



Article

Lithoscaptus aquarius sp. nov. (Decapoda: Cryptochiridae) Described from a *Catalaphyllia jardinei* (Scleractinia) out of the Aquarium Trade [†]

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Abstract: A new species of gall crab collected from elegance coral, *Catalaphyllia jardinei*, is described in this paper. The male holotype was collected from a reef tank in Germany in 2016, and it is described here using integrative taxonomy. This species, named *Lithoscaptus aquarius* sp. nov., is the thirteenth assigned to the genus. It is morphologically and phylogenetically closest to *Lithoscaptus semperi*, a cryptochirid associated with *Trachyphyllia geoffroyi*. Like *L. semperi*, it has a large, broad W-shaped depression on the anterior half of the carapace, but the carapace surface of *L. aquarius* sp. nov. is smooth overall, lacking spines or tubercles. This new species is so named because it was found in a reef tank after searching in vain for material during fieldwork campaigns over the course of several years.

Keywords: elegance coral; gall crab; new species; symbiosis; thoracotremata



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1. Introduction

The stony coral *Catalaphyllia jardinei* (Saville-Kent, 1893) [1], family Merulinidae H. Milne Edwards and Haime, 1857 [2], among aquarium keepers commonly known as the elegance coral, is a popular species in reef tanks [3]. The species is listed as Vulnerable on the IUCN Red List in part due to overexploitation by the aquarium trade [4]. *Catalaphyllia jardinei* has the largest ex situ population, in public aquaria, of all corals and sea anemones [5].

Catalaphyllia jardinei has not previously been recorded as a host for coral-dwelling gall crabs (Cryptochiridae), but the presence of these crabs is well known to saltwater aquarium keepers and gall crabs inhabiting *Catalaphyllia* Wells, 1971 [6], and have been extensively discussed on various reef aquarist websites. Being alerted to the presence of gall crabs in *Catalaphyllia* on these websites, I tried for several years (2014–2022) to collect specimens from this host coral during field surveys across the Indo-West Pacific or to obtain material through collaborators. While this coral is very conspicuous and has a wide distribution, it is relatively uncommon throughout its range [4,7]. Its uncommonness and specific habitat demands of soft bottoms and turbid water, further removed from the reefs where most cryptochirid sampling takes place, likely impacted the success of locating a crab-inhabited *Catalaphyllia* during the reef surveys.

Here, I formally describe the gall crab inhabiting *Catalaphyllia* as a new species to science using an integrative taxonomy approach based on a male specimen obtained from a reef tank in Germany. While this is not an ideal situation, as the type locality is not known, several species have been formally described from aquaria, e.g., [8,9]. Formally describing this species will facilitate future research into this new gall crab species by alerting scientists to its presence in *C. jardinei*. Moreover, this gall crab is, to the best of my knowledge, the first coral-dwelling invertebrate to be recorded living in association with *C. jardinei*.

2. Material and Methods

A male gall crab specimen was collected by Siglinde Müller (Germany) in 2016 from her personal reef tank after contacting the author for background information on Cryptochiridae for a reef aquarium website. The crab was preserved in 80% ethanol and sent to the author for further study. A partial cytochrome c oxidase I (COI) barcode was obtained following a previously published gall crab protocol [10] and deposited in GenBank under accession number OR051026. The holotype is deposited in Naturalis Biodiversity Center in Leiden (The Netherlands) with the voucher code RMNH.CRUS.D.58325. Additional material was studied during a visit to the Muséum national d'Histoire naturelle (MNHN) in Paris in May 2014 before the reef tank specimen was obtained by the author. At the time, the author made notes about this likely new species, and based on gross morphology and host data, these samples could be retroactively matched with *L. aquarius* sp. nov.

