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ORIGINAL ARTICLE

# A new hermit crab of the genus *Calcinus* from Rapa Island, French Polynesia with affinities to *Calcinus dapsiles* Morgan, 1989 and *Calcinus sirius* Morgan, 1991 (Decapoda: Anomura: Diogenidae)

Joseph Poupin[1] orcid.org/0000-0002-8293-0855
Rafael Lemaitre[2] orcid.org/0000-0003-2828-612X

1 BCRM de Brest, École Navale. CC 600, 29240 Brest Cedex 09, France.
JP E-mail: joseph.poupin@ecole-navale.fr

2 Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution. 4210 Silver Hill Road, Suitland, MD 20746, United States of America.
RL E-mail: lemaitrr@si.edu

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## ABSTRACT

A new hermit crab of the genus *Calcinus* Dana, 1851 is described from a specimen collected at a depth of 100 m near Rapa Island, Austral Islands, French Polynesia. In a previous report, we had reported this specimen provisionally as *Calcinus* aff. *sirius*, pending availability of live color data for *Calcinus sirius* Morgan, 1991. Recently obtained color photographs of live *C. sirius* from the Solitary Islands, Eastern Australia, has shown that the specimen from Rapa Island is distinct from Morgan's taxon and represents a new species which is fully illustrated and described herein as *Calcinus shawi* sp. nov. The morphology and coloration of this new species are compared with the closely allied *C. sirius* and *Calcinus dapsiles* Morgan, 1989.

## KEYWORDS

Australia, Austral Islands, Rapa Island, new species, taxonomy

Corresponding Author
Joseph Poupin
joseph.poupin@ecole-navale.fr

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## INTRODUCTION

Hermit crab species of the genus *Calcinus* Dana, 1851 are colorful and ubiquitous inhabitants of tropical reefs. Although often morphologically quite similar, their striking and distinct color patterns can be used to separate the 46 species that are currently recognized worldwide (WoRMS Editorial Board, 2021). In a molecular phylogeographic study of species in this genus, Malay and Paulay (2010) showed that coloration appears

to evolve so rapidly that some sister species that have different color patterns are only slightly or even not genetically differentiated, and hypothesized that coloration probably plays a key role in species recognition and mate choice. Since Malay and Paulay's study, one additional species of this genus was described as *Calcinus fuscus* Malay, Komai and Chan, 2012, distributed from Japan and western Pacific, and is considered a sister species of *Calcinus anani* Poupin and McLaughlin, 1998, from French Polynesia. Based on molecular data and recognizable color patterns, Malay and Paulay (2010) identified nine undescribed "cryptic" taxa, which they treated as Evolutionary Significant Units (ESUs; *sensu* Moritz, 1994) but did not formally name. Instead, those ESUs were reported in their study as having affinities (aff.) to known species, *i.e.*, *Calcinus* aff. *albengai* Poupin and Lemaitre, 2003 (Rapa I.); *Calcinus* aff. *elegans* (H. Milne Edwards, 1836) (Hawaiian Is.); *Calcinus* aff. *hazletti* Haig and McLaughlin, 1984 (Northern Marianas); *Calcinus* aff. *latens* Randall, 1840 (Hawaiian Is.), *Calcinus* aff. *latens* (Oman); *Calcinus* aff. *pulcher* Forest, 1958 (Mascarenes); *Calcinus* aff. *sirius* Morgan, 1991 (Rapa I.); *Calcinus* aff. *vachoni* Forest, 1958 (Cook Is.), and *Calcinus* aff. *vachoni* (Réunion). Subsequently, Malay *et al.* (2018) showed that the Hawaiian ESU attributed by Malay and Paulay (2010) to a color variant of *C. elegans*, actually represents *Calcinus pictus* (Owen, 1839). Recently obtained color photographs of live *Calcinus sirius* Morgan, 1991 from the Solitary Islands, Eastern Australia, has now made possible the clarification of the status of Malay and Paulay's ESU *Calcinus* aff. *sirius* from Rapa Island. The latter ESU is considered a new species that is herein redescribed and can be confidently separated from *C. sirius* based on morphological differences, coloration, and distinct depth and geographic ranges. This new species is compared herein to two allied species, *C. sirius*, and *Calcinus dapsiles* Morgan, 1989 from Australia. Differences in coloration and other morphological characters are presented for all three species.

Fraaije *et al.* (2017), based largely on groove patterns visible on the cephalothoracic shield of fossil hermit crabs, have proposed placing *Calcinus* and six other diogenid genera with Recent species, in a new family Calcinidae Fraaije, Van Bakel and Jagt, 2017. However, until cephalothoracic groove patterns and numerous other body characters, as well as genetic data, are fully evaluated in Recent species across the Diogenidae, the use of the latter family is maintained for *Calcinus*. Specimens used in this study remain deposited in the Australian Museum, Sydney (AM), Muséum national d'Histoire naturelle, Paris (MNHN), Museums of Victoria, Melbourne (MV or MoV), and Naturhistorisches Museum Wien, Austria (NHMW). Cephalothoracic shield length (SL) is measured to the nearest 0.1 mm from the tip of the rostrum to the midpoint of the posterior margin of the shield. Other abbreviations used are: ALA, Atlas of Living Australia; CSIRO, Commonwealth Scientific and Industrial Research Organisation; I., island; id., identifier; EA, Eastern Australia; ESU, Evolutionary Significant Unit; IWP, Indo-west Pacific; NSW, New South Wales; OZCAM, Online Zoological Collections of Australian Museums; P2–3, pereiopods 2–3; WA, Western Australia.

