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EMANUELLY PAULINY MODESTO DOS SANTOS

Taxonomia e biologia de Bopyridae (Isopoda: Epicaridea) associados a camarões-pistola (Decapoda: Caridea: Alpheidae) em regiões estuarinas e praias rochosas de Pernambuco, Brasil

Recife
2025

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Dissertação apresentada ao Programa de Pós-Graduação em Oceanografia da Universidade Federal de Pernambuco, como requisito parcial para obtenção do título de mestre(a) em Oceanografia.

Orientador(a): Prof. Dr. Jesser Fidelis de Souza Filho

Coorientador(a): Prof. Dr. Felipe Bezerra Ribeiro

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RESUMO

Este estudo investiga isópodes parasitos da família Bopyridae infestando camarões da família Alpheidae em ambientes estuarinos e praias rochosas de Pernambuco, Brasil. As coletas foram realizadas entre 2017 e 2023 em planícies de mangue do Rio Massangana e Barra de Catuama; na Praia do Paraíso em Suape e na praia de Carneiros em Tamandaré. No total 1.722 espécimes de camarões foram coletados: 1.362 *Alpheus estuariensis*, 353 *Salmoneus carvachoi*, 3 *Alpheus formosus* e 1 *Alpheus carlae*. Dentre estes, 13 *A. estuariensis*, 5 *S. carvachoi* e todos os *A. formosus* e *A. carlae* estavam infestados com parasitos na branquia. Os parasitos foram cuidadosamente isolados, etiquetados e submetidos a análises morfológicas. Foram registradas medições do comprimento total dos parasitas e do comprimento da carapaça de seus respectivos hospedeiros. As fotografias foram realizadas utilizando um estereomicroscópio Leica, com posterior edição das imagens no software Photoshop CS6. As ilustrações dos parasitas foram elaboradas com o auxílio de uma câmera clara acoplada a um estereomicroscópio Leica DME e posteriormente vetorizadas no software CorelDRAW. A identificação taxonômica foi realizada com base nas chaves dicotômicas mais atualizadas disponíveis na literatura, bem como na revisão das descrições originais dos táxons identificados. Utilizamos a prevalência para inferir a porcentagem de parasitismo na população de *A. estuariensis* e *S. carvachoi*. Com a regressão linear e ANOVA, comparamos o tamanho dos parasitos fêmeas e carapaça dos hospedeiros, para verificar se há diferença no crescimento dos camarões. Para comparar a quantidade de ovos das populações parasitadas e não parasitadas utilizamos o teste de Kruskal-Wallis. As análises taxonômicas resultaram no primeiro registro de ocorrência de *Parabobyrella richardsonae* no Brasil, parasitando *A. estuariensis* e *S. carvachoi* em ambientes estuarinos e *A. formosus* em habitats de praia rochosa. Além disso, foram observadas possíveis alterações nas interações biológicas entre *A. estuariensis* e *P. richardsonae*. O estudo também descreve uma nova espécie do gênero *Ovobopyrus* Markham, 1985, encontrada parasitando *A. carlae*. Essa descoberta representa a segunda espécie do gênero no mundo e o primeiro registro do gênero no Brasil. A fêmea adulta de *Ovobopyrus* sp. nov. é caracterizada pela presença de pequenas projeções anterolaterais na cabeça; antênula com três artículos; maxilípede subquadrado com palpo não articulado, apresentando nove cerdas simples e longas; oostegito 1 com crista interna sinuosa contendo cinco pequenos lóbulos; carpo dos pereópodos com tufos de cerdas distais; e pleômero terminal bilobado. Além disso, são fornecidas chaves dicotômicas para os gêneros de Bopyrinae no Brasil, uma chave de identificação para as espécies de *Ovobopyrus* e uma chave para as espécies de *Parabopyrella* registradas no Brasil.

Palavras-chave: Alpheidae; Bopyridae; Distribuição; Parasita; Taxonomia.

ABSTRACT

This study investigates parasitic isopods of the family Bopyridae infesting shrimps of the family Alpheidae in estuarine environments and rocky beaches of Pernambuco, Brazil. Specimen collections were conducted between 2017 and 2023 in mangrove plains of the Massangana River and Barra de Catuama; at Paraíso Beach in Suape and Carneiros Beach in Tamandaré. A total of 1,722 shrimp specimens were collected: 1,362 *Alpheus estuariensis*, 353 *Salmoneus carvachoi*, 3 *Alpheus formosus*, and 1 *Alpheus carlae*. Among these, 13 *A. estuariensis*, 5 *S. carvachoi*, and all *A. formosus* and *A. carlae* individuals were found to be infested with branchial parasites. The parasites were carefully isolated, labeled, and subjected to morphological analyses. Measurements of both the total length of the parasites and the carapace length of their respective hosts were recorded. Photographs were taken using a Leica stereomicroscope, with subsequent image editing performed in Photoshop CS6. Parasite illustrations were created with the aid of a camera lucida attached to a Leica DME stereomicroscope and later vectorized using CorelDRAW. Taxonomic identification was carried out based on the most up-to-date dichotomous keys available in the literature, as well as a review of the original descriptions of the identified taxa. Prevalence analysis was used to infer the percentage of parasitism in the *A. estuariensis* and *S. carvachoi* populations. Linear regression and ANOVA were applied to compare the sizes of female parasites and host carapaces, aiming to assess whether parasitism influences shrimp growth. To compare the number of eggs in parasitized and non-parasitized populations, the Kruskal-Wallis test was employed. Taxonomic analyses resulted in the first recorded occurrence of *Parabobyrella richardsonae* in Brazil, parasitizing *A. estuariensis* and *S. carvachoi* in estuarine environments and *A. formosus* in rocky beach habitats. Furthermore, possible alterations in the biological interactions between *A. estuariensis* and *P. richardsonae* were observed. This study also describes a new species of the genus *Ovobopyrus* Markham, 1985, found parasitizing *A. carlae*. This discovery represents the second known species of the genus worldwide and the first record of the genus in Brazil. The adult female of *Ovobopyrus sp. nov.* is characterized by the presence of small anterolateral projections on the head; antennule with three articles; subquadrate maxilliped with an unsegmented palp bearing nine long, simple setae; oostegite 1 with a sinuous internal crest containing five small lobes; pereopod carpus with distal tufts of setae; and a bilobed terminal pleomere. Additionally, dichotomous keys for the genera of Bopyrinae in Brazil, an identification key for *Ovobopyrus* species, and a key for *Parabopyrella* species recorded in Brazil are provided.

Keywords: Alpheidae; Bopyridae; Distribuition; Parasite; Taxonomy.

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SUMÁRIO

1 INTRODUÇÃO GERAL

Os crustáceos são um dos grupos de invertebrados mais conhecidos, com cerca de 72.000 espécies descritas. Este grupo apresenta uma alta diversidade morfológica, hábitos e tamanhos, são encontrados em ambientes marinhos, salobros, dulcícolas, e algumas espécies de isópodes e braquiúros migraram para o ambiente terrestre (Brusca; Giribet; Moore, 2023).

A classe Malacostraca Latreille, 1802 é um grupo monofilético, com mais de 43.500 espécies conhecidas (Schultz; Regier, 2000; Watling et al., 2000; WoRMS, 2024). É dividida em três clados: Leptostraca Claus, 1880, Peracarida Calman, 1904 e Stomatocarida, um novo clado formado por Stomatopoda e Syneucarida (Bernot et al., 2023). Apresentam o corpo dividido em três tagmas, de 19 a 20 segmentos, sendo seis segmentos cefálicos, oito segmentos torácicos e seis segmentos no pleon, com exceção de Leptostraca, que apresenta sete segmentos no pléon (Brusca; Giribet; Moore, 2023). Os apêndices do último segmento do pléon podem ser denominados de urópodes e, juntamente com o télson, formam o leque caudal (Brusca; Giribet; Moore, 2023).