The COI barcode was aligned in a dataset containing a wide range of cryptochirid species [11], with duplicates removed, to determine its phylogenetic position. The alignment was constructed using Seaview [12]. A maximum likelihood (ML) analysis was conducted in IQ-TREE [13] with 10,000 ultrafast bootstraps [14], and the selection model was set to automatic detection using ModelFinder [15], resulting in GTR + F + I + G4 according to the Bayesian information criterion. Bayesian inferences (BI) coupled with Markov chain Monte Carlo techniques (six chains) were run for 3,000,000 generations in MrBayes 3.1.2 [16], with a sample tree saved every 100 generations and the burnin set to 25%. The standard deviation of split frequencies was 0.007691. Consensus trees were visualized in FigTree v.1.3.1 [17].

The holotype was photographed using an Olympus SZ51 stereomicroscope, and the material in Paris was photographed with a Canon 450D equipped with a macro lens. Abbreviations used: RMNH = Rijksmuseum van Natuurlijke Historie, currently Naturalis Biodiversity Center (Leiden, The Netherlands), MNHN = Muséum national d'Histoire naturelle (Paris, France), CL = carapace length (mid-length), CW = carapace width (at widest point), P = pereopod, MXP3 = third maxilliped.

3. Systematics

Family Cryptochiridae Paulson, 1875 [18]

Genus *Lithoscaptus* A. Milne-Edwards, 1862 [19]

Lithoscaptus aquarius sp. nov.

Figures 1–3

ZooBank. urn:lsid:zoobank.org:act:3D3BFA1C-BC2E-4A07-8C89-7722C9304C7B

Type material. RMNH.Crus.D.58325, male, coral host *Catalaphyllia jardinei*, collected from a reef tank in Germany in 2016.

Other material examined. MNHN-IU-2022-3435, male, host unknown, originally collected in the Indo-Pacific region, specimen donated to the MNHN by the Aquarium de Nancy (currently Muséum-Aquarium de Nancy, France), leg. B. Condé, 17 March 1986; MNHN-IU-2022-3436, ovigerous female (damaged), coral host *Catalaphyllia jardinei*, collected in Banc Gail, Lagoon, New Caledonia, depth 34 m, leg. P. Laboute [no date].

Type locality. Not known, specimen came in via aquarium trade, origin believed to be Indonesia.

DNA barcoding. A COI sequence of the holotype has been deposited in GenBank under accession number OR051026.

Description (based on male holotype). Carapace (Figure 1A) subrectangular, overall smooth, longer than broad, widest anterior to mid-length, 4.9 × 3.8 (CL × CW) mm. Dorsal surface approximately 40–45° convex in lateral view, deflected anteriorly (Figure 1C). Large, broad W-shaped depression on anterior side of carapace (Figure 1A,B), “W-shape” stems from slightly inflated mesogastric region. Outline of cardiointestinal region visible in preserved specimen, not inflated. Carapace surface overall smooth, lacking presence of spines, tubercles, or granules. Frontal margin smooth, small granules present on anterolateral border; internal

orbital angle does not extend beyond external orbital angle, margin undulating between orbits, orbits shallow (Figure 1B). Anterior half of carapace margin fringed with short, simple setae. Pterygostomial region fused to carapace, suture finely demarcated.

Eyestalk exposed dorsally, smooth, small spines on mesial margin (Figure 1A,B,D). Cornea oval, on anterolateral portion of eyestalk (Figure 1B); antennule longer than eyestalks, distal antennule segments with long, simple setae; apex of antennal segment arrow shaped, longer than broad, ventral surface smooth, extending beyond eyestalk, margins with several small lateral spines, mesial projection of antennal segment not extending beyond eyestalk (Figure 1B).

Anterior extension of sternite of P1 smooth (Figure 1D).

Right MXP3 missing, description based on left MXP3 (Figure 1G). Exopod rectangular; ischium squaroid to triangular, smooth, mesial, and distal margins weakly granulated; merus rounded, surface and extensor margin smooth; carpus, propodus smooth, dactylus with bundle of setae.

Chelipeds (P1), homochelous, slender, few short, simple setae all over; merus length 1.5 times height, smooth, with granules along distodorsal margin; carpus with small granules on dorsal surface; propodus length two times height, smooth, with small granules on dorsal surface; fingers slender, mesial surface of fingers smooth, cutting edge entire, tips of fingers crossing, dactylus with barely visible tooth (Figure 1E).