## Systematics

**Infraorder Anomura MacLeay, 1838**

**Superfamily Paguroidea Latreille, 1802**

**Family Diogenidae Ortmann, 1892**

**Genus *Calcinus* Dana, 1851**

***Calcinus shawi* sp. nov.**
(Figs. 1A–H, 4)
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*Calcinus* aff. *sirius*. — Poupin and Lemaitre, 2003: 17, fig. 1d, 4, 5b [MNHN Pg 6395, Rapa I., 100 m]. — Malay and Paulay, 2010: 640, tab. 1 [same specimen, MNHN Pg 6395, molecular analysis, specimen n° H93b]. — Malay *et al.*, 2012: 166, tab. 1 [same specimen, MNHN-IU-2011-5105 (ex-MNHN Pg 6395), Genbank n° FJ620251]. Not *C. sirius* Morgan, 1991.

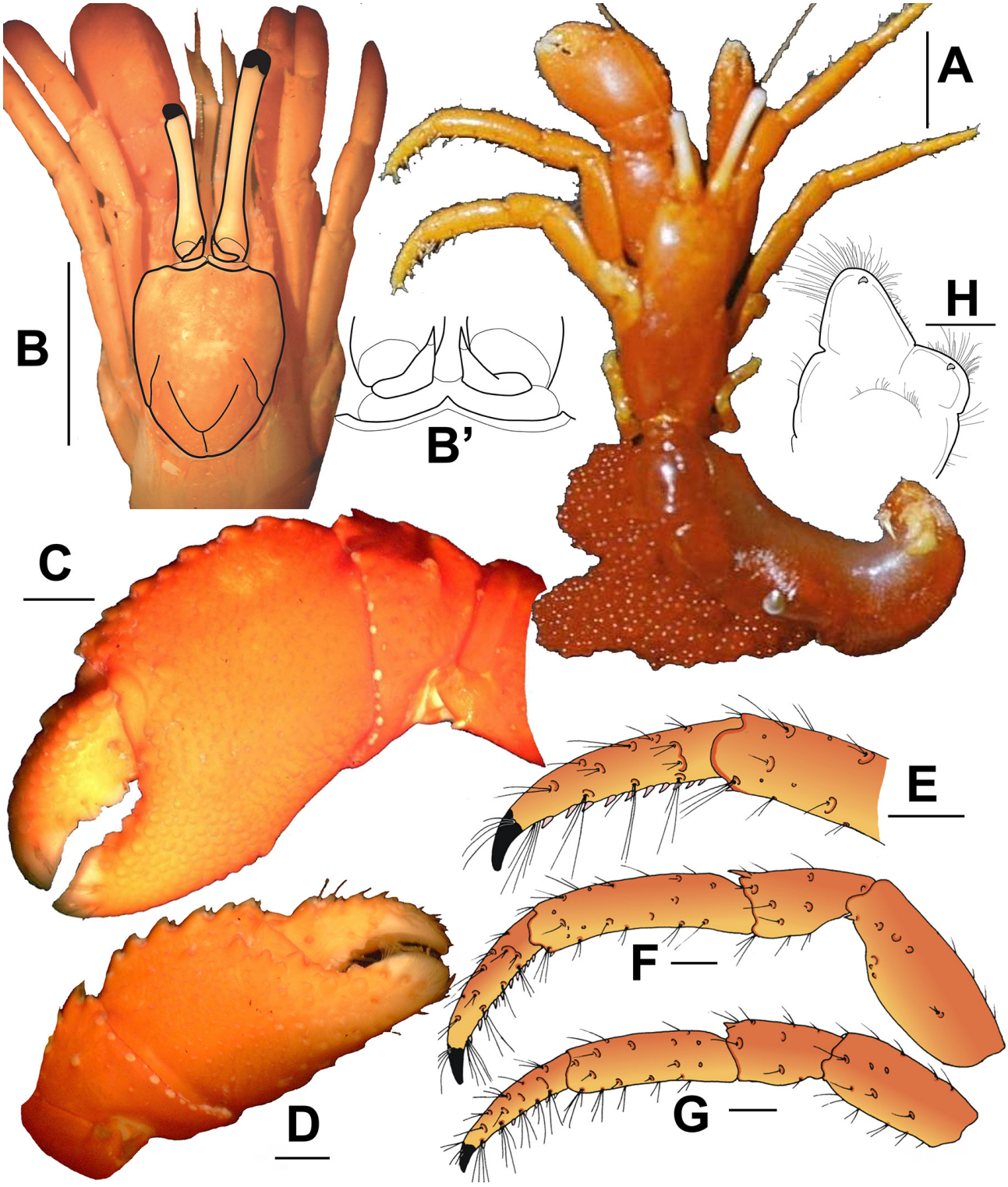


**Figure 1.** *Calcinus shawi* sp. nov., ovigerous female, SL 5.5 mm, holotype MNHN-IU-2011-5105 (ex-MNHN Pg 6395), Genbank n° FJ620251. **A**, color in life; **B**, shield, ocular acicles, and ocular peduncles; **B'**, detail of ocular acicles; **C**, left large chela, outer face; **D**, right small chela outer face; **E**, distal part of propodus and dactyl of left P2, outer face; **F**, left P2, outer face; **G**, left P3, outer face; **H**, telson, ventral face. Scale bars: A, B = 5 mm; C–G = 1 mm; H = 0.5 mm

*Material examined*. French Polynesia, Austral Is., BENTHAUS Expedition. Rapa I., stn DW1894, 27°40.13'S 144°21.51'W, 100 m, 8/11/2002: holotype, ovigerous female, SL 5.5 mm (MNHN-IU-2011-5105, ex-MNHN Pg 6395, Genbank n° FJ620251).

*Diagnosis*. Ocular acicles terminating in simple spine (Fig. 1B, B'). Left chela, largest (Fig. 1A, C) with outer face regularly convex; upper margin of palm with 7 blunt spines; lower margin with few tubercles on distal half. Upper margin of right chela with 6 corneous-tipped spines (Fig. 1A, D). Dactyl of P2 (Fig. 1E, F) slightly shorter than propodus, with 10 movable spines on ventral margin. Dactyl of P3 (Fig. 1G) slightly shorter than propodus, with 7 movable spines on ventral margin. Ventrodistal pilosity of P3 weak, slightly denser than that of P2 (Fig. 1F, G). Telson with posterior lobes each armed with single terminal spine (Fig. 1H). Overall live color orange, paler on ocular peduncles, without colored stripes or spots; eggs bright red.

