length with conical tubercles on dorsal margin; carpus with small anterior lobe; dactylus smooth, sharp, curved ventrally (Fig. 2C).

P4 relatively slender; merus length 1.4 times height, entire length dorsal margin with scattered conical tubercles, ventral margin straight, smooth; carpus, propodus of similar length; carpus with slight anterior lobe; propodus with conical tubercles on dorsal margin; dactylus smooth, sharp, curved ventrally (Fig. 2D).

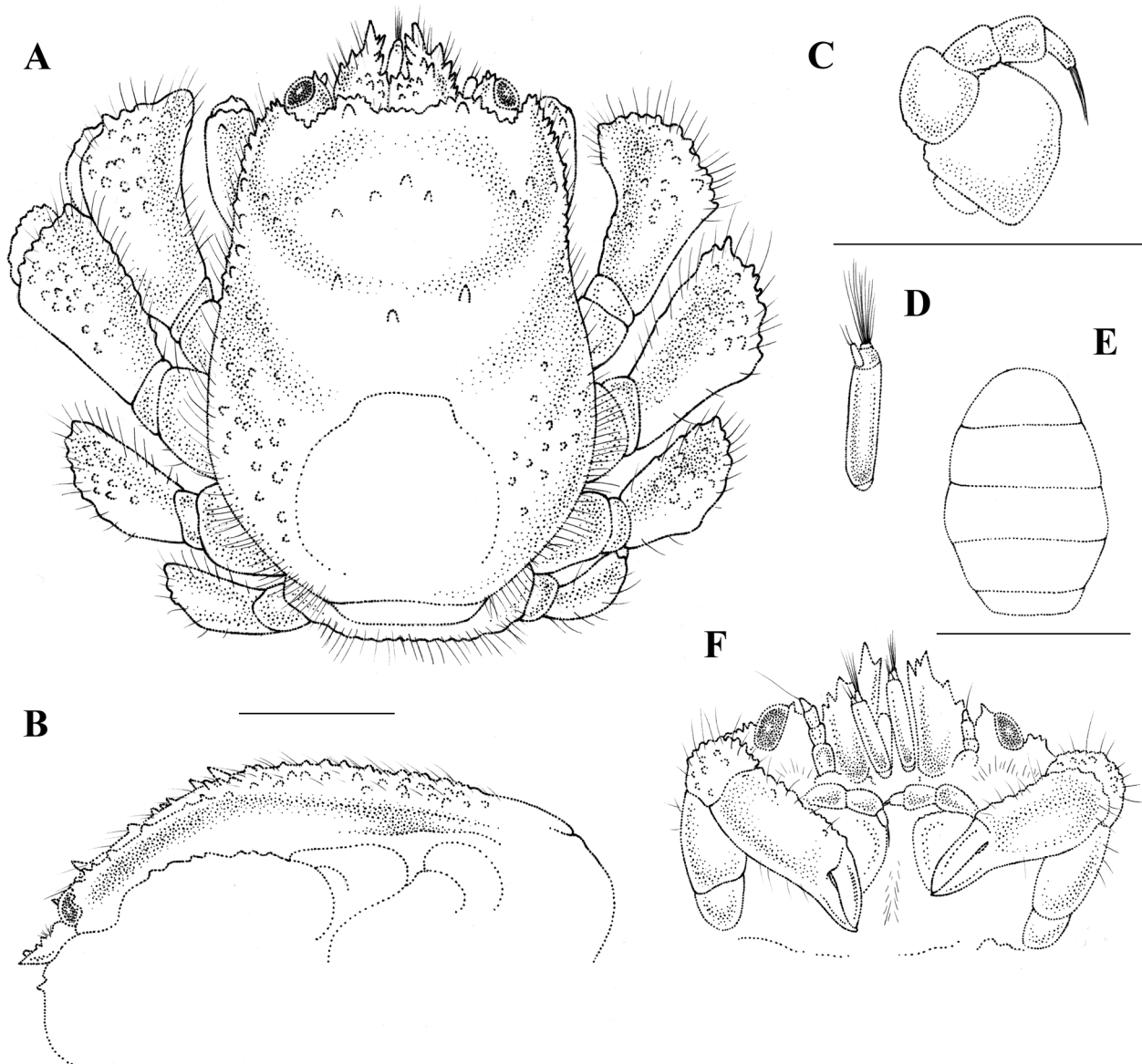
P5 slender; merus length 2.0 times height, straight, smooth margins; carpus, propodus of similar length, margins smooth; dactylus smooth, sharp, curved ventrally (Fig. 2E).