Atualmente, são conhecidas aproximadamente 25.000 espécies de peracáridos, divididos em doze ordens (Brusca; Giribet; Moore, 2023; WoRMS, 2024). Isopoda Latreille, 1816, Tanaidacea Dana, 1849 e Cumacea Kroyer, 1846 segundo Bernot et al. (2023) formam Mancoida, e junto com Amphipoda Latreille, 1816 formam boa parte do bentos marinho (Souza-Filho et al., 2021). Uma das principais características do grupo é desenvolver seus ovos em um marsúpio (bolsa de ovos) formado por oostegitos (epipoditos modificados) (Brusca; Giribet; Moore, 2023).

A ordem Isopoda Latreille, 1816 é muito diversa com 10.719 espécies descritas (WoRMS, 2024) que desenvolveram estilos de vida e morfologias muito diferentes e apresentam uma distribuição geográfica muito ampla (Brandt, 1992; Dreyer & Wägele 2001; Poore & Bruce, 2012). Os isópodes fazem parte da macrofauna, com exceção do gênero *Bathynomus* A. Milne-Edwards, 1879 chegando até 50 cm. Têm habitat bastante diversificado, pois são encontrados em ambientes marinhos, de água salobra e doce, além do terrestre. As principais características do grupo são: ausência de carapaça; tendência de achatamento dorsoventral; primeiro segmento torácico fundido à cabeça; antenas unirremes; péreon não apresenta brânquias; pléon consiste em cinco segmentos (pleonitos) + pleotélson; os ramos dos pleópodos são bastante finos e permeáveis e funcionam como brânquias. No geral, a morfologia entre machos e fêmeas se distingue pela presença de um estilete

acessório na margem interna do endópodo do segundo pleópodo, indica que o espécime é macho, esse caráter tem função de auxiliar na cópula (Brusca; Giribet; Moore, 2023; Fransozo; Negreiros-Fransozo, 2017). Existe grande diversidade de hábitos alimentares no grupo: herbívoros ou saprófagos onívoros, detritívoros, predadores e parasitas. Em geral, as mandíbulas trituradoras e a herbivoria parecem representar as condições plesiomórficas, enquanto as mandíbulas cortantes ou perfurantes e a predação surgiram mais tarde na evolução de vários clados de isópodes (Brusca; Giribet; Moore, 2023). Os trabalhos de An et al. (2023) e Wu et al. (2022) utilizaram análises genéticas para estudar o grau de parentesco entre os principais grupos de isopoda, incluindo os de vida parasita. Neste estudo, os autores puderam encontrar duas conclusões principais: primeiro que a subordem Epicaridea é monofilética e mostraram que os grupos parasitas não possuem uma única origem. Nagler et al. (2017) investigou através da paleoparasitologia um isópode de 168 milhões de anos e comprovou indiretamente que ele é o mais antigo parasita fóssil até o momento, pertencente a Cymothoida, esses dados contribuem para elucidar a origem e a diversificação do parasitismo no grupo de isópodes.

O termo parasita é definido por “o organismo que vive dentro ou sobre outro organismo e se beneficia ao obter nutrientes às custas do outro” (Van As & Van As, 2019). Cymothooidea Leach, 1814 e Epicaridea Latreille, 1825 são os táxons parasitas principais da ordem Isopoda, sendo parasitas (ou micropredadores) de peixes e em sua maioria parasitas de crustáceos marinhos e alguns de água doce, respectivamente (Boyko & Williams, 2023). Epicaridea é um clado monofilético (An et al., 2015) dividido em duas superfamílias, a Bopyroidea Rafinesque, 1815 e a Cryptoniscoidea Kossmann, 1880, com mais de 869 espécies descritas (Boyko et al., 2013; WoRMS, 2024). Possuem ciclo de vida complexo, quase todos os parasitas precisam de dois hospedeiros, intermediário, na maioria dos casos um copépode pelágico e outro definitivo, para se tornarem adultos e reproduzirem (Williams et al., 2022). São considerados castradores parciais porque a reprodução muitas vezes não é completamente bloqueada, ocorre um déficit nutricional no hospedeiro, e acaba afetando na reprodução (Williams & Boyko, 2012). Os Cryptoniscoidea adultos são endoparasitas ou hiperparasitas, e geralmente só são encontrados quando os hospedeiros são dissecados ou quando é coletada a sua forma larval. Essa dificuldade não é observada nos Bopyroidea, que são ectoparasitas e, portanto, mais facilmente identificados em amostras (Boyko & Williams, 2016).

A superfamília Bopyroidea, possui 696 espécies descritas (WORMS, 2024), dividida em três famílias, Bopyridae Rafinesque, 1815, Entoniscidae Kossmann, 1881 e Ionidae H. Milne Edwards, 1840. Bopyridae e Ionidae são ectoparasitas e possuem como hospedeiro definitivo um crustáceo decápode. Entoniscidae são endoparasitas que infestam muitos

grupos de decápodes, principalmente Brachyura Latreille, 1802 (Boyko et al., 2013; McDermott et al., 2020; Detorre; Williams; Boyko, 2023).

Bopiridae é um dos grupos mais diversos de parasitas com 642 espécies descritas (WORMS, 2024). Sua distribuição abrange todo o globo, com maior diversidade encontrada no Noroeste do Pacífico, 139 espécies, e no Atlântico Sul foram registradas 45 espécies, sendo 29 espécies (12 endêmicas) e 21 gêneros para o Brasil (Williams; Boyko, 2012; Ribeiro; Horch, 2023; Horch et al., 2024). Argeiinae Markham, 1977, Bopyrinae Rafinesque, 1815, Orbioninae Codreanu, 1967 e Pseudioninae Codreanu, 1967 residem na câmara branquial de seus hospedeiros. Athelginae Codreanu & Codreanu, 1956, Hemiarthrinae Markham, 1972, Phyllodurinae Markham, 1977 são encontrados no pléon de seus hospedeiros (Boyko et al., 2013). Três das nove subfamílias dentro de Bopyridae são parasitas exclusivos dos camarões carídeos, especialmente da família Alpheidae Rafinesque, 1815: Argeiinae Markham, 1977 com 13 espécies descritas, Bopyrinae Rafinesque, 1815 com 128 espécies descritas e Hemiarthrinae Markham, 1972 com 64 espécies descritas (Markham, 1985; An et al., 2015; Boyko et al., 2024).

O ciclo de vida geral destes grupos consiste na liberação do primeiro estágio larval, o *epicarídium*, que nada ativamente em busca do hospedeiro intermediário, um copépodo calanóide. Após esta infestação, a larva sofre metamorfose passando para o segundo estágio larval, o *microniscus*. Nesta fase, ela cresce às custas do copépodo e realiza mais uma metamorfose, chegando no último estágio de vida larval, o *criptoniscus*, caracterizado por um modo de vida livre, até infestar o hospedeiro definitivo (Anderson, 1975). A determinação do sexo neste grupo se dá pela ordem de infestação, onde a primeira larva se desenvolverá em fêmea e a segunda em um macho (Reinhard, 1949).

Os bopirídeos podem causar uma ligeira diminuição no crescimento, além de pequenas alterações na função sexual dos hospedeiros (Beck, 1980). Os parasitas causam um grande gasto de energia, acarretando a diminuição na atividade metabólica do hospedeiro, afetando seu hábito de vida e limitando sua capacidade de migração. Estes parasitas causam um grande gasto de energia, afetando o hábito de vida e certos aspectos biológicos, causando inchaço nas câmaras branquiais, crescimento lento e até esterilização de seus hospedeiros (Rhode, 2005; Williams; Boyko, 2016).

Um dos principais grupos de crustáceos parasitados por bopirídeos são os camarões carídeos, em especial a família Alpheidae Rafinesque, 1815 (Markham, 1985; An et al., 2015). Esses crustáceos são largamente conhecidos como camarões-de-estalo ou camarões-pistola, devido à assimetria encontrada no primeiro par de pereiópodos, onde o quelípodo maior possui dedos modificados responsáveis pela produção de um som de estalo. Tais

estalos representam um dos sons mais audíveis e familiares nos ambientes onde esses animais vivem, capazes de serem detectados há muitos metros de distância (Anker et al., 2006). Esses camarões são bentônicos, geralmente são encontrados em tocas escavadas no sedimento lamoso em estuários e manguezais, onde vivem com contato direto com o substrato (Almeida et al., 2012). O termo simbiose é geralmente utilizado para associações interespecíficas nas quais as duas espécies vivem juntas. A maioria dos *Alpheus* spp. escavam e mantém tocas e/ou galerias em diferentes substratos (marinhos, lamosos), e é comum que camarões sejam hospedeiras de animais simbióticos, não é surpreendente que algumas espécies de *Alpheus* sirvam como hospedeiras (Bauer, 2004). Os camarões estudados nesse trabalho, *Alpheus estuariensis* Christoffersen, 1984, *Alpheus formosus* Gibbes, 1850, *Alpheus carlae* Anker, 2012 e *Salmoneus carvachoi* Anker, 2007 são parasitados por bopyrídeos e podem viver em associação simbiótica, como *A. estuariensis* (hospedeiro) e *S. carvachoi* (hóspede).