P2, slender, few short, simple setae all over; merus rectangular, smooth, minute granules on distodorsal surface; carpus smooth with minute granules along distodorsal surface, propodus rectangular, smooth with minute granules along distodorsal surface, dactylus smooth, sharp, slightly curved ventrally (Figure 1F).

P3–5 similar to P2, decreasing in size with P5 smallest. P5 right side subsampled for DNA barcoding (Figure 1D).

Pleon narrow, rectangular; telson slightly pointed, with few simple setae (Figure 1D).

Gonopods, G1 slightly curved laterally, broadened at shoulder, apex pointed, with isolated, short, simple setae. G2 short, slender, blunt, approximately $\frac{1}{3}$ length of G1, inserted into the base of G1.

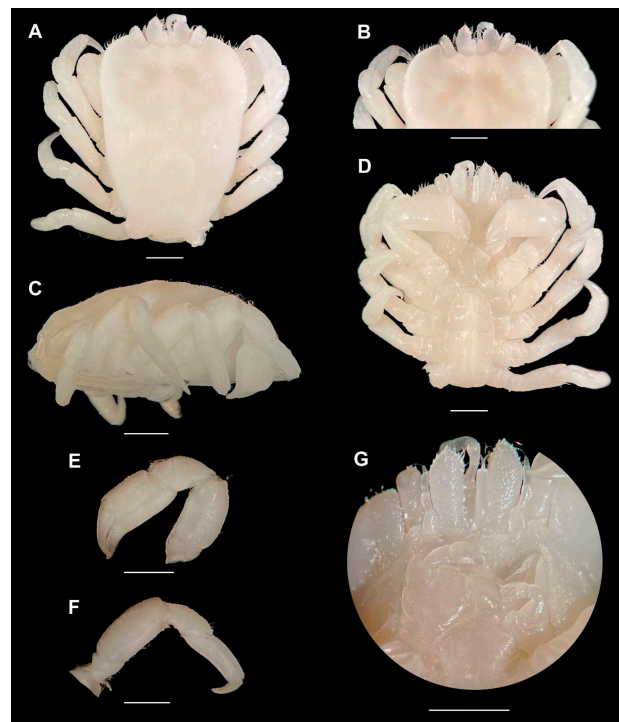


Figure 1. Holotype of *Lithoscaptus aquarius* sp. nov. (RMNH.CRUS.D.58325). (A) Habitus, dorsal view, (B) anterior margin of carapace, ventral view, (C) carapace, lateral view, (D) habitus, ventral view,

(E) right pereopod 1 (cheliped), (F) right pereopod 2, (G) close-up ventral side showing MXP-3 and antennular peduncles. Specimen measures 4.9×3.8 mm (CL \times CW); scale bar is 1 cm. Photographs by T. Xu.

Material in the MNHN. During a visit to the Muséum national d'Histoire naturelle (Paris, France) in May 2014, the author studied the Cryptochiridae collections of Fize and Serène deposited there. Two unidentified lots of Cryptochiridae were studied in the zoothèque and are here assigned to *Lithoscaptus aquarius* sp. nov. Coincidentally, the lot containing a single male (MNHN-IU-2022-3435) was collected from the Aquarium de Nancy in France (currently Muséum-Aquarium de Nancy). The label mentions Indo-Pacific, without further details. The specimen measures 5×4 mm CL \times CW and agrees with the description of the holotype of *L. aquarius* sp. nov. The overall carapace appears even smoother than that of the holotype, and the mesogastric region is slightly more inflated (Figure 2A,B). A second sample (MNHN-IU-2022-3436) was collected from *C. jardinei* by P. Laboute [no date] from Lagon, Banc Gail (New Caledonia), at 34 m depth. Unfortunately, this ovigerous female is damaged, and the specimen was not photographed or measured.