Thoracic sternum 1–3 with transverse row of rounded tubercles at midlength, thoracic sternum 4 with fewer tubercles (Fig. 5B).

Gonopore (vulva); elliptical, lateral margin with small vulvar cover (examined in paratype).

**Description male allotype.** Generally similar to holotype, differences outlined hereafter. Carapace vase-shaped, CL 1.3 longer than CW; median third concave with few scattered small conical tubercles. Carapace surface ornamented with few rounded to conical tubercles, fewer than holotype, most numerous at lateral margins; anterolateral margins of carapace with row of small conical tubercles; anterolateral angle without prominent tubercle; inner orbital angle marked with tubercle. Orbit broadly V-shaped, margin somewhat crenulated. (Fig. 3A–B). Posterior carapace margins fringed with numerous setae (Fig. 3A).

Antennular peduncle dorsal surface with numerous spiny tubercles, slightly inflated distally, scarcely inflated mesially. Basal segment tapering anteriorly in ventral view, length 2.3–2.4 times width; surface relatively smooth (Fig. 3F).



**FIGURE 3.** A–F. Allotype of *Opecarcinus cathyae* sp. nov. (RMNH.Crus.D.53648a). A, habitus, dorsal view; B, carapace, lateral view; C, MXP3 (exopod hardly visible); D, close-up of antennules; E, abdomen; F, anterolateral margin of carapace, ventral view. Scale bars = 1.0 mm.

Eyestalk partly exposed dorsally. Cornea anterolateral. Lateral margin of stalk not extending beyond anterolateral angle; distal margin with two small spines (Fig. 3F). Distal segment of antennules with small protruding segment, visible from ventral side (Fig. 3D).

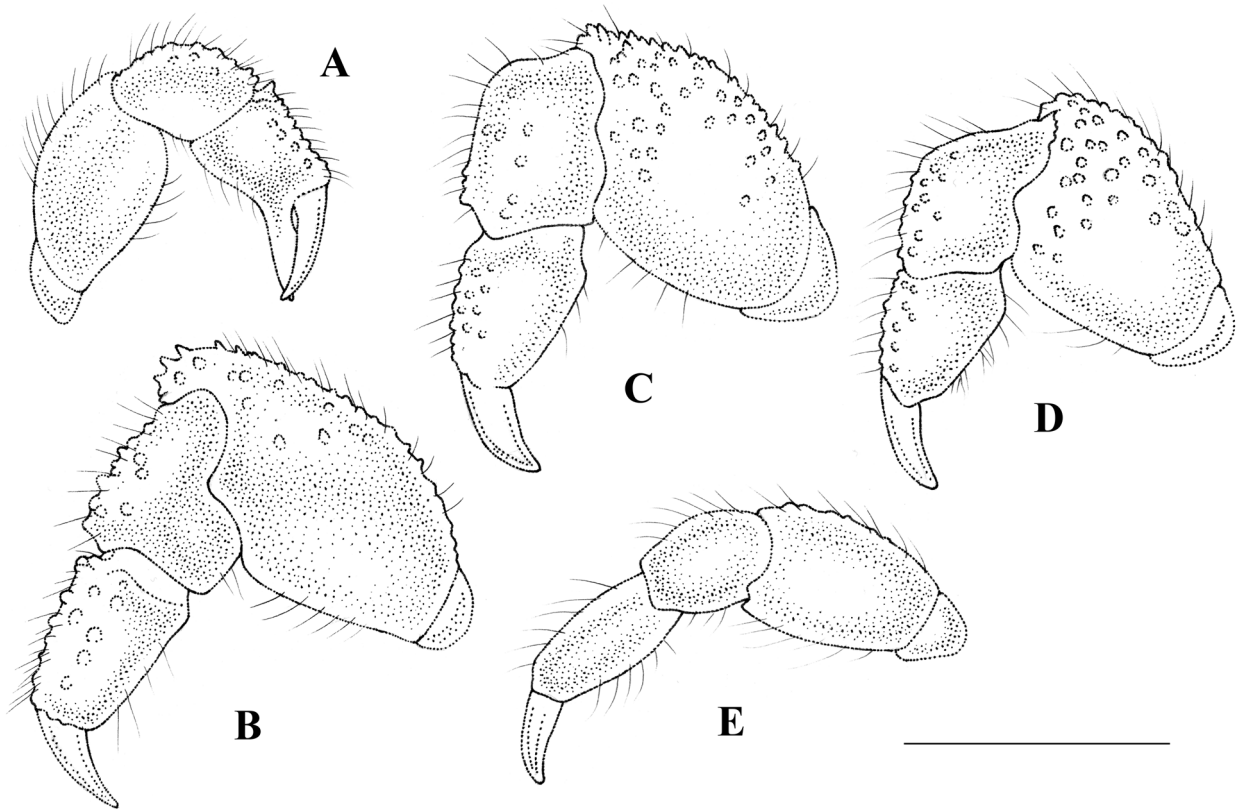
MXP3 with exopod; mesial distal margin of ischium very slightly crenulated; merus with distolateral projection; carpus, propodus dactylus of similar length, dactylus with tuft of setae (Fig. 3C).

