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# Redescription of the Mediterranean endemic parasitic isopod *Anuropodione amphiandra* (Codreanu, Codreanu & Pike, 1966) n. comb. (Crustacea: Isopoda: Bopyridae) from *Munida rutllanti* Zariquiey Alvarez, 1952, with new records from Turkey and a review of the genus *Anuropodione* Bourdon, 1967

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#### Abstract

Seven species of bopyrid isopods were previously known from Turkish Mediterranean waters; a purported eighth species, *Orthione griffenis* Markham, 2004, is based on incorrect identification and likely represents *Epipenaeon ingens ingens* Nobili, 1906, a species already known from the area. In the present study, we report on specimens referable to *Pleurocrypta amphiandra* Codreanu, Codreanu & Pike, 1966, infesting *Munida rutllanti* Zariquiey Alvarez, 1952, collected from the southern Aegean Sea off Turkey; this species was formerly known only from the Mediterranean off Algeria and the Adriatic Sea. The species is redescribed and illustrated for the first time and transferred to *Anuropodione* Bourdon, 1967, which is reviewed and *A. australiensis* Bourdon, 1976, is transferred to *Allorbimorphus* Bourdon, 1976. A key to all species of *Anuropodione* and a list of all bopyrids found on squat lobsters and porcelain crabs in the Mediterranean are provided.

Keywords: Aegean Sea; boyprid; endemic; Epicaridea; squat lobster; Turkey.

#### Introduction

The parasitic isopod family Bopyridae contains over 600 species (Boyko et al., 2008 onwards), all of which are parasitic on calanoid copepods as larvae and decapod crustaceans as adults (Boyko & Williams 2009; Williams & Boyko 2012). Seven of these species have been reported from Turkish waters in the Mediterranean region: Bopyrina ocellata (Czerniavsky, 1868) from *Hippolyte inermis* Leach, 1816 (Artüz, 2017; Sea of Marmara); Bopyrus squillarum Latreille, 1802, from Palaemon adspersus Rathke, 1837, P. elegans Rathke, 1837, and P. serratus (Pennant, 1777) (Geldiay and Kocataş, 1972; Kırkım et al., 2008); Epipenaeon ingens ingens Nobili, 1906, from Penaeus aztecus Ives, 1891 (a western Atlantic species introduced into the Mediterranean) (Korun et al., 2013): Pleurocrypta galateae Hesse, 1865, from Galathea squamifera Leach, 1814 (Geldiay and Kocataş, 1972); P. longibranchiata (Bate & Westwood, 1867) from Galathea nexa Embleton, 1834, and G. squamifera (Geldiay and Kocataş, 1972; Kırkım et al., 2008); P. microbranchiata G. O. Sars, 1898, from *Galathea intermedia* Lilljeborg, 1851 (Geldiay and Kocataş, 1972; Kırkım et al., 2008);

*P. porcellanaelongicornis* Hesse, 1876, from *Pisidia* cf. *bluteli* (Risso, 1816) and *Pisidia* sp. (Geldiay and Kocataş, 1972; Kırkım *et al.*, 2008).

Mediterranean records of a purported eighth species of bopyrid, Orthione griffenis Markham, 2004, found infesting Penaeus kerathurus (Forskål, 1775) (Uluköy et al., 2008, cited by Ceyhan et al., 2009) are obvious misidentifications. Although Orthione griffenis has been documented as an invasive species in mud shrimp (Decapoda: Gebiidea) along the west coast of the US (Williams & An 2009; Hong et al., 2015; Boyko et al., 2017), no species of Orthione infest penaeid shrimp (Markham, 2004). It is most likely that these bopyrids are actually Epipenaeon ingens ingens Nobili, 1906, originally described from the Red Sea but which entered the Mediterranean before 1968 and was first reported from Turkey on the host P. semisulcatus De Haan, 1844 (Bourdon, 1968; An et al., 2014). This bopyrid is now also known in the Mediterranean from the introduced shrimp hosts P. aztecus and P. stylirostris (Stimpson, 1871) (Korun et al., 2013; An et al., 2014). Owens and Rothlisberg (1991) suggested that *E. ingens ingens* might eventually infest the Mediterranean endemic host P. kerathurus and this

prediction appears to have been born out; this is the first record of *E. ingens ingens* on any Mediterranean endemic shrimp host.