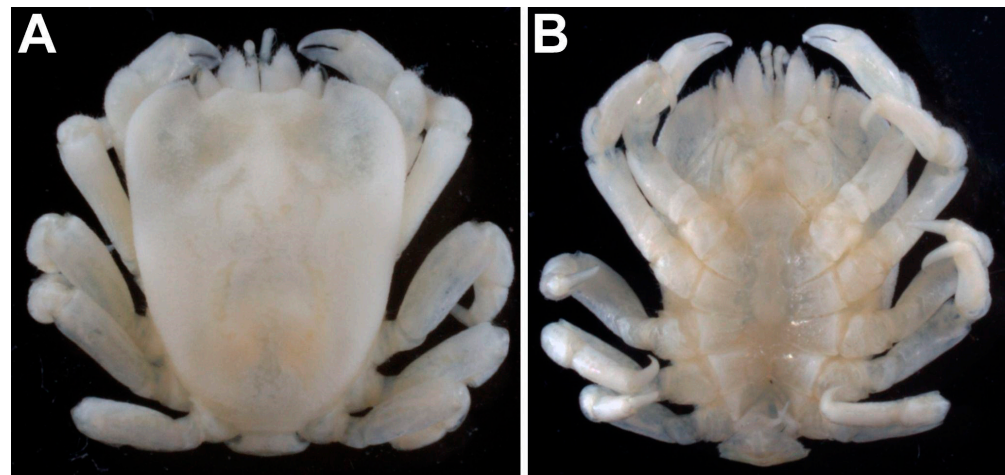


Figure 2. Male specimen of *Lithoscaptus aquarius* sp. nov. (MNHN-IU-2022-3435) collected from the Aquarium de Nancy in 1986. (A) Habitus, dorsal view and (B) ventral view. Specimen measures 5×4 mm (CL \times CW). Photographs by the author.

Female morphology. Contrary to most brachyuran crabs, new species of Cryptochiridae are usually described based on female specimens. Unfortunately, no suitable material was available for study as the only available female specimen in the Paris collections was damaged. Siglinde Müller, the collector of the holotype, provided the author with a photograph of a male and female gall crab collected from a captive specimen of *Catalaphyllia* (Figure 3B). This material was not preserved for scientific study because both crabs were photographed before the contact between the collector and the author of this study was established. The photographs of the male/female pair clearly show the female being much larger than the male. Sexual dimorphism is observed in all gall crabs, and *Lithoscaptus aquarius* sp. nov. is no exception.

Color. Male holotype (RMNH.CRUS.D.58325): Carapace off-white, patterned with chestnut brown lines across anterior region, outlining cardio-intestinal region. Cornea chestnut brown, antennular peduncles and antennules off-white, latter with orange tip. Pereiopods translucent with large orange orange patches (Figure 3A). Coloration is not retained after preservation in ethanol (Figure 1).