Os poucos estudos taxonômicos sobre Bopyridae no Brasil foram realizados para descrever a diversidade desse grupo de parasitas associados a outros crustáceos, em especial Decapoda (Oliveira; Masunari, 2006; Corrêa et al., 2018; Horch et al. 2018; Ribeiro et al., 2019; 2020; 2021; de Barros et al., 2021). Atualmente para o Brasil, 3 das 29 espécies da família Bopyridae conhecidas foram registradas infestando camarões da família Alpheidae (Ribeiro; Horch, 2023; Horch et al. 2024), diante disso, a investigação da ocorrência de infestações nos alfeídeos se faz necessária, bem como a identificação de quais parasitas estão envolvidos e que possíveis prejuízos podem causar ao hospedeiro.

2 OBJETIVOS

2.1 Geral:

Descrever os exemplares de isópodes da família Bopyridae que foram encontrados parasitando camarões da família Alpheidae, e as possíveis alterações morfológicas e reprodutivas nos hospedeiros decorrentes desta relação interespecífica em estuários e praias de Pernambuco.

2.2 Específicos:

- Descrever possíveis novas espécies e/ou novos registros de Bopyridae com base no material estudado.
- Desenvolver chaves dicotômicas de identificação das possíveis novas espécies e/ou novos registros.
- Quantificar a prevalência de infestação por Bopyridae para os camarões Alpheidae estuarinos da área estudada.
- Analisar as alterações no tamanho na carapaça dos camarões *A. estuariensis* parasitados em relação à população total.
- Avaliar se há diferença na quantidade de ovos das fêmeas de camarões *A. estuariensis* parasitadas em relação à população de fêmeas ovígeras total.

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4 ARTIGO 1

Artigo científico a ser encaminhado a Revista **Journal of Natural History.**

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New host and geographic records and biological aspects of *Parabopyrella richardsonae* (Nierstrasz & Brender à Brandis, 1929) (Isopoda: Bopyridae) associated to snapping shrimps (Decapoda, Caridea) in estuarine areas and rocky beach of northeastern Brazil

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Abstract

One species of bopyrid isopods of the Bopyrinae subfamily are recorded from new localities and hosts in northeastern Brazil. *Parabopyrella richardsonae* (Nierstrasz and Brender à Brandis, 1929) was recorded from the state of Pernambuco, found for the first time parasitizing the caridean shrimp *Alpheus estuariensis*, and *Salmoneus carvachoi Anker, 2007*, the second time parasitizing *Alpheus formosus* Gibbes, 1850. In addition, we describe possible changes in the biological aspects of the relationship between the host and the parasites, which can significantly affect the life of the host. An identification key and a distribution map for species of *Parabopyrella* parasitizing Alpheidae shrimps in Brazil are also provided.

Keywords: Alpheidae; Bopyrinae; new records**;** taxonomy

Introduction

Symbiosis is defined here *sensu* De Bary (1879) as different organisms living together, and many crustaceans have developed symbiotic relationships with a high diversity of host species, being several of these relationships related to parasitism (Bauer 2004; Baeza 2015; Shields et al., 2015). Bopyridae (Isopoda: Epicaridea: Bopyridae) are obligate and exclusive parasites of decapods (Williams & Boyko, 2012). Their life cycle of Bopyridae is complex, with different larval stages and two hosts, both of which are crustaceans as their intermediate (Copepoda) and final hosts (Decapoda). The *cryptoniscus* larva, the infective stage for the definitive crustacean host, settles and transforms into a juvenile (*bopyridium*) which moves to the final attachment site on the host and, if female, pierces the host's cuticle and feeds on its hemolymph or ovarian fluids (Hoeg et al., 2005; Lester, 2005; Williams & Bunkly-Williams, 2019). The females feed on the host's hemolymph by piercing a blood sinus, usually in the inner wall of the gill cover or "branchiostegite". Adult males, on the other hand, are much

smaller than females and are usually found trapped between their pleopods and do not feed on blood (Anderson, 1990; Hoeg et al., 2005).

Studies have shown that there are positive correlations between the size of female Bopyridae and the size of their host shrimp, indicating that the host is usually infected early in life and that the parasite remains and grows with the host (Beck, 1980; Cash & Bauer, 1993; Conner & Bauer, 2010; Penha-Lopes et al., 2013; Rash & Bauer, 2015; Baeza et al., 2018; Pralon et al., 2018), resulting in positive linear correlations between parasite and host sizes (Van Name, 1936; Pike 1960; Beck 1980; Cash & Bauer, 1993). These symbionts cause a large expenditure of energy, affecting the life habit and certain biological aspects, causing swelling in the gill chambers, slow growth and even sterilization of their hosts (Rhode, 2005; Williams & Boyko, 2016).

Bopyridae Rafinesque, 1815 being composed of 642 species and is the most diverse family of parasitic isopods species (Williams & Boyko 2012; Boyko et al., 2013; Boyko et al. 2024a). Three subfamilies within Bopyridae: Argeiinae Markham, 1977, Bopyrinae Rafinesque, 1815 and Hemiarthrinae Markham, 1972 are exclusive parasites of caridean shrimps, especially the family Alpheidae Rafinesque, 1815 (Markham, 1985; An et al., 2015). Bopyrinae Rafinesque, 1815 encompass 27 genera and 126 species of branchial parasites of caridean shrimps (An et al., 2015; Boyko et al., 2024b), for Brazil, seven genera of this subfamily have been recorded, but only three have been found parasitizing shrimps of the Alpheidae family: *Bopyrella* Bonnier 1900, *Capitetragonia* Pearse 1953, *Parabopyrella* Markham, 1985 (Ribeiro & Horch, 2023).

The genus *Parabopyrella* has 28 species and is found parasitizing members of the Alpheidae Rafinesque, 1815, Hippolytidae Bate, 1888 and Lysmatidae Dana, 1852 shrimps (Boyko, 2006; An et al., 2015). The shrimps *Alpheus estuariensis* Christoffersen, 1984, *A.*

formosus Gibbes, 1850 and *S. carvachoi Anker, 2007* belong to the Alpheidae and are widely known as snapping shrimps or pistol shrimps, due to the asymmetry found in the first pair of pereiopods, where the larger chelliped has modified fingers responsible for producing a snapping sound (Anker et al., 2006). Most *Alpheus* spp. build and maintain burrows. Because marine burrowers are often hosts to symbiotic animals (Bauer, 2004), *A. estuariensis* and *S. carvachoi* are benthic and are usually found in burrows dug into the muddy sediment in estuaries and mangroves, where they live in direct contact with the substrate (Almeida et al., 2012). *Alpheus formosus* is commonly found in various types of hard substrata, usually found in beach, under the rocks that are uncovered at low tide, accumulating water in the sediments (Anker et al., 2008; Santos et al., 2012).

Taxonomic studies on epicarid isopods (Bopyroidea and Cryptoniscoidea) in Brazil are still growing, with 38 species recorded in the country, the family Bopyridae is the most representativeness with 29 species (Ribeiro & Horch, 2023, Horch et al. 2024). In view of this, we investigated the occurrence of infestations in Alpheidae, as well as identifying which parasites are involved. In addition, this study aims to verify whether the shrimp *A. estuariensis* and *S. carvachoi* that live in the same gallery and the rocky shore shrimp *A. formosus* are parasitized by the same group of parasites or whether there is specificity in this symbiosis, providing observations and ecological data on this parasite-host relationship.

