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A new species of *Parthenopea* Kossmann, 1874 (Cirripedia: Rhizocephala: Parthenopeidae) from Florida: the first record of a rhizocephalan from a lobster (Decapoda: Nephropoidea)

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Abstract.—A new species of rhizocephalan barnacle is described parasitizing the Florida lobsterette *Nephropsis aculeata* Smith, 1881. This is the first record of a nephropoid as a host for any rhizocephalan and represents the first record of a rhizocephalan parasitizing any marine lobster (Achelata, Astacidea, Glypheidea, Polychelida). The new species belongs to the genus *Parthenopea* Kossmann, 1874, which now contains three species: *Parthenopea australis* Lützen, Glenner & Lörz, 2009 (on a callianassid in New Zealand), *P. subterranea* Kossmann, 1874 (on a callianassid and an axiid in the Skagerrak strait, Black Sea, and Mediterranean), and *P. reinhardi* n. sp. (on *N. aculeata* from Dry Tortugas, Florida, USA). The new species can be distinguished from the other two in the genus based on the shape of the seminal receptacle ducts (proximally straight in *P. subterranea* versus coiled in *P. reinhardi* n. sp.) and annuli on the stalk (present in in *P. australis* but absent in *P. reinhardi* n. sp.) and the position of the mantle opening (on the surface and close to the stalk in *P. australis* versus in a groove and more distant from the stalk in *P. reinhardi* n. sp.). We urge researchers and fisheries scientists working on marine lobsters to examine specimens for rhizocephalans, potentially leading to additional new records among lobster hosts.

Keywords: Astacidea, barnacle, lobster, new species, parasite, rhizocephalan, western Atlantic

Rhizocephalan barnacles are mesoparasites known to infest a variety of crustacean hosts (Høeg & Lützen 1985). Previously, rhizocephalans have been reported from six of the ten infraorders of Pleocyemata (Anomura, Axiidea, Brachyura, Caridea, Gebiidea, Stenopodidea), with brachyurans most commonly parasitized (hosts for ~67% of all rhizocephalans; Shields et al. 2015). To date, rhizocephalans have never been reported associated with any marine lobsters: Achelata (spiny and slipper lobsters), Astacidea (lobsters and crayfish), Glypheidea, and Polychelida (deep-sea blind lobsters) (Høeg 1995, Boyko & Williams 2009). Although historically debated, current evidence indicates these lobster-like decapods are a non-monophyletic grouping (Bracken-Grissom et al. 2014). While examining material for revisions of the epicaridean isopod genera *Danalia* Giard, 1887, and *Faba* Nierstrasz & Brender à Brandis, 1930 (Boyko 2014), one of us (CBB) recognized that a specimen of the Florida lobsterette *Nephropsis aculeata* Smith, 1881 (Astacidea: Nephropoidea) bore a rhizocephalan rather than an

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isopod on its abdomen, contrary to the previous identification given on the specimen label. This parasite, which is described herein as a new species of *Parthenopea* Kossmann, 1874, shows that rhizocephalans do indeed occur on marine species belonging to Astacidea.

Previously, *Parthenopea* contained only two species (Høeg et al. 2019), both known from hosts belonging to Axiidea (ghost shrimp). The type species, *Parthenopea subterranea* Kossmann, 1874, is known from *Pestarella tyrrhena* (Petagna 1792) and *Callianassa subterranea* (Montagu 1808) in the Black Sea and Mediterranean, as well as *Calocarides coronatus* (Trybom 1904) in the Skagerrak strait (Rybakov and Høeg 2013). *Parthenopea australis* Lützen, Glenner & Lörz, 2009, is known only from an undescribed species of *Vulcanocalliax* sp. in New Zealand (Lützen et al. 2009). With the description of the present new taxon, species of *Parthenopea* are now known to parasitize hosts belonging to both Axiidea and Nephropoidea.