P1 (chelipeds) somewhat stout; merus length 1.4 times height; carpus granular on dorsal margin; propodus with stronger granulation on dorsal margin than carpus; cutting edge fingers entire, tips of fingers crossing (Fig. 4A).

P2 stout; merus length 1.8 times height, dorsal margin slightly convex, entire length with tubercles, slightly larger distally, ventral margin straight, smooth (Fig. 4B).

P3 stout; merus length 1.5 times height, dorsal margin evenly convex, entire length with scattered conical tubercles, ventral margin rounded smooth; carpus with anterior lobe (Fig. 4C).

P4 stout; merus length 1.1 times height, dorsal margin slightly convex, entire length with scattered conical tubercles, ventral margin straight, smooth; carpus, propodus of similar length with conical tubercles on dorsal margin; carpus with anterior lobe (Fig. 4D).



**FIGURE 4.** A–E. Allotype of *Opecarcinus cathyae* sp. nov. (RMNH.Crus.D.53648a). A, right P1 (cheliped) - drawn from ventral side; B, right P2; C right P3; D, right P4; E, right P5. Scale bar = 1.0 mm.

P5 slender; merus length 1.3 times height, margins crenulated, ventral margin relatively straight; carpus slightly shorter than propodus, margins smooth (Fig. 4E).

Thoracic sternum 1–3 with transverse row of rounded tubercles at midlength, thoracic sternum 4 with fewer, somewhat scattered tubercles (Fig. 5D). Abdomen widest at somite 3, somite 6 not visible in ventral view because of curvature; telson rounded (Fig. 3E).

Gonopods; G1: slightly curved laterally, slightly cinched in the middle, apex blunt, distal margin with 6–7 simple, long setae; G2: almost straight, slightly cinched in the middle, apex blunt with two large non-plumose setae at distal margin of the same length as G2.

**Variation.** The tubercle on the margin of the inner orbital margin is prominent in some individuals only. The setae along the carapace margins are more numerous in large individuals, especially in females.

**Colour.** Carapace bright orange-red to rust, darker rust on the lateral sides. Cardio-intestinal region outlined by a lighter colouration, off-white in some specimens. Anterolateral region off-white, sometimes with tubercles of contrasting (dark) colour. MXP ischium, merus off-white with orange hue, carpus, propodus, dactylus rust-coloured. P1 to P5 opaque with fine orange network of lines, giving an orange hue. Cornea bright rust colour (Fig. 5B, C). Some specimens are quite pale, and lack the intense orange-red colouration. These specimens do have the cardio-intestinal region outlined by a lighter colouration and have black chromatophores visible on the carapace, predominantly on the lateral margins (Fig. 5C).