Material and methods

The specimens of hosts *A. estuariensis* was collected between 2017 and 2023 on the tidal flats of the Massangana River, of Suape Bay and Barra de Catuama Beach, Pernambuco, Brazil. The species *S. carvachoi* was almost collected in 2018 and only one specimen in 2017 both in Massangana River. The methodological sampling was performed by Guéron et al. (2022) and Santos et al. (in prep.). A total of 1.362 and 353 were collected, respectively. Three

specimens of *A. formosus* were collected with pitfall traps, details of the methodology in the work by Bochini et al. (2020), and by beach rocky on Paraíso beach in Suape Bay during the same period. The material will be deposited in the Crustacea Collection of the Prof. Petrônio Alves Coelho Oceanography Museum of the Federal University of Pernambuco (MOUFPE), Brazil and in the Crustacean Collection of the Biology Department of the Ribeirão Preto School of Philosophy, Sciences and Letters (CCDB) of the University of São Paulo.

All the shrimps collected were sexually mature based on size of carapace (<5.8mm) (Costa-Souza et al., 2018), and to differentiate the sexes, according to Bauer, 2004, we examined the second pleopod to check for the presence (male) or absence (female) of *appendix masculina*, the secondary male sexual character used to determine sex in caridean shrimps. Female parasites were identified by their large, asymmetrical bodies that take up most of the branchial chamber of the shrimp's host. The presence or absence of a male was then determined for each female parasite by inspecting the female body for attached males. Male parasites were identified by their smaller, symmetrical bodies (Boyko, 2006).

Specimens were dissected and female appendages were mounted on slides Chlorazol black diluted in 70% alcohol was used on some specimens to better observe the dissected structures and body morphology. Glycerine gel slides were mounted to fix the dissected structures so that they could be observed at a higher magnification using a LEICA DME optical microscope. Parasitic isopods and hosts were photographed with the same stereomicroscope and final plates were created with Photoshop. Drawings and parasite measurements were produced with the aid of a *camara lucida* fitted on a stereomicroscope (Leica DME), then vectorized with CorelDRAW. Map of the *P. richardsonae* distribution was created with the QGIS program, using the data available in the literature and the new records (Geographic Information System; http://www.qgis.org). The identification key was based on original

descriptions of the two species registered of genus *Parabobyrella* from Brazil. References are provided for taxonomic authorities of parasite taxa but not for those of hosts.

The parasite specimens were measured for total length (TL), i.e. from the anterior margin of the cephalon to the posterior margin of the pleotelson, and the hosts for carapace length (CL), i.e. measured along the line from the posterior edge of the eye orbit to the middorsal posterior edge of the carapace. To assess the prevalence of parasites, the number of hosts infected with one or more parasites divided by the number of hosts collected was calculated (Bush et al., 1997). The prevalence of *A. formosus* was not calculated because the population data was not available. A regression analysis determined the relationship between the CL of the host and the TL of the females and the least squares method was also used (Wilkinson, 1988). The Kruskal-Wallis test was used to compare the length of the CL of parasitized and non-parasitized females, as well as the number of eggs in the same individuals. Mann-Whitney pairwise comparisons were used with Bonferroni corrected/uncorrect

Systematic account

Order **ISOPODA** Latreille, 1817

Suborder **EPICARIDEA** Latreille, 1825

Superfamily **BOPYROIDEA** Rafinesque, 1815

Family **BOPYRIDAE** Rafinesque, 1815

Subfamily **BOPYRINAE** Rafinesque, 1815

Genus ***Parabopyrella*** Markham, 1985

Parabopyrella richardsonae Nierstrasz and Brender à Brandis, 1929

Bopyrella richardsonae Nierstrasz and Brender à Brandis, 1929, p. 33-34, figs. 41-42 [type-locality U.S. Virgin Islands: infesting *Alpheus formosus* Gibbes]; Shiino, 1933, p. 282; Hutton and Sogandares-Bernal, 1960, p. 287 [Boca Ciega Bay, Florida: infesting *Alpheus heterochaelis* (Say)]; Hutton, 1964, p. 447 [Pinellas County: infesting *Alpheus heterochaelis*]; Danforth, 1970, p. 208-209, fig. 8; Bourdon, 1980, p. 187, 221-224, fig. 16, tab. IV [reexamination of types].

Parabopyrella richardsonae – Markham, 1985, p. 67 (key), p. 78, fig. 36 [W Florida, Gulf of Mexico: infesting *Alpheus normanni*], p. 129 (Table 2), p. 132 (Table 3); Markham, 1988, p. 57 (list); Kensley and Schotte, 1989, p. 112 (Table 2), p. 267 (Table 6); Camp et.al., 1998, p. 133 (list); Boyko and Williams, 2004, p. 368 [Bahamas: infesting by *Alpheus viridari*]; McLaughlin et. al., 2005, p. 188 (list); Schotte, Markham and Wilson, 2009, p. 981 (Table); An, Boyko and Li, 2015, p. 61 (key); Briggs et. al., 2017, p. 655 (Table 1).

Material examined

One adult female parasitizing one male of *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 23 February 2018; **one adult female** parasitizing one female *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 01 March 2018; **one adult female** parasitizing one male of *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 03 September 2018; **one adult female and one adult male** parasitizing one male of *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 07 December 2018; **one adult female and one adult male** parasitizing one male of *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 07 December 2018; **one adult female and one adult male** parasitizing one ovigerous female of *A. estuariensis*, Almeida, O. A. det. Host;

Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 10 September 2018; **one adult female and one adult male** parasitizing one ovigerous female of *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 07 December 2018; **one adult female and one adult male** parasitizing one ovigerous female of *A. estuariensis*, Modesto, E. P. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 28 October 2019; **one adult female and one adult male** parasitizing one male of *A. estuariensis*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 20 October 2017; **one female adult** parasitizing one ovigerous female of *A. estuariensis*, Modesto, E. P. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 11 August 2022; **one adult female and one adult male** parasitizing one male of *A. estuariensis*, Modesto, E. P. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 26 October 2022; **one adult female and one adult male** parasitizing one ovigerous female of *A. estuariensis*, Modesto, E. P. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 26 October 2022; **one adult female and one adult male** parasitizing one ovigerous female of *A. estuariensis*, Modesto, E. P. det. Host; Barra de Catuama Beach, Pernambuco, Northeastern Brazil; 27 October 2023; **one female adult** parasitizing one adult of *S. carvachoi*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 10 September 2018. **one adult female and one adult male** parasitizing one adult of *S. carvachoi*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 17 September 2018; **one female adult** parasitizing one adult of *S. carvachoi*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 30 November 2018; **one adult female and one adult male** parasitizing one adult of *S. carvachoi*, Almeida, O. A. det. Host; Massangana River Suape Bay, Pernambuco, Northeastern Brazil; 07 December 2018; **one adult female and one adult male** parasitizing one ovigerous adult of *S. carvachoi*, Almeida, O. A. det. Host; Massangana River,

Suape Bay, Pernambuco, Northeastern Brazil; 26 October 2017; **one female adult** parasitizing one female of *Alpheus formosus*, Almeida, O. A. det. Host; Carneiros Beach, Pernambuco, Northeastern Brazil; 13 July 2018; **one adult female and one adult male** parasitizing one male of *Alpheus formosus*, Almeida, O. A. det. Host; Carneiros Beach, Pernambuco, Northeastern Brazil; 20 August 2019; **one adult female and one adult male** parasitizing one male of *Alpheus formosus*, Almeida, O. A. det. Host; Paraíso Beach, Suape Bay, Pernambuco, Northeastern Brazil; 28 October 2019.

Diagnosis: Female - body suboval, head deeply fused with the first pereomere, frontal lamina narrow and without projections (Figure 3A, B); first oostegite as long as it is wide and with serrated adornments (Figure 4A); marsupium widely open (Figure 3B); coxal plates present from the first to the fourth pereomere (Figure 3A); pereopods of the same size with several scales on the carpus and merus (Figure 4B); on the shorter side of the pleon with pointed margins and the longer side with rectangular margins and very wide and semicircular pleotelson (Figure 5C). Male - head narrower than pereon and completely fused with first pereomere (Figure 6A); small eyes (Figure 6A); pleon a little wider or much wider than the size of the pereon and vestigial pleomere (Figure 6A, B); antenna 1 with 4 articles (Figure 7A); merus and carpus of pereopods with cluster of scales (Figure 7C, D).