*Description*. Shield 0.85 times as broad as long. Rostrum (Fig. 1B, B') triangular, slightly overreaching level of broadly subtriangular lateral projections; anterior margins between rostrum and lateral projections concave. Anterodorsal plate of branchiostegite with dorsal margin nearly smooth, with few spinules on proximal half.

Ocular peduncles (Fig. 1B) 1.14 times (right) or 0.70 times (left, probably regenerating) as long as shield, slightly constricted medially; cornea weakly dilated, diameter approximately one-sixth length of ocular peduncle. Ocular acicles (Fig. 1B, B') well developed, subtriangular, terminating in simple spine.

Antennular peduncles reaching to distal 0.25–0.30 of right ocular peduncle. Ultimate segment 0.38 times as long as shield. Antennal peduncles shorter than antennular peduncles, reaching between midpoint and distal one-third of right ocular peduncle. First segment with ventrolateral angle produced, bearing 2 or 3 spines. Second segment with laterodistal angle produced, terminating in bifid spine; distomesial angle with minute spine. Third segment with strong spine at ventrodistal angle. Fourth segment with dorsodistal spine. Fifth segment unarmed. Antennal acicle reaching beyond proximal margin of fifth antennal segment, terminating in strong spine; dorsolateral margin with spine distally, dorsomesial margin with row of spines.

Left chela larger than the right, (Fig. 1C), 0.74 times as high as long. Dactyl 0.55 times palm length; cutting edge with 2 subtriangular calcareous teeth on proximal half; dorsal margin granulated. Fixed finger with 3 triangular teeth on proximal half of cutting edge; outer and lower faces with granules. Palm with outer face regularly convex, without depressions, coarsely granular; inner face smooth; upper margin of palm with a row of 7 blunt spines and a few accessory tubercles in between. Carpus with prominent submedian tubercle on outer face; upper margin with 1 or 2 small indentations and 1 strong spine at dorsodistal angle. Merus stout, triangular in cross-section; ventromesial margin with few spines distally; ventrolateral margin with 2 spines distally; upper margin unarmed.

Right chela smaller than left (Fig. 1D), with 6 corneous spines on upper margin of palm. Dactyl about as long as palm; cutting edge with 3 triangular teeth on proximal half; dorsal surface with 2 subparallel rows each of 5 or 6 spines; fixed finger with 1 large triangular tooth on cutting edge, proximally, outer face with tubercles, those near tip bearing setae. Palm with outer face weakly convex, smooth on proximal two-thirds, tuberculated distally, near base of fingers; inner face flat, smooth. Upper margin of carpus with 2 or 3 spines increasing in size distally. Merus similar to that of left cheliped.

Ambulatory legs similar from left to right. P2 (Fig. 1E, F) exceeding left cheliped by length of dactyl when fully extended; dactyl 0.81 times as long as propodus; ventral margin with widely-spaced, sparse tufts of setae and 10 minute spines; propodus with few long setae, and minute movable spine at ventrodistal angle; carpus 0.60 times as long as propodus, with strong dorsodistal spine; merus slightly longer (1.06 times) than propodus, with lateroventral spine distally. P3 (Fig. 1G) shorter than P2, overreaching tip of left cheliped by distal half of dactyl when fully extended; ventrodistal pilosity not brush-like and only slightly denser than that of P2; dactyl shorter (0.85) than propodus, ventral margin armed with 7 minute spines; propodus unarmed on ventral and dorsal distal angles; carpus 0.68 times as long as propodus,

with dorsodistal spine; merus slightly shorter (0.96 times) than propodus, with indistinct lateroventral spine, distally. Fourth pereopod semichelate; dactyl terminating in corneous claw, ventrolateral margin with row of spinules; propodus with broad rasp consisting of several rows of corneous scales; carpus with dorsodistal spine; merus unarmed, ventral margin with long setae. Fifth pereopod chelate, with rasp on propodus and dactyl; carpus and merus unarmed, subovate in cross-section.

Abdomen with 4 unpaired biramous left pleopods. Sixth abdominal tergite calcified, with dorsal face divided into 4 subequal areas by longitudinal and transverse furrows. Telson with posterior lobes asymmetrical (Fig. 1H), left more elongated than right; lobes with long setae marginally, each with 1 posterior spine slightly curved ventrally.

*Live color* (Fig. 1A). Shield and posterior carapace orange. Ocular peduncles pale orange on proximal third, fading gradually to white on distal two-thirds. Antennular peduncles orange, becoming pale on distal fourth of terminal segment; flagella orange. Antennal peduncles orange, with white-tipped spines; flagella orange. Chelipeds bright orange. Ambulatory legs orange, a little darker at setal pores. Abdomen red-brown; eggs bright red.

*Distribution and habitat* (Fig. 4). So far known only from Rapa Island, Austral Islands, French Polynesia; dredged at 100 m on hard bottom of rocks and corals.

*Etymology*. Named in honor of Ian Shaw, who took the first color photographs of Australian specimens of *C. sirius*, which made possible the determination of the characters that distinguish that species from this new one.

*Remarks*. *Calcinus shawi* sp. nov. and three other IWP species, *C. albengai*, *C. dapsiles*, and *C. sirius*, share the following characters: 1) ocular acicle with a single terminal spine; 2) spinose upper margin of right chela; 3) regularly convex outer face of left chela, lacking depressions; 4) single posterior spine on left lobe of telson; 5) without distinct brush of setae on ventral margin of P3. The latter three species were included in Malay and Paulay's (2010, fig. 14) Clade X along with the ESU *C.* aff. *albengai*, the shallow water (< 50 m) color variant of the deep water (50–280 m) *C. albengai*, and two species having a distal brush of setae on the ventral margin of P3, *Calcinus argus* Wooster, 1984, and *Calcinus anani* Poupin and McLaughlin, 1998. Subsequently, Malay *et al.* (2012) have found that Poupin and McLaughlin's (1998) *C. anani* is restricted to French Polynesia, and described *C. fuscus* from Japan and western Pacific. The photograph of *C. anani* from Japan in Malay and Paulay (2010, fig 14) and their sequences of *C. anani* from Bismarck archipelago, Papua New Guinea (UF4808), actually represent *C. fuscus*.