Depending on which aspects of its biology are emphasized (externa morphology, larval morphology, molecular data), the position of *Parthenopea* has moved from Lernaeodiscidae (Boschma 1928), to Peltogastridae (Høeg & Lützen 1985), and to its own family (Rybakov & Høeg 2013). It has also moved from Kentrogonida (Høeg & Lützen 1985) to Akentrogonida (Glenner & Hensgaard 2006) and back again (Rybakov & Høeg 2013). Most recently, Høeg et al. (2019) used molecular data to show that the suborders Kentrogonida and Akentrogonida are polyphyletic and supported the conclusion that *Parthenopea* represents a distinct family (Parthenopeidae) sister to Sacculinidae.

Materials and Methods

Line drawings were made with a camera lucida drawing tube attached to Olympus compound or dissecting microscopes. Final images were created by tracing a scanned copy of the original sketch with a Wacom Cintiq pen display using Adobe Illustrator. In addition to conventional light micrographs, the externa was imaged with a Macropod Pro kit (MacroscopicSolutions), resulting pictures were aligned and stacked with the focus stacking software Zerene Stacker (10–65 images from bottom to top of specimens), and lighting adjusted with Adobe Photoshop.

Carapace length (CL) of the host was measured from the tip of the rostrum to the midpoint of the posterior concavity. Rhizocephalan size is given as maximum length (L; from base of attachment stalk to opposite margin of externa) and maximum width (W; at approximately the mid-point of the externa). Host and rhizocephalan externa measurements were made to 0.1 mm using an ocular micrometer or micro-scale tool (Electron Microscopy Services). Early embryos of the rhizocephalan were traced with a drawing tube attachment and measurements made with Image J software after calibration with a slide micrometer. The host and parasite were borrowed from the National Museum of Natural History, Smithsonian Institution, Washington D.C., USA (USNM). References are provided for authors and dates of parasitic taxa, including higher classifications, but not for those of hosts. This work has been registered in ZooBank with the registration number urn:lsid:zoobank.org:pub:90EBD4E7-7236-4EE9-AEA6-E15F5655720B.

Systematic Account

Infraclass Cirripedia Burmeister, 1834
Order Rhizocephala Müller, 1862
Family Parthenopeidae Rybakov & Høeg, 2013
Genus *Parthenopea* Kossmann, 1874
Type species: *Parthenopea subterranea* Kossmann, 1874, by monotypy

***Parthenopea reinhardi* n. sp.**
LSID: urn:lsid:zoobank.org:act:1D8C622C-68A8-47E1-891C-4FFCB592CDD6
Fig. 1

Material examined.—Mature externa (5.8 mm L x 4.6 mm W), emerging from ventral surface of third abdominal somite of male *Nephropsis aculeata* Smith, 1881 (30.7 mm CL incl. rostrum), southwest of Dry Tortugas, Florida, USA, 24°28′N 83°29′W, 212 fms (=387.7 m), 18 June 1956, coll. M/V "Oregon" Sta 1550, (USNM 103737).

Description of holotype.—Externa (Fig. 1A, B) solitary, rounded and slightly compressed laterally, small, slit-like mantle opening situated distally in deep groove on dorsal side; plane of symmetry perpendicular to longitudinal axis of host. Fixed specimen pale yellow. Stalk short and broad. Dorsal and ventral sides of externa subequal in size. Mesentery broad, on dorsal side from mantle opening to base of stalk. Visceral mass subcircular, folded nearly in half, giving the appearance of two lobes (Fig. 1C, D). Colleteric glands (glandular oviducts) oval-shaped in outline, appearing convoluted internally, positioned symmetrically near median of visceral mass (Fig. 1C, D). Seminal receptacles paired (Fig. 1E), separate, symmetrically arranged in visceral mass, cylindrical, slightly curved, tapering gradually toward ducts; ducts distally straight, proximally coiled, opening into mantle cavity on ventral side of the body, near base of stalk (Fig. 1E).

Etymology.—The species is named after Dr. Edward G. Reinhard (1899–1958) in recognition of his contributions to rhizocephalan taxonomy and parasitological research in general (see Reischman, 1958).

Distribution.—Known only from southwest of the Dry Tortugas, Florida, USA, parasitizing *Nephropsis aculeata*.