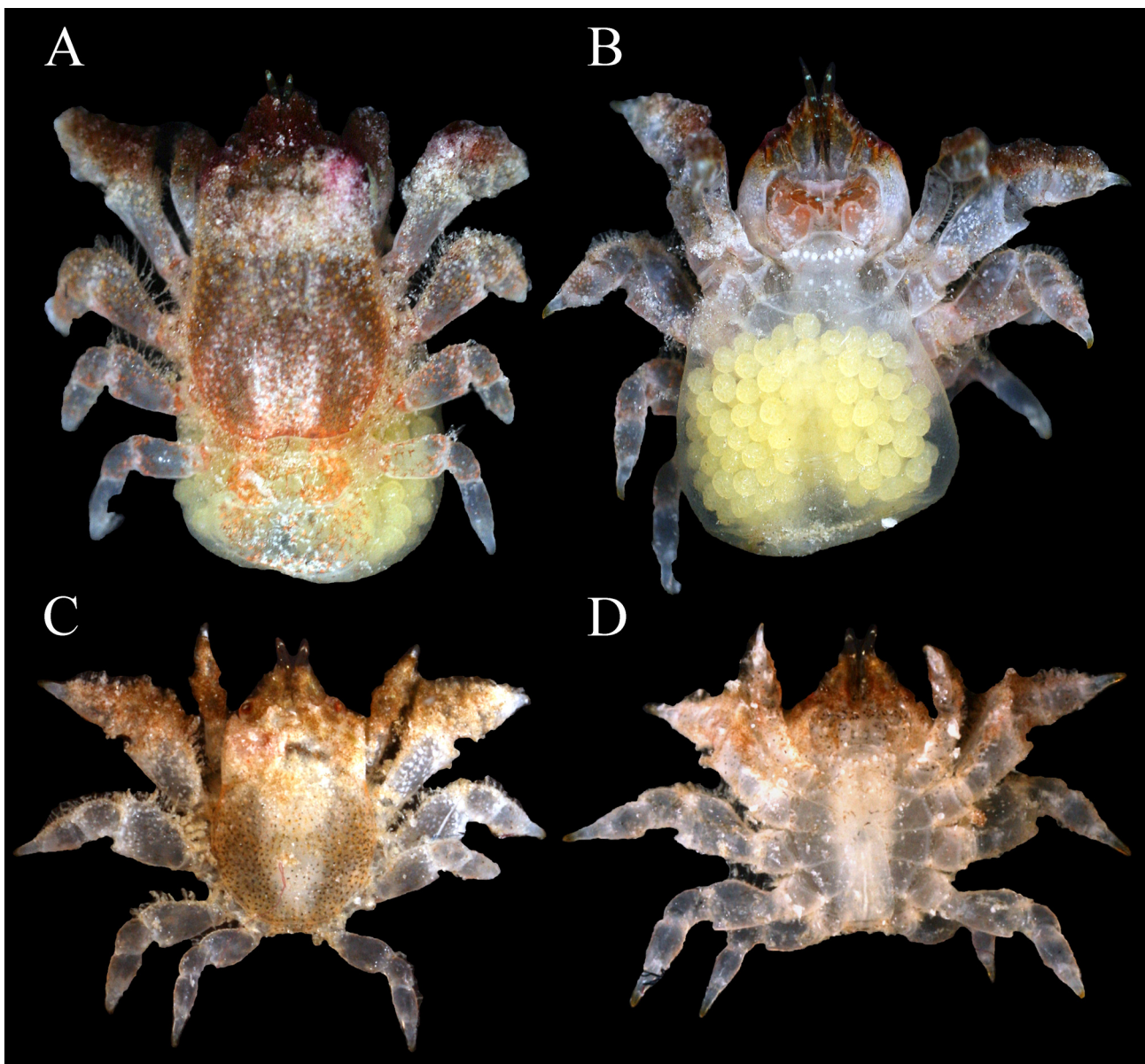
**Remarks.** The orientation of the cornea on the eyestalk was used by Kropp (1989) to separate the species of *Opecarcinus* into two groups. *Opecarcinus cathyae* sp. nov. has anterolaterally oriented corneas, which places it in the same group as *O. hypostegus*, *O. granulatus* (Shen, 1936) and *O. pholeter* Kropp, 1989. The five remaining species of *Opecarcinus* have terminally oriented corneas. In *Opecarcinus hypostegus*, an Atlantic species, and *O. granulatus* the anterior third of the carapace is sharply set off from the posterior carapace and the transverse depression confined to the protogastric region. In *O. cathyae* sp. nov. and *O. pholeter* the anterior third is not sharply set off from the posterior carapace and the transverse depression is shallow. The new species can, furthermore, be separated from *O. granulatus* by the smooth dorsal margin of the P5 carpus in females, and from



*O. pholeter* by the smooth surface of MXP3 and the lack of depressions on the carapace. *Opearcinus cathyae* **sp. nov.** can also be separated from its Indo-West Pacific congeners in this species group by its colour pattern: *O. granulatus* is opaque with black chromatophores and *O. pholeter* has nine amber-coloured bands (Kropp, 1989), whereas *O. cathyae* **sp. nov.** is orange-red (rust) overall, with an off-white anterolateral region.