*Calcinus shawi* can be easily separated from all species of Malay and Paulay's (2010) Clade X by their color patterns. Live colors of *C. anani* and *C. fuscus* are illustrated in Malay *et al.* (2012, fig. 2) and that of *C. albengai*, *C.* aff. *albengai*, and *C. argus* in Poupin and Lemaitre (2003, fig. 1) and Hoover (1999: 253). Additional photographs can be found in the Internet databases of Legall and Poupin (2021) and Myorin (2021). In *C. shawi* the ambulatory legs are overall uniformly orange (a little darker at setal pores), while most other species of Clade X have a pattern of spots or lines on the ambulatory legs. *Calcinus albengai*, *C.* aff. *albengai*, and *C. argus* have the ambulatory legs punctuated with white spots. *Calcinus fuscus* and *C. anani* have a pattern of reticulated lines forming elongated oval patches on propodi and dactyls.

*Calcinus shawi* sp. nov. cannot be confused with any other *Calcinus* species that are not in clade X. All of them are different by their color pattern and/or by morphological characters presented in the key of Poupin and McLaughlin (1998) including: several distal spines on the ocular acicle and/or lobes of telson; external face of the right palm not regularly convex; dorsal margin of the right chela smooth; and distal setation of P3 more pronounced than that of P2, sometimes forming a brush of setae.

*Calcinus shawi* sp. nov. is closely related to two Australian species also in Malay and Paulay's (2010) Clade X and reported from similar latitudes in the southern hemisphere, *C. dapsiles* from WA and *C. sirius* from EA. The live coloration of the *C. dapsiles* was previously known by the color photograph in Jones and Morgan (2002: 116), whereas that of *C. sirius* has only now been discovered by the first author in the

'Hermit crab visual dictionary' managed by Myorin (2021). The differences in coloration of these three species, which can be useful in their identification, are contrasted below under the discussion of *C. dapsiles* and *C. sirius*.

### *Calcinus dapsiles* Morgan, 1989
(Figs. 2A–D, 4)

*Calcinus dapsiles* Morgan, 1989: 407 [WA, between 25–35°S, 0–20 m: Shark Bay, 5 m; Seven Mile Beach, north of Dongara, 2 m; north of Little I., off Hillarys Marina, Perth; Burns Beach, Perth, 20 m; Nancy Cove and Parker Point, Rottnest I.; Cottesloe Beach, Perth, 2–4 m; Canal Rocks, south of Yallingup, 33°41'S, 114°59'E, 2 m; Prevelly Park, west of Margaret River; Little Bay in Two Peoples Bay, east of Albany, 3 m; Ledge Point, King George Sound, east of Albany, 2–3 m; Michaelmas I., King George Sound, east of Albany, 15–18 m; Frenchman's Bay, old whaling station, south of Albany, 1.5 m; Princess Royal Harbour, near Albany, 3 m; Shelter I., west of Albany, 1–3 m; Cosy Corner, near Migo I., west of Albany, 2–3 m]. — Morgan, 1991: 873 [WA, between 23–35°S, 0–97 m: Warroora, S. end of Ningaloo Reef; Steep Point, opposite Cape Ransonnet and Monkey Rock, Shark Bay; Port Gregory; Houtman Abrolhos Is.; Dyer I., Rottnest I.; Cockburn Sound; Whaling Cove, King George Sound; Ataturk Entrance to Princess Royal Harbour, Albany; False I., King George Sound]. — Jones and Morgan, 2002: 116 [WA, no location, color photograph by C. Bryce]. — ALA, 2021a and OZCAM, 2021a: Internet databases, specimens of *Calcinus dapsiles* in Australian Museums [WA, several places from Museum collections, in part in material examined herein]. — Myorin, 2021: Internet [WA, Perth, Ammo Jetty, 6–8 m, photographs by Matthias Liffers and Rokus Groeneveld; examined herein, see Figs. 2B–D].

*Calcinus* sp. MoV 5268, 5389, 5393, 5396 (Southern Surveyor voyage SS10-2005). — Poore *et al.*, 2008: 24 [WA, between 22–35°S, 95–102 m; color photograph for 5268 (?juvenile), Carnarvon, 100 m, and 5389 (adult; herein in Fig. 2A), D'Entrecasteaux, 95–102 m]. — McEnnulty *et al.*, 2011: 118, 180 [same, with detail on stations data, WA between 22–35°S, 95–102 m: Ningaloo, Carnarvon, Kalbarri, D'Entrecasteaux, and color photograph for 5389, CAAB number 28827109, D'Entrecasteaux, 95–102 m (here in Fig. 2A)]. — CSIRO, 2021: Internet database [same, color photograph for 5389, CAAB number 28827109, image catalogue number MIIC-03696, 19 November 2005, -31.7243° 115.244°, 102. 3 m, color photograph Karen Gowlett-Holmes]. Photograph 5389, presented here in on Fig. 2A, is determined confidently as *C. dapsiles* based on live color; other specimens (MoV 5268, 5393, 5396) are probably juveniles of the same species.