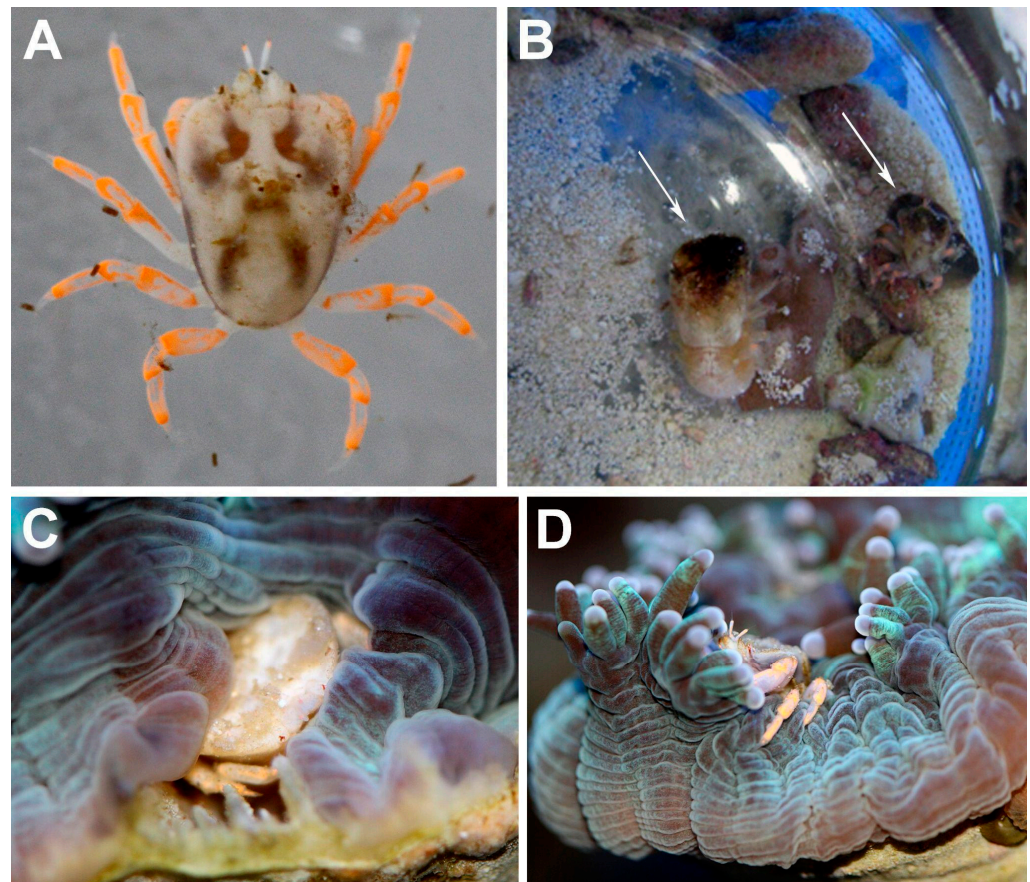


Figure 3. (A) Color image of the holotype of *Lithoscaptus aquarius* sp. nov. (RMNH.CRUS.D.58325). (B) Ovigerous female (left arrow) and male (right arrow) of *L. aquarius* sp. nov. after removal from their host, highlighting the size difference between sexes. (C) female *L. aquarius* sp. nov. inside dwelling and (D) wandering on coral. Crabs in images (B–D) were photographed but not collected for scientific study. All photographs by Siglinde Müller.

Remarks on color. A female and male specimen collected at an earlier date from the same reef tank (see female morphology for details) appear much darker in color than the holotype, especially on the anterior side of the carapace, but that might be due to debris and algae (Figure 3B). Close-ups of a different female specimen show an off-white carapace and the striking orange patterning of the pereiopods also observed in the male holotype (Figure 3A,C,D).

Phylogenetic position. *Lithoscaptus aquarius* sp. nov. clusters in the largest Cryptochiridae clade (Figure 4; see also [20]), together with cryptochirid genera that all associate with hosts belonging to the Robust coral clade [21]. *Lithoscaptus* is a composite genus and in need of taxonomic revision [22,23]; however, *Lithoscaptus aquarius* sp. nov. is retrieved in the clade with the type species *Lithoscaptus paradoxus* A. Milne-Edwards, 1862 [19] (Figure 4, see also [20] for a three-marker analysis) confirms its placement in the genus. *Lithoscaptus semperi* Van der Meij, 2015 [22] is identified as the sister species of *L. aquarius* sp. nov.



Figure 4. Phylogeny reconstruction of the Cryptochiridae based on COI, showing the phylogenetic position of *Lithoscaptus aquarius* sp. nov. Topology derived from maximum likelihood (ML) analysis with UFBoot in IQTree; support values represent ML/BI support. GenBank accession numbers for all species can be found in Supplementary Table S1 [10,11,22,24–27].