Distribution: Central west coast of Florida; U. S. Virgin Islands; Northeastern Brazil (Figure 1).

Remarks

Based on the original description by Nierstrasz and Brender à Brandis, 1929, the redescription by Markham (1985) and key of An et al. (2015), the specimens belong to the species *P. richardsonae* Nierstrasz and Brender à Brandis, 1929 (Figures 2-8). Within *Parabopyrella*, *P. richardsonae* is considered to be part of the ‘B’ group which has the

pleotelson tip entire, but convex and produced into a rounded distal region (An et al., 2015). The first record of *P. richardsonae* (basionym *Bopyrella richardsonae*) attached the host *Alpheus formosus* Gibbes, 1850 is from Virgin Islands (Nierstrasz & Brender à Brandis, 1929). According to Markham (1985), *P. richardsonae* has a known distribution in the Gulf of Mexico, where it was reported parasitizing *Alpheus normanni* Kingsley, 1878 and Boyko & Williams (2004) recorded it infesting other shrimp *Alpheus viridari* Armstrong, 1949, in the Bahamas. In the present study, females and males' specimens found parasitizing new hosts, *A. estuariensis* (Figure 2C, D), *A. formosus* Gibbes, 1850 (Figure 3A) and *S. carvachoi* (Figure 3B) has been preliminarily assigned to *P. richardsonae*. It is also the first record of the species for Brazil and for the state of Pernambuco.

We observed some differences in relation to the female diagnosis proposed by Markham (1985), as follows: distortion angle of body 19º (versus 28º) (Figure 4A, B); antenna 2 (Figure 4D) with 10 to 12 sparse setae in the distal article and the base article with six sparse setae (versus both articles tipped with sparse setae); internal margin of maxilliped distal article with several small and simple setae distally placed and two longer simple setae near the palp insertion (Figure 5B) palp with five to nine long and simple setae (versus maxilliped with extended, setose palp not fully articulated); internal crest of the 1st oostegite (Figure 5A) with serrated adornments (versus without adornments); articulation of all merus and carpus of pereopods unconspicuous (Figure 5C, D) with a cluster of scales, but the carpus with sparse bristles along the distal margin and tufted bristles on the upper part (versus carpus with several setae on the distal margin); pereopod 7 (Figure 5D) ischium with several long setae; on the shorter side of the pleon (Figure 6C) with pointed margins and the longer side with rectangular margins and very wide and semicircular pleotelson.

Comparing the male this present study with description and illustration of Niertrasz & Brender à Brandis (1929) and Bourdon (1980), we observed some differences: small eyes (Figure 7A) (versus large eyes); antenna 1 (Figure 8A) of four articles (versus three articles), distal article smaller with 3 simple setae, only one is plumose seta; second is longer than wide with four robust setae, three simple setae and one plumose seta; third is wider than long with one robust setae and; the basal article with one seta (versus distal one tipped with long setae, middle one bearing cluster of short seta, and basal article with seta); antenna 2 (Figure 8B) of two articles, distal longer with 4 setae and basal one glabrous (versus both with same size, only distal one setose); pereon broadest at pereomere 4 (versus broadest at pereomere 3) (Figure 7A, B); pereopod 7 (Figure 8C) ischium and merus with a cluster of scales, carpus with tuft setae and propodus with one long and simple seta; pereopod 7 (Figure 8D) ischium and merus with a cluster of scales. Pereon usually abruptly narrower than pleon (Figure 7A, B) (versus pleon abruptly narrower than pereon – probably Markham, 1985 had a mistranslation from German to English).

Key to species of *Parabopyrella* parasitizing Alpheidae shrimps in Brazil (based on adult females)

1a: Maxilliped palp with ten setae, dorsolateral bosses present on pereomeres II–IV, pleotelson medially indented.....*Parabopyrella lata*

1b: Maxilliped palp with six setae, dorsolateral bosses present on pereomeres I-IV, pleotelson smoothly rounded.....*Parabopyrella richardsonae*

Biological Aspects

A total of 1.718 caridean shrimps was collected, of which 18 were infested (taxa of prevalence 0.01%). The species with more representativeness was *A. estuariensis* with 13 of

1.362 (0.01%) attached for *P. richardsonae*, six males (0.004%), and seven females (0,005%). The prevalence of *S. carvachoi* was 5 of 353 (0.014%), only one was an ovigerous female (0.002%).

The largest carapace size of parasitized *A. estuariensis* was 9.74 mm (mean 8.05 mm ± 1.08 mm) and the largest female *P. richardsonae* was 6.88 mm (mean 5.54 mm ± 0.75 mm), see Table 1. The total length (Y) of the female and male parasites was positively correlated with the carapace length (X) of the host (Fig. 9). The regression equations calculated for the female and male parasites were $Y = 0.62(X) + 0.48$ (Pearson correlation coefficient $r = 0.81$, $N = 13$) and $Y = 0.14(X) + 0.17$ ($r = 0.03$, $N = 9$), respectively. In the randomly selected group of non-parasitized shrimp, the largest CL was 15.05 mm (mean 8.93 mm ± 1.48 mm), there was no statistical difference between the size of the carapace of the parasitized and non-parasitized groups, ANOVA $F=0.4253$, $df=22.01$, $p=0.5211$ ($p>0.05$).

Six shrimps were parasitized of a total of 122 ovigerous females of *A. estuariensis*, representing 0.04% of prevalence. The number of eggs differed between parasitized and non-parasitized ovigerous females (Kruskal-Wallis $p<0.05$). The mean of eggs parasitized females was 57.83 (± 74.60), while in non-parasitized ovigerous females was 145.83 (± 58.24). The CL of females' hosts ranged from 6.45 mm to 9.18 mm, and females non-parasitized was 6.28 mm to 9.19 mm, however there was not differences between these groups (Kruskal-Wallis $p>0.05$).

Discussion

This is the third record of the species parasitizing the genus *Alpheus*, the first record for the genus *Salmoneus* and the first record for *A. formosus* and *A. estuariensis* in Brazil. These records show that some parasites are able to use different species of hosts when they inhabit the same environment. The species *S. carvachoi* is symbiotic with *A. estuariensis*, as it inhabits

the galleries built by the Alpheidae in the mangrove mud. We therefore believe that *P. richardisonae* benefits from the greater number of definitive hosts available in these microhabitats. The species *A. formosus* was found on a beach close to the mangrove location, where they are connected by the tidal flow, increasing the possibility of infestation by another shrimp of the same genus, in the work of Pralon et. al. (2018) and Detorre et al. (2023), it was observed that the same parasites infested different hosts of the same genus in nearby locations.

Prevalence of *P. richardsonae* in the studied *A. estuariensis* population was 0.01%, which is low compared with that reported by Briggs et al. (2017), who mentioned that from 1.851 specimens of the genus *Alpheus* (Florida), 0.16 % had the bopyrid of the same species. Studies with other caridean shrimp species have shown that biotic and abiotic factors can interfere with this rate, such as the abundance of hosts, the presence of seagrass (Briggs et. al., 2017) and temperature (Brinton & Curran, 2015). Among the thirteen parasitized *A. estuariensis*, seven were females, which may represent advantages for the parasite, such as greater longevity, thus obtaining a longer infestation time, since host females have a longer life expectancy than host males and greater release of larva because parasitized females have a shorter molting period (Anderson, 1975; Beck, 1980; Cash & Bauer, 1993; Conner & Bauer, 2010).

The regression between TL and CL of parasitized *A. estuariensis* was positive, in line with data presented in the literature where bopyridae usually infect very young shrimps (Anderson, 1990) and then grow together with the hosts, resulting in positive linear correlations between parasite and host sizes (Van Name 1936; Pike 1960; Truesdale & Mermilliod 1977; Beck 1980; Cash & Bauer 1993). The energy and nutrients that the host usually directs toward reproduction and growth is apparently deviated for growth and reproduction of the parasite (Conner & Bauer, 2010).