The squat lobster *Munida rutllanti* Zariquiey Alvarez, 1952, lives on muddy bottoms in depths between 130 and 540 m and is historically distributed in the eastern Atlantic from northwestern Spain south to Mauritania, including the Canary and Cape Verde Islands, as well as in the western Mediterranean and Aegean Sea (Fransen, 2014). However, the species has spread eastward into the eastern Mediterranean and the Adriatic Sea (Froglia *et al.*, 2010; Petric *et al.*, 2010). *Munida rutllanti* has potential as a fishery due to its relatively large size (carapace length, excluding rostrum, up to 22 mm) and ability to be caught in large quantities (Kocak *et al.*, 2008; Froglia *et al.*, 2010; Fransen, 2014) but does not currently have commercial value and is not a target species (Kocak *et al.*, 2008).

Four squat lobster species in the genus *Munida* Leach, 1820 (*M. intermedia* A. Milne Edwards & Bouvier, 1899, *M. rugosa* (Fabricus, 1775), *M. rutllanti*, and *M. tenuimana* G. O. Sars, 1872) have been reported from Turkish waters (Bakır *et al.*, 2014), all of which have been recorded bearing bopyrids elsewhere in the Mediterranean (Table 1) but no bopyrids have previously been reported on any Turkish specimens belonging to these species of *Munida*. Three species of *Pleurocrypta* have been reported from squat lobster hosts collected off Turkey, but all were on hosts in the genus *Galathea* Fabricius, 1793 (Galatheidae) (Table 1; see also Boyko *et al.*, 2012; Bakir *et al.*, 2014).

The present paper reports for the first time the presence of *Anuropodione amphiandra* (Codreanu, Codreanu & Pike, 1966) n. comb., parasitic on *M. rutllanti* from Turkish waters. Examination of a large series of specimens allowed us to determine that this species does not belong to *Pleurocrypta* Hesse, 1865, the genus to which it was originally assigned, and to quantify the variability in the pleon morphology of males.

# **Material and Methods**

Squat lobsters were collected at depths from 60 to 400 m with a commercially used bottom trawl (mesh size: 44 mm; time of haul period: 08:00-12:00 and 13:00-17:00; engine power of the commercial trawler: 700 hp; bottom type: muddy), off Babakale Port, North Aegean Sea, Turkey (39°25'2.32"N-39°28'11"N; 26°03'39.46"E-26°20'18"E) in March 2017 (93 specimens) and August 2018 (150 specimens).

Hosts and parasites were placed in 70% ethanol and parasites were subsequently removed from the host branchial chambers; male parasites were firmly attached to the ventral pleon region of females in all cases. Select parasites were dissected using a Wild M5 and an Olympus XZS12 stereomicroscope. Dissected parts were mounted

**Table 1.** List of bopyrid species known from squat lobsters and porcelain crabs (Anomura: Galatheoidea) in the Mediterranean Sea.

Bopyrid Species	Hosts	Mediterannean Localities	References Codreanu, Codreanu & Pike, 1966; Petric <i>et al.</i> , 2010	
<i>Anuropodione amphiandra</i> (Codreanu, Codreanu & Pike, 1966) n. comb.	Munida rutllanti Zariquiey Álva- rez, 1952	Algeria; Adriatic Sea		
Pleurocrypta galateae Hesse, 1865	Galathea dispersa Bate, 1859 Galathea nexa Embleton, 1834 Galathea squamifera Leach, 1814	France, Monaco, Turkey	Bourdon, 1968; Geldiay & Kocataş, 1972	
Pleurocrypta longibranchiata (Bate & Westwood, 1867)	<i>Galathea nexa</i> Embleton, 1834; <i>Galathea squamifera</i> Leach, 1814	France, Turkey	Geldiay & Kocataş, 1972	
Pleurocrypta microbranchiata G. O. Sars, 1898	Galathea intermedia Lilljeborg, 1851	Spain, Turkey	Bourdon, 1968; Geldiay & Kocataş, 1972	
Pleurocrypta piriformis Bour- don, 1968	Galathea strigosa (Linnaeus, 1761)	Spain	Bourdon, 1968	
Pleurocrypta porcellanaelongi- cornis Hesse, 1876	Pisidia longicornis (Linnaeus, 1767)	Turkey	Geldiay & Kocataş, 1972	
Pleurocrypta strigosa Bourdon, 1968	Galathea strigosa (Linnaeus, 1761)	Spain, Italy	Bourdon, 1968	
<i>Pseudione crenulata</i> G. O. Sars, 1898	Munida intermedia A Milne Edwards & Bouvier, 1899 Munida rugosa (Fabricius, 1775) Munida tenuimana G. O. Sars, 1872	Spain, Italy	Zariquiey Alvarez, 1958; Castriota <i>et al.</i> , 2010	