Remarks.—This parasite was originally identified by E. G. Reinhard circa 1956 (https://collections.nmnh.si.edu/search/iz/?ark=ark:/65665/3747c571052e24e37b688437b6037a6f9) who placed a specimen label in the jar with the host indicating the parasite's identity as "*Danalia* or *Faba*" (Isopoda: Cryptoniscoidea) but it is clearly a rhizocephalan. Reinhard did not examine any of the internal structures and species of *Parthenopea* are odd even by rhizocephalan standards (in terms of orientation of the externa relative to the host; see Rybakov & Høeg 2013) so it is understandable that he erroneously identified the specimen. Although it is possible that the new species described herein belongs to a new genus allied to *Parthenopea*, given the condition of the externa, which is not amenable to more detailed morphological description or molecular study, we prefer to take the conservative approach and place it in the genus with which it shares the most morphological characters.

As with the other two species of *Parthenopea*, the stalk is located medially in the part of the externa facing the host, the mesentery is broad, and the visceral mass appears to form two symmetrical lobes. The colleteric glands, with only slight structural complexity, are also similar to those described for other species of *Parthenopea*. The plane of symmetry is perpendicular to the long axis of the host's body, as seen in the other two species of *Parthenopea*, although some species in Peltogastridae also show this orientation (e.g., species of *Galatheascus* Boschma, 1929 and *Tortugaster* Reinhard, 1948) (Rybakov & Høeg 2013).

Comparisons with the other species of *Parthenopea* are limited by the preservation of the present material, as well as the brevity of the morphological description of *P. australis*. The major difference between the present species and *P. subterranea* is in the shape of the seminal receptacles, which are proximally straight in the type species (Kossmann 1874, Rybakov & Høeg 2013) but coiled in *P. reinhardi* n. sp. Differences between the new species and *P. australis*