The castration of decapod hosts by bopirids is a well-known phenomenon (Baudoin, 1975; Beck, 1980; O'brien & Van Wyk, 1985; Oliveira & Masunari, 1998; Masunari et al., 2000; Romero-Rodríguez & Román-Contreras, 2013). This is possibly due to the nutritional drainage carried out by the parasite, which can result in partial or total castration of the host (Beck, 1980; O'brien & Van Wyk, 1985). In the work of Calado et al. (2008), an experiment was carried out with the shrimp *Stenopus hispidus* parasitized by the bopyrid *Argeiopsis inhacae* and total castration was observed, with no production of eggs or vitellogenic oocytes.

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Disclosure statement

No potential conflict of interest was reported by the author.

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Figure Legends

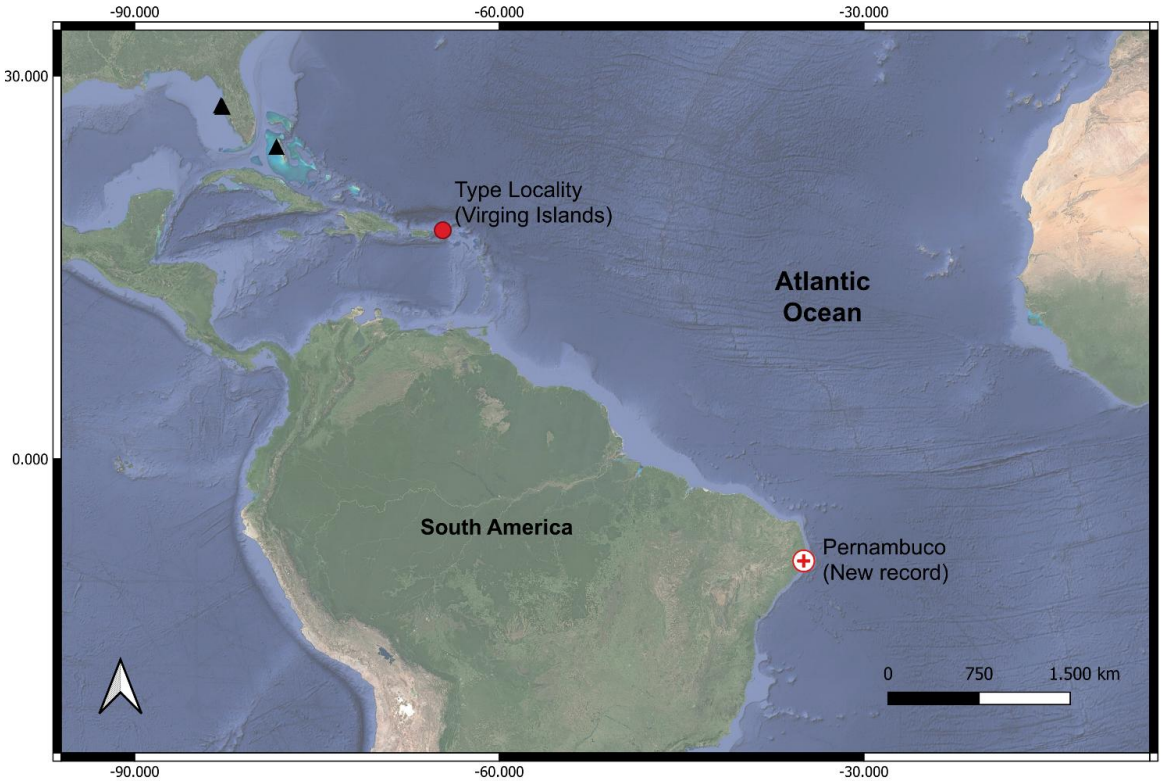

Figure 1. Geographic distribution of *Parabopyrella richardsonae* Nierstrasz and Brender à Brandis, 1929. Red circle = type locality (Virgin Islands); Black triangle = Bahamas (Boyko and Williams, 2004) and Gulf of Mexico (Markham, 1985); Circle with red plus sign = new record (Pernambuco, Brazil).

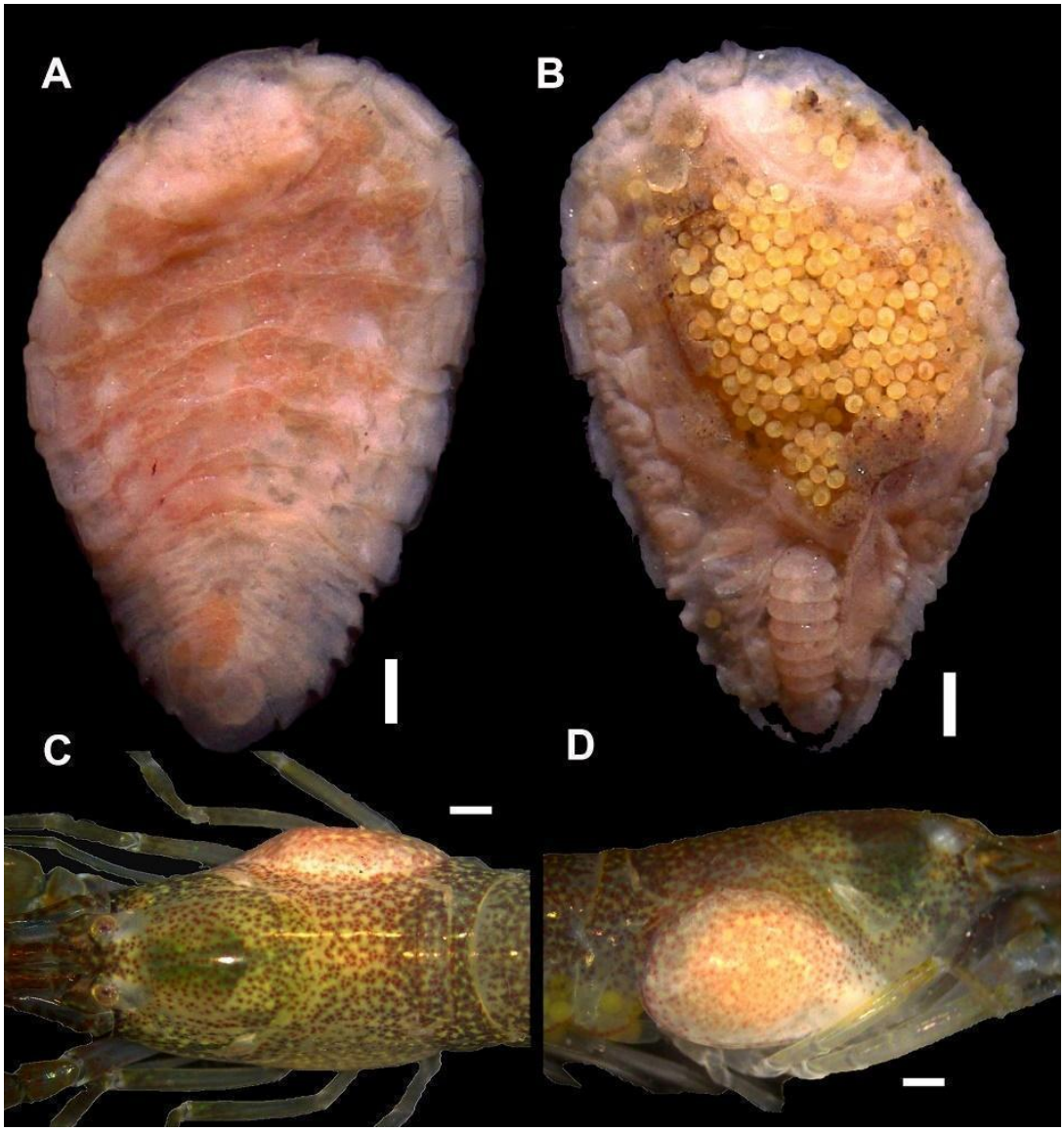

Figure 2. *Alpheus estuariensis* Christoffersen, 1984 with *Parabopyrella richardsonae* (Nierstrasz and Brender à Brandis, 1929). A, *P. richardsonae* female, dorsal view; B, same specime in A, with male into pleon, ventral view; C, *A. estuariensis*, ovigerous female (9.01 mm CL) showing swollen right gill chamber with female and male of *P. richardsonae*; D, same specimen in C, lateral view. Scale bars: A, B = 0.5 mm; C, D = 1 mm.