on slides in glycerine-gelatine mounting medium; pleopods were stained with methylene blue. 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, some specimens were imaged with a Macropod Pro kit (MacroscopicSolutions) and resulting pictures were aligned and stacked with the focus stacking software Zerene Stacker (10–65 images from bottom to top of specimens).

Carapace length (CL, inclusive of rostrum) is provided as an indicator of size for the hosts. Isopod size is given as total body length (anterior margin of head to posterior margin of pleotelson). Measurements were made to 0.1 mm using an ocular micrometer, micro-scale tool (Electron Microscopy Services), or a micrometric programme (Pro-way).

Authors and dates of hosts and bopyrid parasites were verified using WoRMS (Boyko *et al.*, 2008 onwards). Bibliographic references are provided for authors and dates of all parasite taxa but not for those of host species.

Voucher specimens were deposited in the collections of the Muséum National d'Histoire Naturelle (MNHN) and the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM).

# Results

**Systematics** 

Family Bopyridae Rafinesque, 1815 Subfamily Pseudioninae Codreanu, 1967 Genus *Anuropodione* Bourdon, 1967 Type species: *Anuropodione senegalensis* Bourdon, 1967

### Remarks

Prior to the present study, Anuropodione contained five species (Boyko et al., 2008 onwards) but a review of these taxa shows that A. australiensis Bourdon, 1976, is not properly placed in this genus, A. dubius (Nierstrasz & Brender à Brandis, 1929) is questionably placed here, and Pleurocrypta amphiandra should be transferred to Anuropodione. Examination of the description and illustrations of A. australiensis shows that this species is not correctly generically placed. The minimal development of the lateral plates on the pleon, expanded posterior lobe with acute ventral point on the first oostegite of the female, as well as the rounded, extended head and weakly projecting pleotelson and overall body proportions of the male indicate that this species is not congeneric with A. senegalensis Bourdon, 1967, the type species of Anuropodione. In many characters, A. australiensis is closer to Allorbimorphus haigae Bourdon, 1976, but it differs from that species in the females of A. haigae having only four pairs of biramous pleopods (four pairs biramous pleopods, fifth pair uniramous in *A. australiensis*), uniramous uropods (no uropods in *A. australiensis*), and in males of *A. haigae* having all pleomeres distinct (1-3 pleomeres in *A. australiensis*). It is possible that *A. australiensis* should be placed in a new genus, but we refrain from such an action in the absence of material; however, we transfer the species to *Allorbimorphus* Bourdon, 1976, the genus to with which it shares most characters, as *Allorbimorphus australiensis* (Bourdon, 1976) n. comb.

It is unclear if A. dubius is correctly placed in this genus. The female shows essentially no lateral plate development on the pleomeres compared to other species of Anuropodione and there are 5 uniramous pleopods, which contrasts with the typical 5 biramous pairs in species of Anuropodione (excepting A. megacephalon, which has 4 biramous and 1 uniramous pair). However, the pleon of the male greatly resembles that of one of the morphs found in A. amphiandra and the morphology of the first oostegite and maxilliped (see Bourdon, 1972) are very similar to those of other Anuropodione species. Bourdon (1972) compared Probopyrus dubius, which was clearly not correctly placed in Probopyrus Giard & Bonnier, 1888, to all other species known where females lacked uropods: Parioninella obovata Shiino, 1958 (now Ovoionella obovata (Shiino, 1958); see Boyko, 2004)), A. senegalensis, and Bopyrissa magellanica (Nierstrasz & Brender à Brandis, 1929) and concluded that the male and female of *P. dubius* resembled those of *A. senegalensis* more than the other species. We concur with Bourdon's (1972) conclusion, inasmuch as the male of O. obovata is very different from that of *P. dubius* and the female of *B*. magellanica actually does have well-developed uropods, a fact not known to Bourdon (1972; see Williams et al., submitted). Unfortunately, it will be difficult to recollect A. dubius and garner a larger sample size, as the host was only given by Nierstrasz & Brender à Brandis (1929) as "Galathea spec."