*Material examined*. Several specimens in MV (determined between 1990 and 2009 by G. Morgan, S.W. Gunn, G. Poore, and J. Poupin; not verified for present study, see Remarks) — 3 specimens, King George Sound, N of False Island, 15/04/1984, 25 m, -35.0117 118.168, id. G. Morgan, MV J 18376. — 1 specimen, 2 miles NW of naval base Groyne, Cockburn Sound, 23/11/1969, 6–10 m, -32.2 115.72, id. G. Morgan, MV J 18370. — 1 male, Central Bass Strait, 65 km ENE of Cape Rochon, Three Hummock Island, BSS157, 13/11/1981, 75 m, -40.1817 145.738, id. J. Poupin, MV J 52817. — 1 specimen, Port Gregory, reef 500 m offshore, 1 m, 28/04/1986, -28.2 114.25, id. S W. Gunn, MV J 20511. — 1 specimen, South WA no station, id. S W. Gunn, MV J 20516. — 1 male, off Carnarvon, 07/12/2005, 100 m, -24.6194 to -24.6228 112.666, id. J. Poupin, MV J 54972; Southern Surveyor voyage SS10-2005 (same as *Calcinus* sp. MoV 5268, 5389, 5393, 5396 in Poore *et al.*, 2008 and McEnnulty *et al.*, 2011): 1 specimen, off Carnarvon, 08/12/2005, 100 m, -24.6244 to -24.6288 112.671 to 112.669, id. J. Poupin, MV J 54754; 2 males, 3 females, off Two Rocks, 18/11/2005, 102 m, -31.7244 to -31.7148 115.244, id. J. Poupin, MV J 54753 (1 male), MV J 55372 (3 females), MV J 54755 (1 male); 2 males, off D'Entrecasteaux, 21/11/2005, 95–100 m, -34.8861 to -34.8839 115.507 to 115.499, id. G. Poore, MV J 55371; 1 male, off Kalbarri, 05/12/2005, 96–98 m, -27.8133 113.311, id. J. Poupin, MV J 55343. (List also at https://collections.museumsvictoria.com.au/search?taxon=Calcinus+dapsiles ).

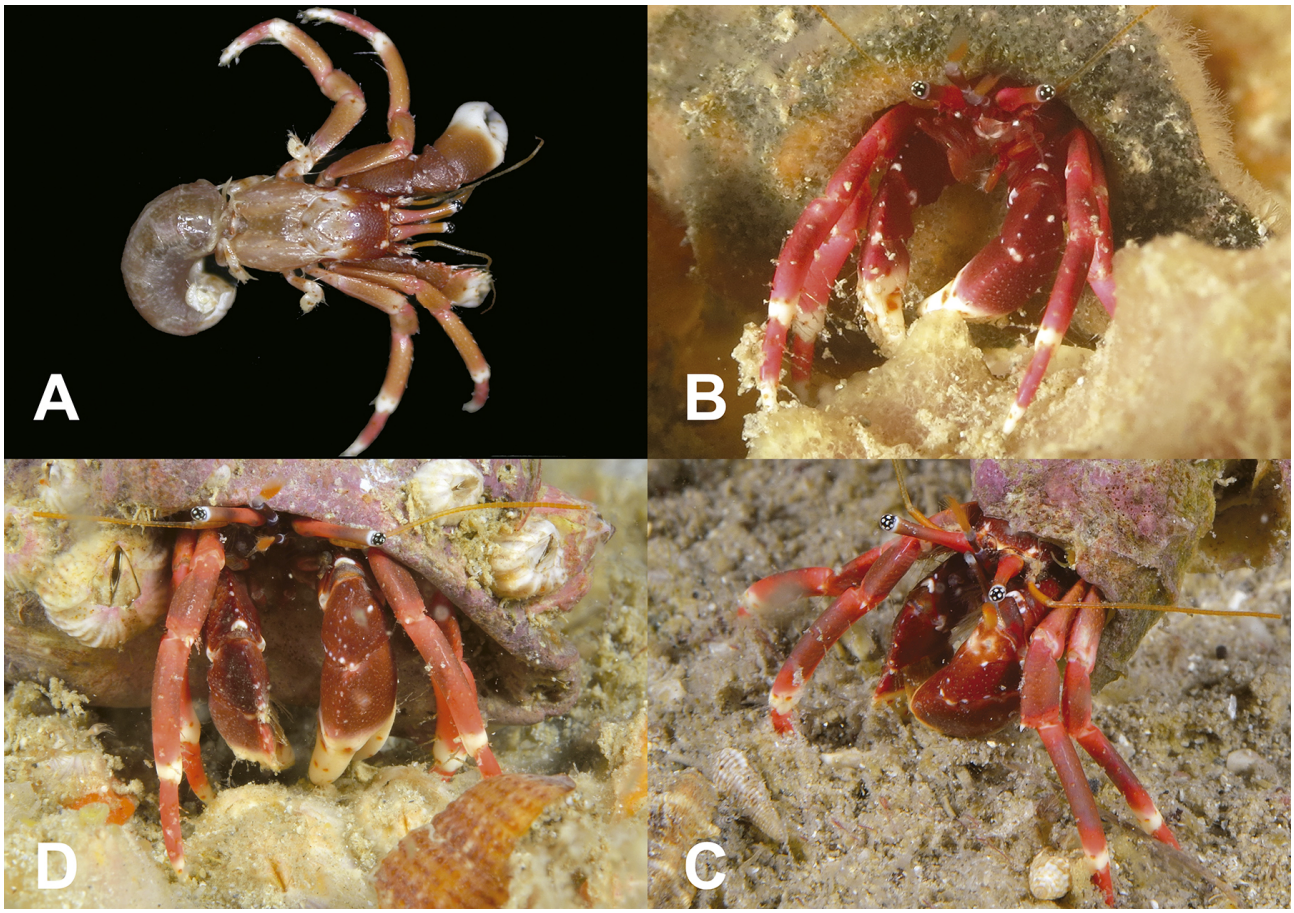


**Figure 2.** *Calcinus dapsiles* Morgan, 1989, live color. **A**, off Perth, -31.7243 115.244, 102.3 m, 19 November 2005, photograph Karen Gowlett-Holmes, CSIRO Catalogue Number MIIC-03696 (also in Poore *et al.*, 2008; McEnnulty *et al.*, 2011); **B**, Perth, Ammo Jetty, 2 January 2015, 7.7 m, photograph Matthias Liffers (also in Myorin, 2021); **C**, Perth, Ammo Jetty, 9 March 2020, -32.1240 115.7582, 7.5 m, silt and sand bottom, photograph Rokus Groeneveld (also in Myorin, 2021); **D**, same place and photographer, 11 March 2020, 6.5 m.