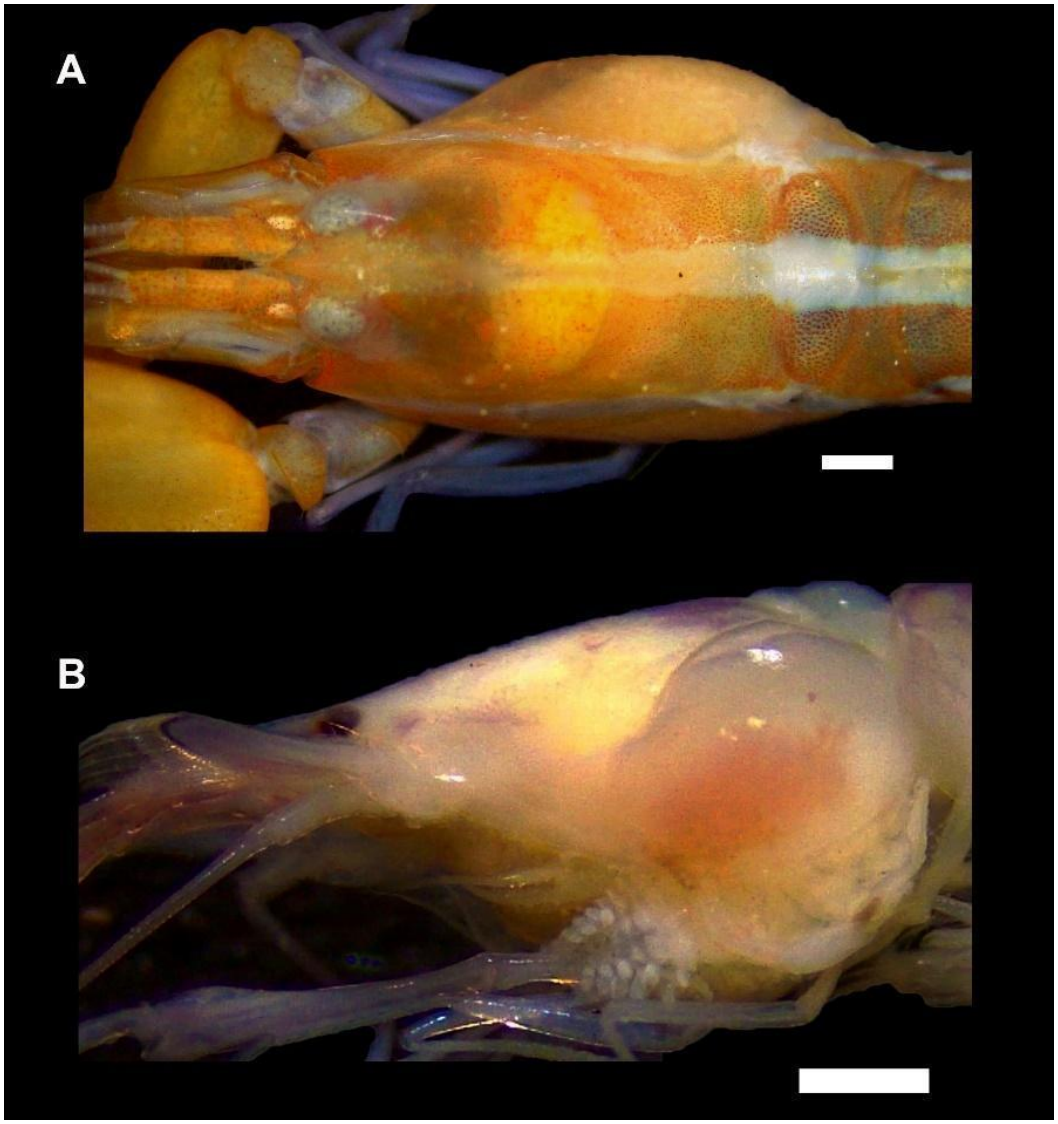

Figure 3. *Parabopyrella richardsonae* (Nierstrasz and Brender à Brandis, 1929) attached others hosts shrimps. A, *A.formosus* Gibbes, 1850, male (9.54 mm CL) showing swollen right gill chamber with female and male of *P. richardsonae*, dorsal view*;* B, *S. carvachoi Anker, 2007*, adult hemarfrodit (4.87 mm CL) showing swollen right gill chamber with female and male of *P. richardsonae*, dorsal view. Scale bars: A, B = 1 mm.

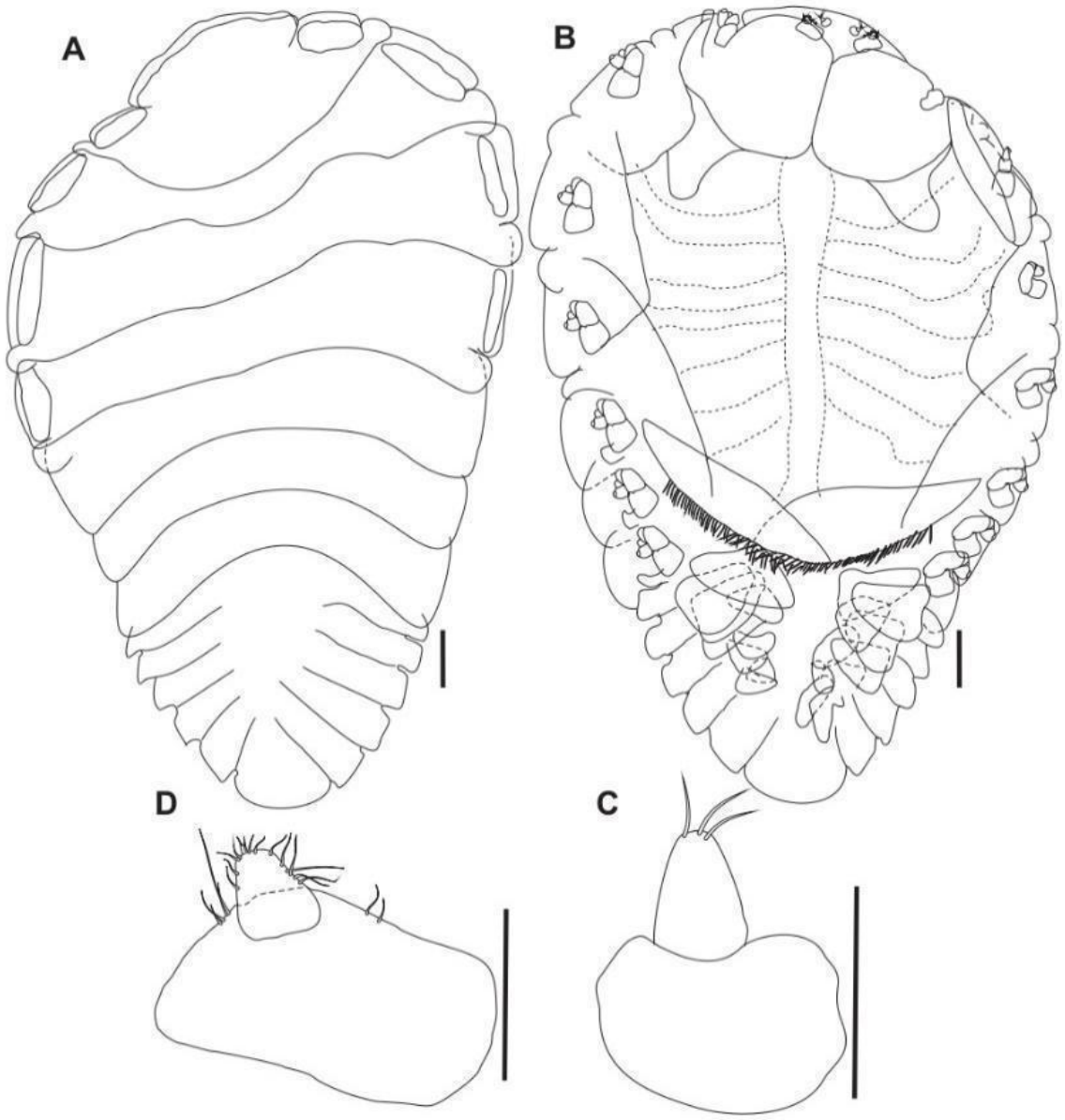

Figure 4. *Parabopyrella richardsonae* adult female. A: habitus dorsal; B: habitus ventral; C: antenna 1; D: antenna 2. Scale bars: A and B: 0.5mm; C and D: 0.1mm.