**Coral hosts.** The new species appears to be strictly associated with the *Pavona clavus* and *P. bipartita*, sister species that form a rather distinct lineage within the Agariciidae (F. Benzoni, pers. comm.). In his overview of the Pacific *Opearcinus* species, Kropp (1989) does not mention *P. clavus* and *P. bipartita* as hosts, hence *O. cathyae* **sp. nov.** is the first species described in association with these corals. A figure of the dwelling of *O. cathyae* **sp. nov.** in *P. clavus* was provided by Hoeksema & van der Meij (2013: Fig. 1b, c). In *P. bipartita* the new species lives in tunnels on the coral surface. According to Kropp (1989) host specificity has been observed for *O. aurantius* Kropp, 1989 (host *Pavona minuta* Wells, 1954), *O. peliops* Kropp, 1989 (host *P. duerdeni* Vaughan, 1907), and *O. lobifrons* Kropp, 1989 (host *Gardineroseris planulata* (Dana, 1846)). *Opearcinus cathyae* **sp. nov.** also seems to be host-specific by inhabiting two closely related species: *P. clavus* and *P. bipartita*.

**Ecology.** The carapace and pereopods are fringed with numerous setae (Fig. 1A, E; Fig. 2A–E), which, in case covered with trapped sediment, can give the crab a mucky appearance.



**FIGURE 5.** A–D, dorsal and ventral view of *Opearcinus cathyae* **sp. nov.** A, B, RMNH.Crus.D.53916, female with regular colour pattern; C, D, RMNH.Crus.D.54297, male with pale colour pattern.

**Distribution.** So far known from Indonesia and Malaysian Borneo. The holotype of *P. clavus*, illustrated by Veron & Pichon (1980), appears to have a dwelling of a cryptochirid. This coral species was described by Dana (1846) from Fiji, which is therefore a possible distribution record for *O. cathyae* **sp. nov.** *Pavona clavus* is widespread, occurring from the Red Sea and East Africa to the eastern Pacific (Veron & Pichon 1980; Veron 2000). *Pavona bipartita* also shows a wide range, occurring from the Red Sea and East Africa to the Central Pacific (Veron 2000). It is thus possible that *O. cathyae* has a wider distribution based on the distribution ranges of its host corals. *Opeccarcinus cathyae* **sp. nov.** can be very abundant locally, with estimated densities up to 200 per m<sup>2</sup> because its coral host can form large monospecific stands (Veron & Pichon 1980; Hoeksema & van der Meij 2013).

**Etymology.** This species is named after Cathy [Catherine] DeGeorge to celebrate 15 years of Trans-Atlantic friendship.

## Acknowledgements

Fieldwork in Halmahera in 2009 was organized by Naturalis and the Indonesian Institute of Sciences (LIPI), under the umbrella of Ekspedisi Widya Nusantara (E-Win). Fieldwork in Lembah Strait in 2012 took place during a Marine Biodiversity Workshop based at the Bitung Field Station (LIPI), co-organized by Universitas Sam Ratulangi in Manado, N Sulawesi. I am grateful to LIPI and RISTEK for granting research permits. Bert Hoeksema (Naturalis) and Yosephine Tuti Hermanlimianto (RCO-LIPI) are acknowledged for all their efforts in organizing fieldwork in Indonesia. Funding for the fieldwork in Indonesia was provided by the A.M. Buitendijkfonds (Naturalis), L.B. Holthuisfonds (Naturalis), and the Schure-Beijerinck-Poppingfonds (KNAW). The 2010 Semporna Marine Ecological Expedition was jointly organized by WWF-Malaysia, Universiti Malaysia Sabah's Borneo Marine Research Institute, Universiti Malaya's Institute of Biological Sciences and Naturalis, and was funded through WWF-Malaysia. The 2012 Tun Mustapha Park Expedition was jointly organized by WWF-Malaysia, Universiti Malaysia Sabah, Sabah Parks and Naturalis, and was funded by the Ministry of Science, Technology and Innovation and USAID Coral Triangle Support Partnership. The research permits were granted by the Economic Planning Unit, Prime Minister's Department, Sabah Parks, Sabah Biodiversity Centre and Department of Fisheries Sabah. Zarinah Waheed (Naturalis & Universiti Malaysia Sabah), and Bert Hoeksema (Naturalis) collected samples used in this study. Bastian Reijnen (Naturalis) is thanked for all his help with photography. Chris Boyko (American Museum of Natural History & Dowling College) confirmed the identity of the parasite in RMNH.Crus.D.53923. The COI sequence was produced as part of a Naturalis Barcoding Project. The beautiful line drawings in this manuscript were made by Erik-Jan Bosch (Naturalis). Peter Ng, an anonymous reviewer, and the editor provided useful comments on an earlier version of this manuscript.

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