*Pleurocrypta amphiandra* Codreanu, Codreanu & Pike, 1966, belongs to *Anuropodione* on the basis of the females lacking well-developed uropods as well as maxilliped palps. Females of *Pleurocrypta* always have well-developed uropods (uniramous or biramous, depending on the species) and maxilliped palps. Codreanu *et al.* (1966) described the pleotelson of *Pleurocrypta amphiandra* as bearing "exceptionnellement des uropodes rudimentaires"; in all specimens we examined, there are small ridges on the pleotelson but they are not true uropods. Bourdon (1972), however, did report very small, poorly developed uropods on some specimens of *A. senegalensis*.

# Key to species of *Anuropodione* Bourdon, 1967, based on females

1a. Lateral plates of pleon weakly developed, closely adpressed ... A. dubius (Nierstrasz & Brender à Brandis, 1929) [Thailand, 27.4 m depth, infesting "Galathea sp."]

1b. Lateral plates of pleon forming distinct lateral ex-

tensions, not closely adpressed ... 2

2a. Head length greater than that of first four pereomeres combined ... *A. megacephalon* Markham, 1974 [28°48'N; 85°02'W, Gulf of Mexico, 54-60 m depth, infesting *Munida pusilla* Benedict, 1902]

2b. Head length less than that of first four percomeres combined  $\dots$  3

3a. Lateral plates of pleon thin, tapered distally ... *A. carolinensis* Markham, 1974 [35°05'N 74°33'W to 37°09'N 75°11.5'W, 83-662 m depth, infesting *Munida iris* A. Milne Edwards, 1880]

3b. Lateral plates of pleon expanded distally, ovate ... 4

4a. Lateral plates of pleon non-overlapping ... *A. senegalensis* Bourdon, 1967 [Senegal to Republic of the Congo, 200-300 m depth, infesting *Munida* sp. and *M. speciosa* von Martens, 1878]

4b. Lateral plates of pleon overlapping ... *A. amphiandra* (Codreanu, Codreanu & Pike, 1966) n. comb. [Mediterranean Sea: Algeria to Turkey; Adriatic Sea, 60-400 m depth, infesting *Munida rutllanti* Zariquiey Alvarez, 1952].



# Anuropodione amphiandra (Codreanu, Codreanu & Pike, 1966) n. comb. (Figs. 1-4)

*Pleurocrypta* sp. Délye, 1955: 84 [Béni-Saf, west of Oran, Algeria, infesting *Munida iris* ssp. *ruttlandi* [*sic*] = *M. rutllanti*]; Petric *et al.*, 2010: 1395-1403, fig. 7a [Adriatic Sea, infesting *M. rutllanti*].

"un bopírido sp.?" Zariquiey Alvarez, 1958: 101 [mention].

*Pleurocrypta amphiandra* Codreanu, Codreanu & Pike, 1966: 1071-1072 [type locality: Béni-Saf, west of Oran, Algeria, 205-230 m; type host: *Munida iris rutllanti* Zariquiey Alvarez, 1952 = *M. rutllanti*]; Markham, 1974: 270 [mention], 271 [table], 265 [list]; Bourdon, 1976: 366 [mention]; Boyko & Williams, 2011: 285 [mention]; Boyko *et al.*, 2012: 9, 18 [list].

"le Bopyridae des *Munida iris rutlanti* [sic] Zariquiey Alvarez des côtes algériennes" Bourdon, 1968: 221 [mention].

"parasite (non encore décrit à notre connaissance) des Munida iris rutlanti [sic]" Bourdon, 1972: 833 [mention].