*Color photographs examined* (Fig. 2). Fig. 2A, photographer Karen Gowlett-Holmes, also published in Poore *et al.* (2008), McEnnulty *et al.* (2011) and CSIRO (2021). Figs. 2B–D, photographs from Perth, Ammo Jetty, 6–8 m, photographers Matthias Liffers (Fig. 2B) and Rokus Groeneveld (Fig. 2C–D) (also in Myorin, 2021). A few additional photographs of *C. dapsiles* were also consulted in the Atlas of Living Australia (ALA, 2021a).

*Affinities*. Overall this species is most similar to *C. shawi* sp. nov., from which it differs as follows: upper margin of left larger palm (in male) with indistinct row of low tubercles, instead of having 7 blunt spines in *C. shawi* sp. nov.; dactyl of left larger chela (male) approximately as long as upper margin of palm, instead of noticeably shorter (× 0.55) in *C. shawi* sp. nov.; dactyl of P2 as long as propodus with row of 6–8 short corneous spines on ventral margin, instead of shorter than propodus (× 0.81) with row of 10 minute spines on the ventral margin in *C. shawi* sp. nov.

*Live color* (Fig. 2). The live coloration of *Calcinus dapsiles* (Fig. 2) cannot be confounded with that of *C. shawi* sp. nov. which is overall orange without remarkable markings (Fig. 1). The ground color of *C. dapsiles* is chocolate brown to pink with white on fingers of chelae and distal parts of ambulatory dactyls and propodi. The ocular peduncles are pink on proximal half turning to chocolate brown distally with a thin cream band at base of corneas. In *C. shawi* sp. nov. the ocular peduncles are pale orange on proximal one-fourth fading to white on distal part without distal band at base of corneas. Morgan

(1989: 411) indicates that *Calcinus dapsiles* can be "readily recognized in the field by its distinctive red and white colour patterns, together with the small reddish spots on the chelipeds and walking legs".

*Distribution and habitat* (Fig. 4). *Calcinus dapsiles* is one of the most common and ubiquitous shallow water hermit crabs in WA (Morgan, 1989; 1991). Its geographic distribution is plotted in Fig. 4 based on localities reported by Morgan (1989; 1991), Poore *et al.* (2008), McEnnulty *et al.* (2011), photographs studied during the present study, ALA (2021a) and CSIRO (2021) databases, and specimens deposited in MV collections (Material examined). This species is known with certainty only from WA, including Houtman Abrolhos Islands, between latitudes 22–35°S. Morgan (1991) indicates a depth range of 0–97 m, slightly extended herein to 102 m, from collections of the Southern Surveyor voyage SS10-2005 (off Two Rocks, MV J 54753, J 55372, J 54755).

A doubtful record in Central Bass Strait, 65 km ENE of Cape Rochon, Three Hummock Island, 75 m, -40.1817 145.738 (MV J 52817) is out of the usual range for this species. A re-examination by G. Poore, at the end of this study, confirms that the setation of P2 and P3 is scarce, similar for both legs, different from *C. dapsiles* where distal setation of P3 is more pronounced than on P2. It is however a juvenile that has lost its color. In the future, it will be interesting to confirm the presence of *C. dapsiles* in Bass Strait with adults and colored specimens. According to O'Hara and Poore (2000) the species richness of southern Australian marine fauna graded with latitude from high diversity in the warm temperate regions around Perth and Sydney to low diversity in cool temperate southern Tasmania. This would be an indication that *C. dapsiles* perhaps does not occur south of 35°S, its ultimate confirmed WA latitudinal occurrence. Conversely, a disjunct distribution, such as it is presented in Fig. 4 for *C. dapsiles* (WA and Bass Strait), has also been reported by Poore *et al.* (2008: 3, fig. 2) for the slipper lobster *Ibacus alticrenatus* Spence Bate, 1888, attributed to the scarcity of collections in the Great Australian Bight, and an indication that *C. dapsiles* would be indeed present in Bass Strait.

*Remarks*. To our knowledge, the only color photograph published for *C. dapsiles* previous to the present study was that in Jones and Morgan (2002, of a specimen from WA but without further detail of location). Our study of color photographs (Fig. 2B, C) obtained by scuba divers operating in the Perth area and included in Myorin (2021), as well as additional color photographs in the Atlas of Living Australia (ALA, 2021a), confirmed the remark by Morgan (1989) that *C. dapsiles* is abundant in south-western Australia, and is the only species of *Calcinus* that occurs south of the Rottnest Island (32°S) in that region. It is morphologically related to *C. shawi* sp. nov. but differs in a few morphological differences (see Affinities) and live coloration (compare Figs. 1 and 2). The two species have also been sequenced by Malay and Paulay (2010), and their molecular data confirm the genetic separation of these two species.

### *Calcinus sirius* Morgan, 1991

(Figs. 3A–D, 4)

*Calcinus sirius* Morgan, 1991: 899, figs. 49–55 [Norfolk and Lord Howe Is. Middleton and Elizabeth Reefs; 2–22 m]. — Asakura, 2002: 30 [comparison specimens, paratypes from Norfolk and Lord Howe Is]. — Springthorpe and Lowry, 1994: 91 [AM, paratype specimens: Lord Howe Is. Middleton and Elizabeth Reefs; 2–22 m]. — Ahyong, 2015: 423 [Meyer and Raoul Is., Kermadec; 10–27 m]. — Myorin, 2021: Internet [NSW, Solitary Islands, photographs by Ian Shaw]. — ALA, 2021b and OZCAM, 2021b: Internet databases, specimens of *Calcinus sirius* in Australian Museums [EA, same as in Morgan, 1991, with an additional record in WA, probably an error, see herein distribution and Fig. 4].