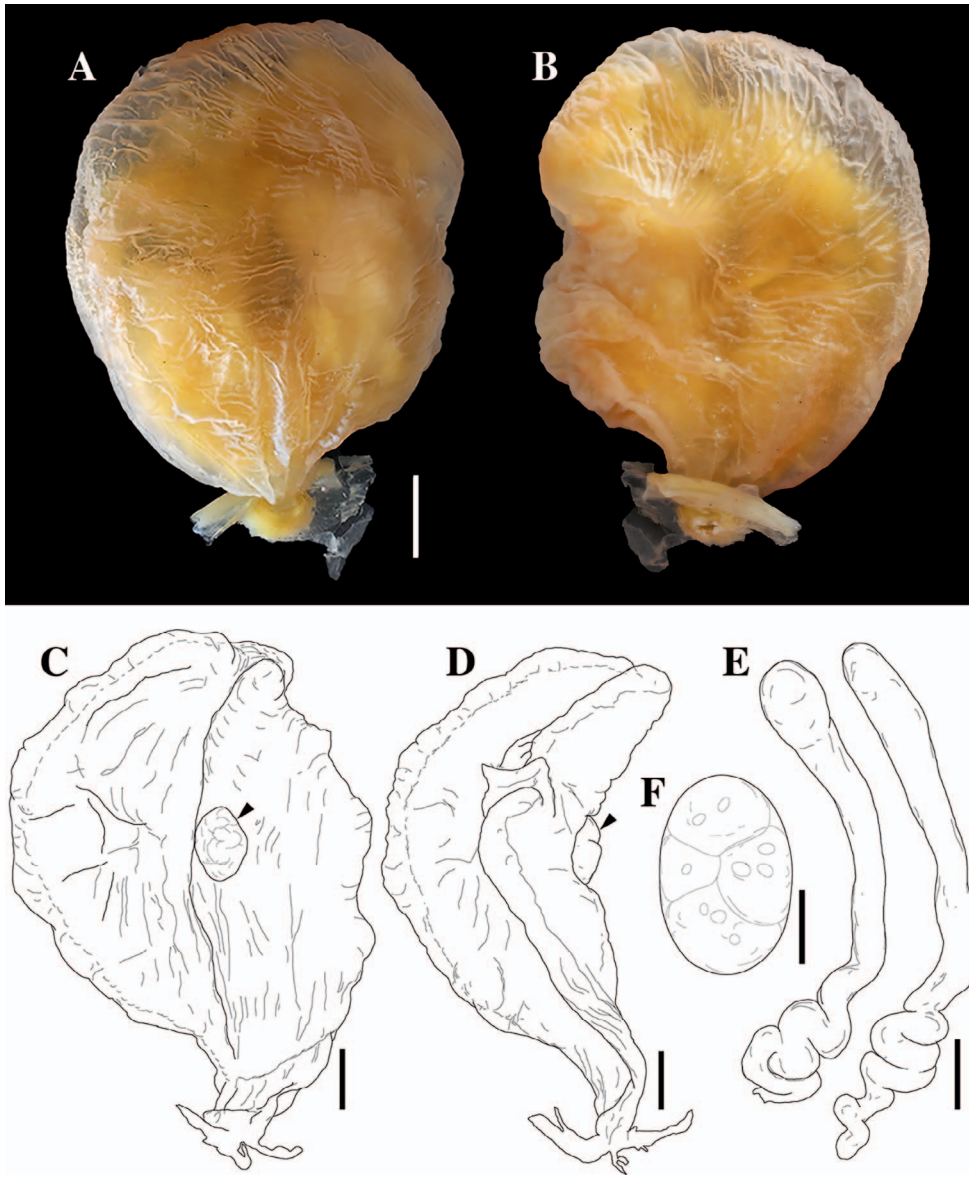

Fig. 1. *Parthenopea reinhardi* n. sp., holotype female (USNM 103737) detached from the host *Nephropsis aculeata*. A, externa, ventral view. B, externa, dorsal view. C, visceral mass, ventral view (arrowhead indicates colleteric gland). D, visceral mass, lateral view (arrowhead indicates colleteric gland). E, seminal receptacles, F, embryo. Scale: A, B, 2.5 mm; C, D, 1 mm; E, F, 0.5 mm.

include the lack of annuli on the stalk in *P. reinhardi* n. sp. (also seen in *P. subterranea*) and the position of the mantle opening (situated in a groove and relatively far from the stalk in *P. reinhardi* n. sp. [also seen in *P. subterranea*] vs. on the surface and relatively close to the stalk in *P. australis*). We recognize that the presence/absence of annuli on the stalk is a dubious character, as these are probably related to the number of molts the externa has undergone. However, Lützen et al. (2009) included this character in their description of *P. australis* so we mention it here as

well, although we do not include this character in the description of the holotype. The structure of the seminal receptacles in *P. australis* is unknown. The few embryos that remained in the externa of *P. reinhardi* n. sp. measured 0.12–0.15 mm (0.14 ± 0.01 mm; n = 30) in length (Fig. 1F) and were in early stages of cleavage.

The present finding expands our understanding of the diversity of hosts utilized by rhizocephalan barnacles. Lobster-like decapods represent a diverse assemblage with an evolutionary history dating back to the Devonian (Bracken-Grissom et al. 2014); however, until the present study, they were not known as hosts for rhizocephalans (Boyko & Williams 2009, Høeg et al., 2019). The suggestion by Boyko & Williams (2009) that "perhaps the nature of their lobster-type morphology and ecology ("lobsterness") is resistant to rhizocephalan invasion" does not hold for all marine lobsters. There is no evidence to suggest that the present finding is an anomaly (the parasite is sexually mature) and there is nothing unique about the ecology or distribution of the host; it is therefore likely that additional overlooked occurrences of rhizocephalans on marine lobsters exist. Because nephropoids are an important fishery worldwide (see Power et al. 2019 and references therein) and have been examined for symbionts (e.g., Shields et al., 2006, Stentiford & Neil 2011), it is surprising they have not previously been recorded as hosts for rhizocephalans. However, parasitized hosts are typically not recognized early in infection, when only the interna is present, or even later on if the externa is incorrectly interpreted as the brood of the host. Therefore, we encourage researchers to examine other groups of marine lobsters that may also be overlooked as hosts for these ecologically important parasites, especially considering that there are some lobster species overlapping geographically with *N. aculeata* that are being examined as a potential fishery (e.g., the Caribbean lobster *Metanephrops binghami* (Boone, 1927); Paramo & Saint-Paul 2012).

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