## Material examined and used as basis for redescription

1 dextral ovigerous female (5.5 mm), 1 mature male (1.6 mm, pleon elongate with 3 pleomeres) from right branchial chamber of unknown sex and size *Munida rutllanti* Zariquiey Alvarez, 1952, off Babakale Port (39°25'2.32"N-39°28'11"N; 26°03'39.46"E-26°20'78"E, North Aegean Sea, Turkey)



*Fig. 1: Munida rutllanti* Zariquiey Alvarez, 1952, dorsal view of male specimen (USNM 1492241) with swollen right branchial chamber caused by *Anuropodione amphiandra* (Codreanu, Codreanu & Pike, 1966) n. comb. Scale bar = 3 mm.

*Fig. 2:* Anuropodione amphiandra (Codreanu, Codreanu & Pike, 1966) n. comb., female specimen USNM 1492250 (A-I). A, dorsal view. B, ventral view. C, right antennule (top) and antenna (bottom). D, left barbula. E, left maxilliped, outer view. F, left oostegite 1, outer view. G, left oostegite 1, inner view. H, left pereopod 1. I, left pereopod 7. Scale bars = 2 mm (A, B), 250  $\mu$ m (C, D, H), 500  $\mu$ m (E-G, I).





*Fig. 3:* Anuropodione amphiandra (Codreanu, Codreanu & Pike, 1966) n. comb., female specimen USNM 1492250 (A), personal collection (B-M). A, Pleon, dorsal view, B-F, pleopods 1-5, respectively, G-M, pereopods 1-7, respectively. Scale bars =  $500 \ \mu m$  (A), 1 mm (B-F), 250  $\mu m$  (G-M).

in March 2017 or August 2018 (USNM 1492241; Fig. 1) (all other specimens cited below with same collection data); 1 dextral ovigerous female (8.6 mm), 1 mature male (4.8 mm, pleon elongate with 5 pleomeres), from right branchial chamber of unknown sex and size M. rutllanti (USNM 1492244); 1 dextral ovigerous female (7.5 mm), 1 mature male (1.7 mm, pleon short with all pleomeres coalesced), from right branchial chamber of unknown sex and size M. rutllanti (USNM 1492250); 1 sinistral ovigerous female (7.0 mm), 1 mature male (pleon elongate with 5 pleomeres), from left branchial chamber of unknown sex and size M. rutllanti (USNM 1492279); 1 dextral ovigerous female (5.5 mm), 1 mature male (pleon short with all pleomeres coalesced), from right branchial chamber of male M. rutllanti (15 mm CL) (USNM 1492233); 1 dextral ovigerous female (7.3 mm), infesting unknown size and sex M. rutllanti (MNHN-IU-2017-72).

## Additional material examined

All specimens with same collection data as USNM 1492241: 1 sinistral ovigerous female (6.48 mm), 1 mature male (1.85 mm), infesting left branchial chamber of female *M. rutllanti* (36 mm CL); 1 sinistral ovigerous female (6.89 mm), 1 mature male (1.24 mm), infesting left branchial chamber of female *M. rutllanti* (37 mm CL); 1

*Fig. 4: Anuropodione amphiandra* (Codreanu, Codreanu & Pike, 1966) n. comb., male specimens USNM 1492250 (A-D), USNM 1492279 (E), USNM 1492241 (F). A, dorsal view. B, ventral view. C, mouthparts, left antennule (top), left antenna (bottom) and left pereopod 1. D, left pereopod 7. E, pleon with 5 segments. F, pleon with 3 segments. Scale bars =  $250 \mu m$  (A, B, E, F),  $50 \mu m$  (C, D).