*Calcinus latens*. — Heller, 1865: 88 [in part, Sydney, 2 females, SL 1.8, 2.1 mm, 1 ovigerous female, SL 3.2 mm, 2 specimens, missing most appendages, not removed from shells, NHMW 19434]. According to McLaughlin and Dworschak (2001: 155) these 5 specimens are *C.* cf. *sirius* Morgan. Not *C. latens* (Randall, 1840).

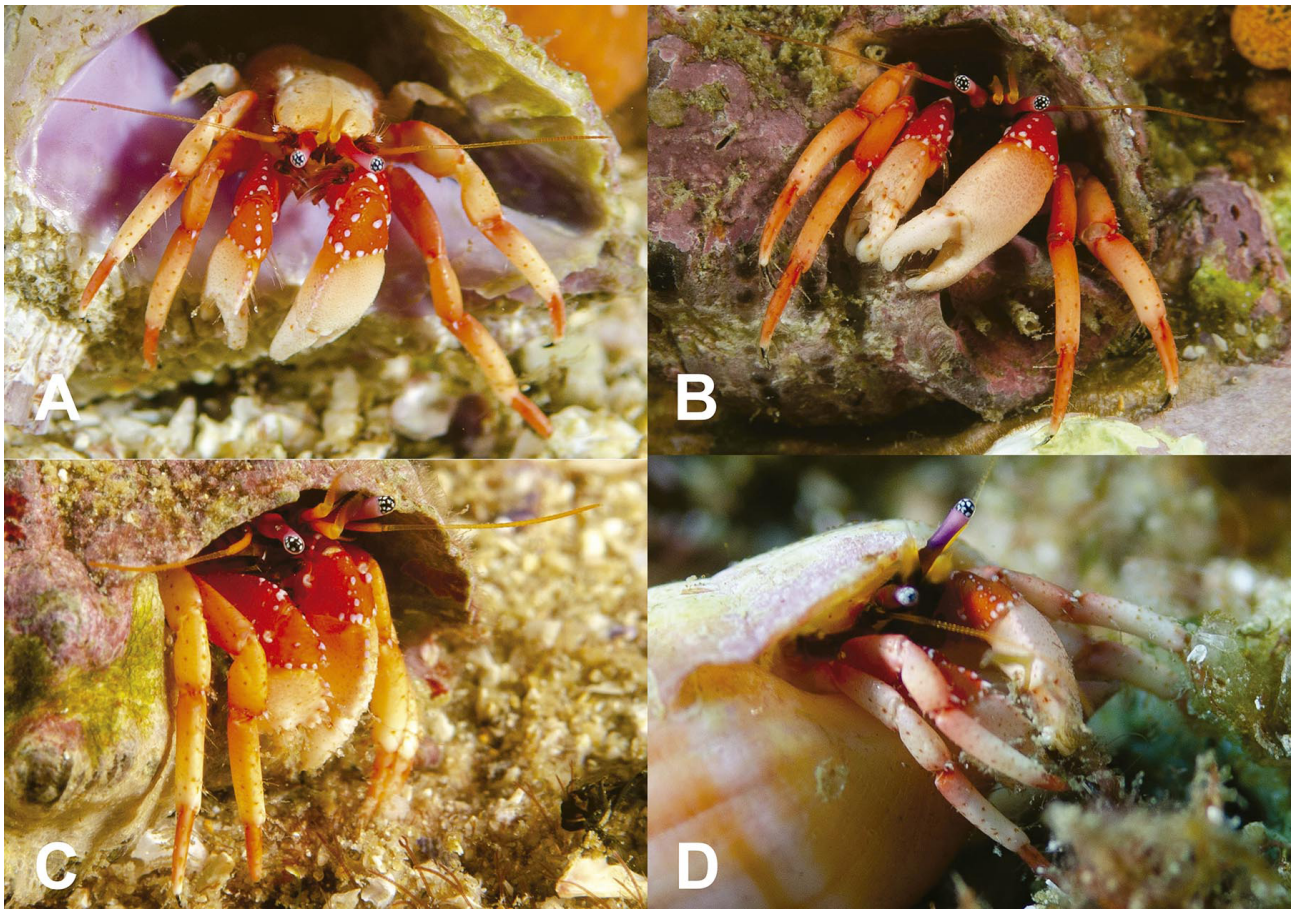


**Figure 3.** *Calcinus sirius* Morgan (1991), live color. **A**, North Solitary Island, 26 February 2017; **B**, Northwest Solitary Island, 13 May 2020 (also in Myorin, 2021); **C**) South Solitary Island, 18 February 2019; **D**) South Solitary Island, 9 May 2019. Photographs Ian Shaw.

*Calcinus tibicen*. — Heller, 1865: 87 [in part, Sydney, 1 juvenile, SL = 0.92 mm, NHMW 19588]. According to McLaughlin and Dworschak (2001: 154), this juvenile is possibly *C. sirius* Morgan. Not *C. tibicen* (Herbst, 1791).

*Color photographs examined* (Photographer Ian Shaw). Solitary Islands, Eastern Australia, depth 8–15 m, 26 February 2017, North Solitary Island (approximately -29.9275 153.3910, Fig. 3A); 13 May 2020, North West Solitary Island (approximately -30.0178 153.2713, Fig. 3B); 18 February 2019 (Fig. 3C), 9 May 2019 (Fig. 3D), and 4 October 2019, South Solitary Island (approximately -30.2055 153.2669).