Comparisons. Twelve species of *Lithoscaptus* are currently recognized [28]. The herein described male of *Lithoscaptus aquarius* sp. nov. is very distinctive and can be distinguished from all other species by its overall smooth dorsal carapace. The large, broad W-shape depression on the anterior half is prominent and at a first glance superficially resembles the carapace morphology of *Fizesereneia* Takeda and Tamura, 1980 [29]. *Lithoscaptus aquarius* sp. nov. lacks a (partial) division of the carapace depressions in two bowl-shaped concavities, as present in the species of *Fizesereneia*. *Lithoscaptus aquarius* sp. nov. is closest to *L. semperi*, but the male carapace of *L. semperi* is subrectangular to trapezoid in shape and has small tubercles on the anterior half of the carapace. Moreover, in life, *L. aquarius* sp. nov. is off-white, patterned with chestnut brown lines across the anterior region, outlining the cardio-intestinal region, and has translucent pereopods with large orange patches, whereas *L. semperi* has an opaque carapace with a distinctive off-white pattern and opaque pereopods with translucent violet on the P-1 carpus and dactylus.

Coral host. *Lithoscaptus aquarius* sp. nov. is so far only known to inhabit the stony coral *C. jardinei*. Given the high host specificity observed in many cryptochirid species, e.g., [22,23], I consider it highly unlikely that future surveys will yield other host coral species for *L. aquarius* sp. nov.

Species of Cryptochiridae display a striking variety in carapace shapes (see, e.g., [30,31]). Many gall crab species use the anterior part of their carapace as an operculum to close off their dwelling when feeling threatened. Species inhabiting corals with large, flabello-meandroid polyps have similar carapace morphologies. Their carapaces are smooth and widest at the anterior half, with either large bowl-shaped concavities (e.g., *Fizesereneia* species associated with Lobophyllidae corals) or with large, broad W-shaped depressions, such as *L. semperi* (inhabiting *Trachyphyllia geoffroyi* (Audouin, 1826) [32]) and *L. aquarius* sp. nov. [22,30].

Distribution. *Lithoscaptus aquarius* sp. nov. is described from a reef tank in Germany and, intriguingly, two out of three known specimens attributed to *L. aquarius* sp. nov. were discovered in aquaria and not in the field. Many of the corals in the ornamental trade originate from Indonesia, the world's largest exporter of marine ornamental species since the 1980s, supplying up to 91% of the live corals on the global market [33]. The dealer who supplied the corals for the reef tank in Germany most likely also obtained his animals from Indonesia (pers. comm. S. Müller).

One of the two specimens in the Paris collections was also collected from a reef tank (from the Aquarium de Nancy), whereas the other specimen was collected from a lagoon in New Caledonia. The recorded natural range of *L. aquarius* sp. nov. thus includes New Caledonia, and likely Indonesia. *Catalaphyllia jardinei* has a wide distribution in the Indo-West Pacific [4,6], and further research is needed to determine if *L. aquarius* sp. nov. follows its host's distribution range.

Gall crab larvae have yet to be successfully reared ex situ [34]. The male holotype likely settled on its host in the field, and the coral was collected for the ornamental trade through a wild collection or was grown in a coral farm. If a coral farm is located in an enclosed bay with natural water flowing through, gall crab larvae (megalopae) can potentially settle on corals intended for the international aquarium trade. Such coral farms, like coral nurseries, thus might become unintended reservoirs of coral-associated fauna [35,36].

Conservation status. The conservation status of many marine invertebrates is poorly known. Bravo et al. (2022) [37] argued that species living in obligate symbiosis with a host coral—using gall crabs as an example—can be evaluated based on the Red List status of their host. Following their logic, the conservation status of *L. aquarius* sp. nov. could be considered as Vulnerable according to the IUCN Red List criteria, following the status of its host *C. jardinei*.

Etymology. Aquarius [water carrier or water bearer] refers to saltwater aquarium; two out of three known specimens of *Lithoscaptus aquarius* sp. nov. were collected from aquaria. The author was alerted to the presence of gall crabs in *C. jardinei* on reef aquarist websites, and after searching for a wild specimen (to no avail), this new species was described from a specimen collected from a reef tank. Used as a noun in apposition.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/arthropoda1030012/s1>. Table S1. Voucher codes, GenBank accession numbers and references to the original publications for the specimens used in the phylogeny reconstruction.

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Conflicts of Interest: The author declares no conflict of interest.

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