dextral ovigerous female (6.94 mm), 1 mature male (1.57 mm), infesting right branchial chamber of female M. rutllanti (39 mm CL); 1 sinistral ovigerous female (7.09 mm), 1 mature male (1.28 mm), infesting left branchial chamber of female M. rutllanti (39 mm CL); 1 dextral ovigerous female (6.94 mm), 1 mature male (1.57), infesting right branchial chamber of female M. rutllanti (39 mm CL); 1 dextral ovigerous female (7.01 mm), 1 mature male (1.49 mm), infesting right branchial chamber of female M. rutllanti (39 mm CL); 1 dextral ovigerous female (7.65 mm), 1 mature male (1.76 mm), infesting right branchial chamber of female M. rutllanti (40 mm CL); 1 sinistral ovigerous female (7.09 mm), 1 mature male (1.72 mm), infesting left branchial chamber of female M. rutllanti (40 mm CL); 1 sinistral ovigerous female (7.47 mm), 1 mature male (1.56 mm), infesting left branchial chamber of female *M. rutllanti* (41 mm CL); 1 sinistral ovigerous female (7.22 mm), 1 mature male (2.47 mm), infesting left branchial chamber of female M. rutllanti (41 mm CL); 1 sinistral ovigerous female (7.29 mm), 1 mature male (2.65 mm), infesting left branchial chamber of female M. rutllanti (41 mm CL); 1 dextral ovigerous female (7.24 mm), 1 mature male (3.63 mm), infesting right branchial chamber of female M. rutllanti (42 mm CL); 1 sinistral ovigerous female (7.74 mm), 1 mature male (1.82 mm), infesting left branchial chamber of female M. rutllanti (42 mm CL); 1 sinistral ovigerous female (7.87 mm), 1 mature male (1.74 mm), infesting left branchial chamber of female M. rutllanti (42 mm CL); 1 sinistral ovigerous female (7.96 mm), 1 mature male (2.10 mm), infesting left branchial chamber of female M. rutllanti (42 mm CL); 1 sinistral ovigerous female (6.65 mm), 1 mature male (2.31 mm), infesting left branchial chamber of female M. rutllanti (43 mm CL); 1 dextral ovigerous female (7.63 mm), 1 mature male (1.64 mm), infesting right branchial chamber of female M. rutllanti (43 mm CL); 1 sinistral ovigerous female (7.90 mm), 1 mature male (1.89 mm), infesting left branchial chamber of female M. rutllanti (44 mm CL); 1 sinistral ovigerous female (8.02 mm), 1 mature male (1.51 mm), infesting left branchial chamber of female M. rutllanti (45 mm CL); 1 sinistral ovigerous female (7.68 mm), 1 mature male (1.69 mm), infesting left branchial chamber of female M. rutllanti (45 mm CL); 1 dextral ovigerous female (7.67 mm), 1 mature male (2.99 mm), infesting right branchial chamber of female M. rutllanti (45 mm CL); 1 dextral ovigerous female (8.15 mm), 1 mature male (1.87 mm), infesting right branchial chamber of female M. rutllanti (46 mm CL); 1 sinistral ovigerous female (8.42 mm), 1 mature male (1.54 mm), infesting left branchial chamber of female *M. rutllanti* (47 mm CL); 1 sinistral ovigerous female (8.34 mm), 1 mature male (2.19 mm), infesting left branchial chamber of female M. rutllanti (50 mm CL); 1 sinistral ovigerous female (8.30 mm), 1 mature male (1.98 mm), infesting left branchial chamber of female M. rutllanti (52 mm CL).

# Additional hosts examined

All specimens with same collection data as USNM 1492241: 1 female *M. rutllanti* (16 mm CL), with swollen left branchial chamber (parasite not present) (USNM 1492232); 1 male *M. rutllanti* (22.4 mm CL), with swollen right branchial chamber (parasite not present); host also infested with immature *Lernaeodiscus ingolfi* (1.0 x 2.5 cm) (see Remarks) (USNM 1492232).

# Redescription

Female (based on USNM 1492250): body length 8.9 mm, maximal width 6.1 mm, head length 1.8 mm, head width 2.6 mm, pleon length, 2.7 mm. Head dextrally deflexed with  $\sim 10^{\circ}$  distortion angle. Body broad anteriorly, tapered posteriorly, all body regions and segments distinct (Fig. 2A, B). Head large, subovate, moderately set into pereon; frontal lamina broad, posterior margin with small median projection (Fig. 2A); eyes absent. Antennules and antennae of 3 articles each, with setae at distal tip of distal segment of both; antennae with basal segment greatly expanded, approximately 3x width of second segment (Fig. 2C). Maxilliped with short, acute spur, palp absent or as a low non-articulated lobe with few marginal setae,