*Affinities*. Overall this species is similar to *C. shawi* sp. nov., with the following differences: dactyl of left larger chela (male) approximately as long as upper margin of palm, instead of noticeably shorter (× 0.55) as in *C. shawi* sp. nov.; upper margin of left larger palm (in male) with row of low tubercles, instead of having 7 blunt spines in *C. shawi* sp. nov.; ventral margin of dactylus and propodus of P3 with greater development of setae than on P2 but not forming a brush of setae, whereas in *C. shawi* sp. nov. the setation density is similar on P2 and P3.

*Live color* (Fig. 3). Shield cream, with darker orange anterior and anterolateral margins. Ocular peduncles pink to violet on proximal half, grading to paler distally without thin cream band at base of corneas; corneas black with large white spots. Distal antennular peduncles and flagella orange. Antennal peduncles and flagella orange. Chelipeds with fingers and palm cream to pale orange with a few minute scattered red dots; carpus and merus deep orange with white at tip of spines and tubercles. P2 and P3 uniformly

orange with minute scattered red dots but without reticulation or spots, dactylus deep orange, propodus deep orange proximally fading to paler distally, carpus and merus pale orange or orange.

*Distribution* (Fig. 4). Australia, New South Wales (Solitary Islands), Tasman Sea (Norfolk and Lord Howe Islands, Elizabeth and Middleton reefs), and New Zealand, Kermadec Islands (Meyer and Raoul Is.); 2–27 m. Probably also Sydney, from Heller's specimens of *C. latens* and *C. tibicen* in the NHMW, tentatively assigned to *C.* cf. *sirius* by McLaughlin and Dworschak (2001: 154, 155). A record from WA in ALA (2021b) and OZCAM (2021b) databases (South of Perth, shallow water near Penguin Island, -32.30833 115.69333, AM P.42071) is probably an error for *C. dapsiles* (see Fig. 4).

*Remarks*. The color photographs examined for the present study were taken at a depth of 8–15 m in the Solitary Islands (North, Northwest, and South), about 5–10 km offshore in EA. According to the photographer, Ian Shaw, this species is commonly seen throughout the year. Its geographic limit has been greatly extended by Ahyong (2015) to the East, to Kermadec Is. Poupin and Lemaitre (2003) had speculated that *C. sirius* could reach Rapa I., still more to the East (Fig. 4), if the live coloration of *C. sirius* and *C.* aff. *sirius* were shown to be the same. The present study has shown that this is not the case, and that *C. sirius* and *C. shawi* sp. nov. have different distinctive coloration. Possibly, the latter new species evolved from the former by allopatric speciation. For the time being *C. sirius* appears to live in shallow waters (2–27 m; never reported during the numerous deep-water expeditions organized off eastern Australia), whereas *C. shawi* sp. nov. lives deeper (100 m; not found in shallow waters also surveyed during BENTHAUS campaign). However, as reported in this study for *C. dapsiles*, known from 0 to 102 m, the depth range of species of *Calcinus* can be wide and depth distributions of the species are still not known accurately because of the vagaries of collections and too fragmentary data.

The live color photographs of *C. sirius* make it also possible to remove the doubt of a potential synonymy between *C. anani* (and sibling *C. fuscus*) with *C. sirius* suggested by Poupin and McLaughlin (1998: 11) and Asakura (2002: 34–35), the latter author indicating that "it is highly probable that *C. anani* [also *C. fuscus*] and *C. sirius* are conspecific. However, until the living coloration of the ambulatory legs of *C. sirius* can be observed, this problem cannot be resolved". The color photographs examined herein confirm that no reticulations are seen in live color of *C. sirius* and that it is distinct from *C. anani* and its sibling-species *C. fuscus*.

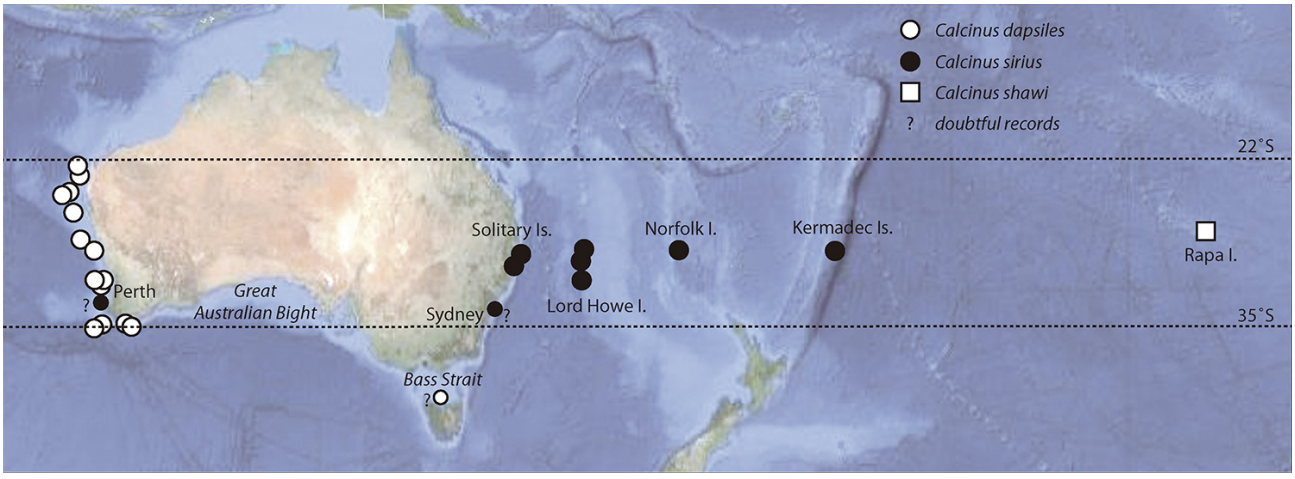


**Figure 4.** Geographic distribution of *Calcinus dapsiles* (0–102 m), *C. sirius* (2–27 m) and *C. shawi* sp. nov. (100 m), from published records complemented with additional records in Australian databases; three doubtful records indicated by '?' (see text). Map background adapted from Google Map.

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