no setae on margins (Fig. 2E). Barbula with two short, smooth, falcate lateral projections with tapered tips; median region smooth (Fig. 2D). Oostegite surfaces smooth, completely enclosing brood chamber; setae on posterior margin of fifth oostegite (Fig. 2B); oostegite 1 with ovate anterior lobe, narrow triangular posterior lobe with short, rounded, posterolateral extension (Fig. 2F); inner ridge of oostegite 1 with numerous low digitate projections (Fig. 2G). Pereon of 7 distinct pereomeres, broadest across pereomere 3, tapering gently towards head, markedly towards pleon. Prominent coxal plates on percomeres 1-7, those on 1-4 elongate, recurved ovals, those on 5-7 as posteriorly expanded flattened plates, flat on longer side of body, curled on shorter side of body; elongate, ovate dorsolateral bosses on percomeres 1-4, smaller than corresponding coxal plates (Fig. 2A). Tergal projections absent. Pereopods subequal in size, each with large smoothedged lobe projecting from dorsal surface of basis, size of basal lobe increasing on posterior pereopods, surface of lobe with minute scales; percopods 1-3 spaced apart, 4-7 spaced closely together (Figs. 2H, I, 3G-M). Pleon of 6 distinct pleomeres, first 5 pleonal segments with lateral plates expanded posteriorly and overlapping from pleomeres 1-5 (Figs. 2A, 3A). Five pairs of biramous pleopods, visible in dorsal view, posteriorly extending well beyond margins of lateral plates; anterior pairs triangular, posterior pairs more elongate and tapered distally, all margins smooth (Figs. 2A, B, 3A-F); pleomere 6 lacking uropods (Figs. 2A, 3A).

Male (based on USNM 1492241, 1492250, 1492279): length 1.8 mm, maximal width 0.8 mm at percomere 4, head length 0.3 mm, head width 0.5 mm, pleon length 0.5 mm. Head subovate, distinct from percomere 1, all body segments distinct (Fig. 4A); prominent eyes on posterolateral border of head (Fig. 4A). Antennules of 3 articles each, setae on distal tip of article 3, setae subterminally on other articles (Fig. 4C); antennae of 4 articles each, tuft of setae on distal tip of terminal article (Fig. 4C). Pereon of 7 distinct percomeres, broadest across percomeres 3-5, tapering slightly anteriorly and posteriorly. Pereopods subequal in size, all articles distinct; dactyli of pereopods 1-3 proportionally longer than those of 4-7, propodi with ridges of scales on anterior portion underneath dactyl, tuft of setae on anterior tip of propodi opposed to tip of dactyli (Fig. 4C, D), meri and carpi slightly larger in posterior pairs. Pleon variable, ranging from one large, triangular, posteriorly tapered segment (Fig. 4A) with faint lateral undulations to 3 distinct segments (2 narrow pleomeres plus a globose pleotelson; Fig. 4F) or 5 distinct segments (4 narrow pleomeres plus elongate pleotelson showing lateral constriction; Fig. 4E). Midventral tubercles, pleopods and uropods absent; anal cone present but not projecting (Fig. 4B, E, F).

# Variation

Females occur in both dextral and sinistral forms in approximately equal numbers ( $\sim 40\%$  dextral vs.  $\sim 60\%$ 

Species	Number	r of Pleomere	Reference(s)			
A. amphiandra n. comb.	1 (29)	2 (2)	3 (1)	5 (4***)	6 (3)	Codreanu <i>et al.</i> , 1966; Pres- ent Study
A. australiensis	1 (1)		3 (1)			Bourdon, 1976
A. carolinensis	1 (147*)		3 (2)		6 (38)	Markham, 1974; Wenner & Windsor, 1979
A. dubius				5 (1)		Nierstrasz & Brender à Bran- dis, 1929; Bourdon, 1972
A. megacephalon	1 (1**)					Markham, 1974
A. senegalensis	1 (7***)	2 (2***)		5 (3***)		Bourdon, 1967; Bourdon, 1972

Table 2. Known variation in the number pleomeres for males of species in Anuropodione Bourdon, 1967.

\* 93 males with 1 pleomere but with lateral undulations suggesting incipient segmentation.

\*\* Terminal segment with dorsal indications of 3 coalesced pleomeres.

\*\*\* Terminal pleomere with lateral undulations suggesting coalesced pleomeres.

sinistral). Male pleon morphology is highly variable (see redescription above); a similar level of variation was noted by Codreanu *et al.* (1966) for this species and is known across the genus as a whole (Table 2).

### Ecology

The rate of parasitism by *A. amphiandra* on *M. rutllanti* is relatively high compared to what is known for most bopyrid species (~1-5%; Cericola & Williams, 2015). At least 9 of the 93 squat lobsters (~9.7%) collected in March 2017 bore bopyrids and at least 16 of the 150 hosts (~10.7%) collected in August 2018 contained *A. amphiandra* (these prevalences are conservative estimates because six additional parasitized hosts were collected but not assignable to a specific collecting date). All of the hosts were female, except for a single male that was co-infested with a rhizocephalan.

## Remarks

Codreanu *et al.* (1966) reported that, of their nine males examined, four had all pleomeres fused into a single segment, two had two segments, and three had six segments and an overall elongate pleon. We found males with one, three, and five pleonal segments in the present material (Table 2). Codreanu *et al.* (1966) also described the pereomeres of the males as having "finement spinuleux" but these are merely small setae.

Codreanu *et al.* (1966) interpreted the variation in the number of pleomere segments as a response by males to incomplete inhibition of pleomere development by some kind of chemical secretion exuded by the female bopyrids. They labeled the males as being "néoténiques" but as that term specifically refers to the retention of larval features in the adult, they applied it incorrectly in this situation. The assumption that male bopyrids are in some way prevented from transitioning from the male to female phase by the influence of females already present in or on the host has been mentioned in the literature (summarized in Trilles, 1999) but the mechanism is unknown and there are few studies which have experimentally demonstrated that it occurs (see Reverberi & Pitotti, 1943; Reverberi, 1947; Reinhard, 1949). Reinhard (1949) dealt with the transformation of cryptoniscus larvae, so the only studies that have shown males transforming into females are those on Ione thoracica Montagu, 1808 (Reverberi & Pitotti, 1943; Reverberi, 1947) and in this species the pleomeres of males are quite similar morphologically to those of the female and not variable in the number of segments, unlike in the present case with Anuropodione or with species of Pleurocrypta (Bourdon, 1965). In fact, in the case of the observed variability in the number of pleomeres of males in species of Anuropodione, it is unlikely that a male to female transition is occurring because if the male with one pleomere was transitioning to six pleomeres (the number possessed by the females), then that would mean the cryptoniscus larvae had all their pleomeres fused and subsequently separated again, a seemingly non-parsimonious developmental trajectory. The converse situation, that a male with six segments will transition to a male with one segment is also not probable, as females consistently present six pleomeres. It is more likely that in all species of Anuropodione, as with species of Pleurocrypta, the number of pleomeres of males is a polymorphic character lacking an evolutionary pressure for fixation at a particular number of segments. These genera provide an opportunity to test this hypothesis and examine the underlying genetic controls of the segmentation process.

One host (USNM 1492232) was doubly infested by A.

amphiandra n. comb. and an immature specimen of Lernaeodiscus cf. ingolfi Boschma, 1928. There is one prior record of a species of Lernaeodiscus on a M. rutllanti host, collected in the Ionian Sea (Øksnebjerg, 2000, who recorded the parasite as L. ingolfi and the host variously as Munida iris, M. iris ssp. ruttllanti [sic], and M. iris ssp. ruttlanti [sic]). However, because the host examined by Øksnebjerg (2000) bore a dried externa and the present specimen is immature, it is not certain that M. rutllanti hosts true L. ingolfi.

Petric *et al.* (2010) incorrectly stated that *M. rutllanti* was parasitized by two species of bopyrids: *Pleurocryp-ta amphiandra* (which they incorrectly credited Délye, 1955, with authorship of the species) and *P. intermedia* Bonnier, 1900 (which they incorrectly credited Codreanu *et al.*, 1966, with authorship and which is a synonym of *P. microbranchiata* G. O. Sars, 1898). *Pleurocrypta microbranchiata* has never been reported from *M. rutllanti*.

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