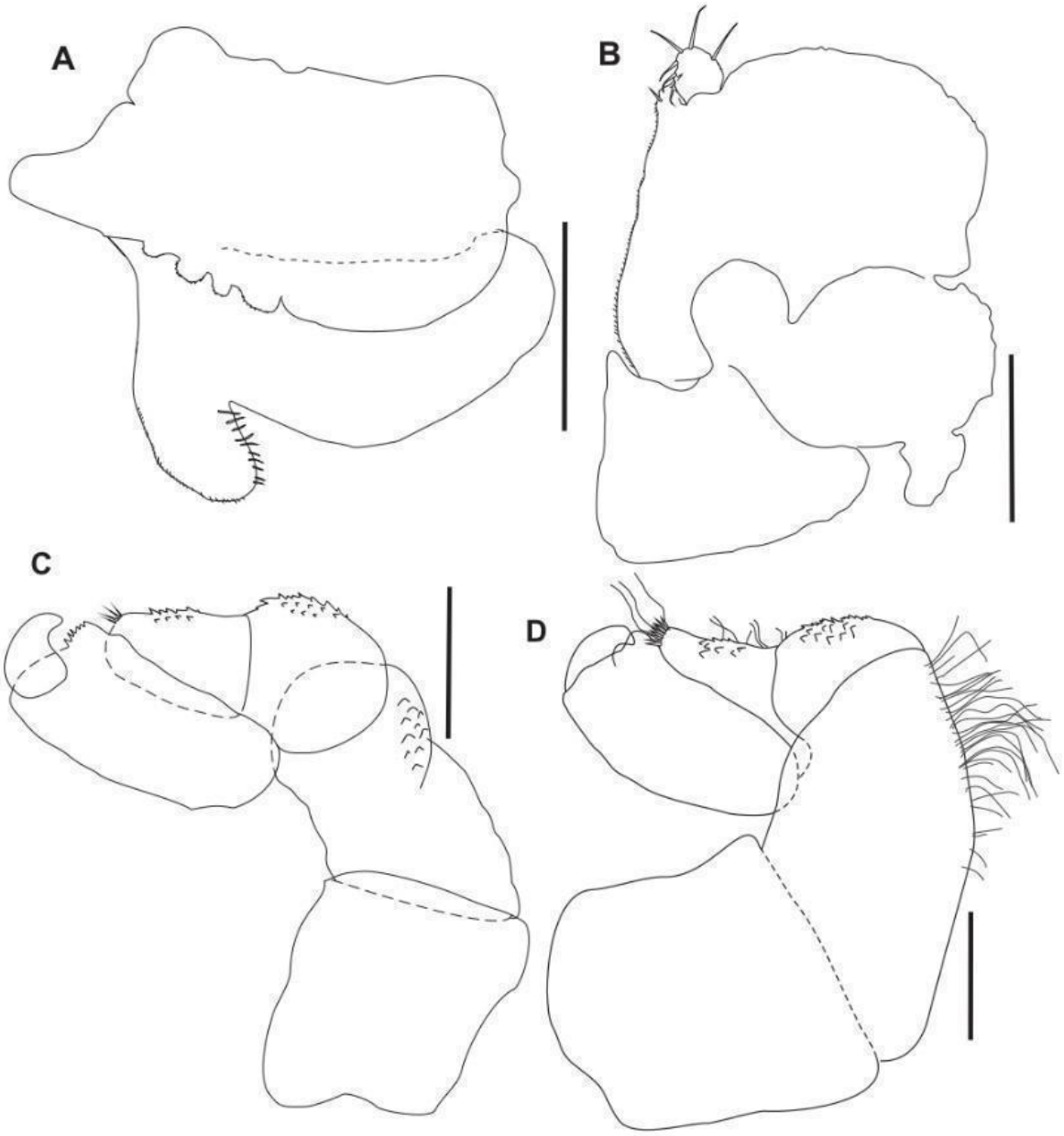

Figure 5. *Parabopyrella richardsonae* adult female. A: Oostegite 1; B: Maxilliped; C: pereiopod 1; D: pereipod 7. Scale bars: A and B: 0.5 mm; C and D: 0.1 mm.

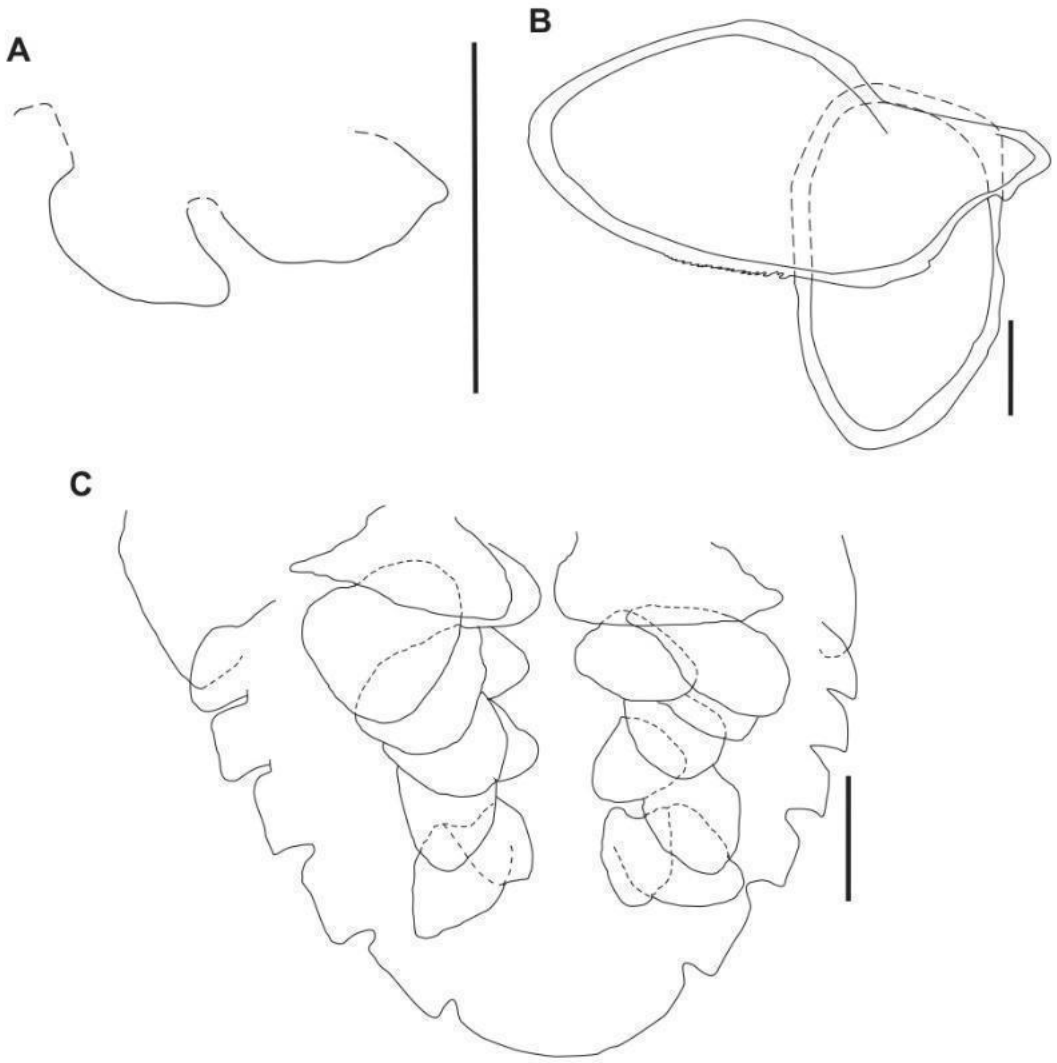

Figure 6. *Parabopyrella richardsonae* adult female. A: barbula; B: pleomere 1; C: pleon. Scale bars: A and C: 0,5mm; B: 0,1mm.

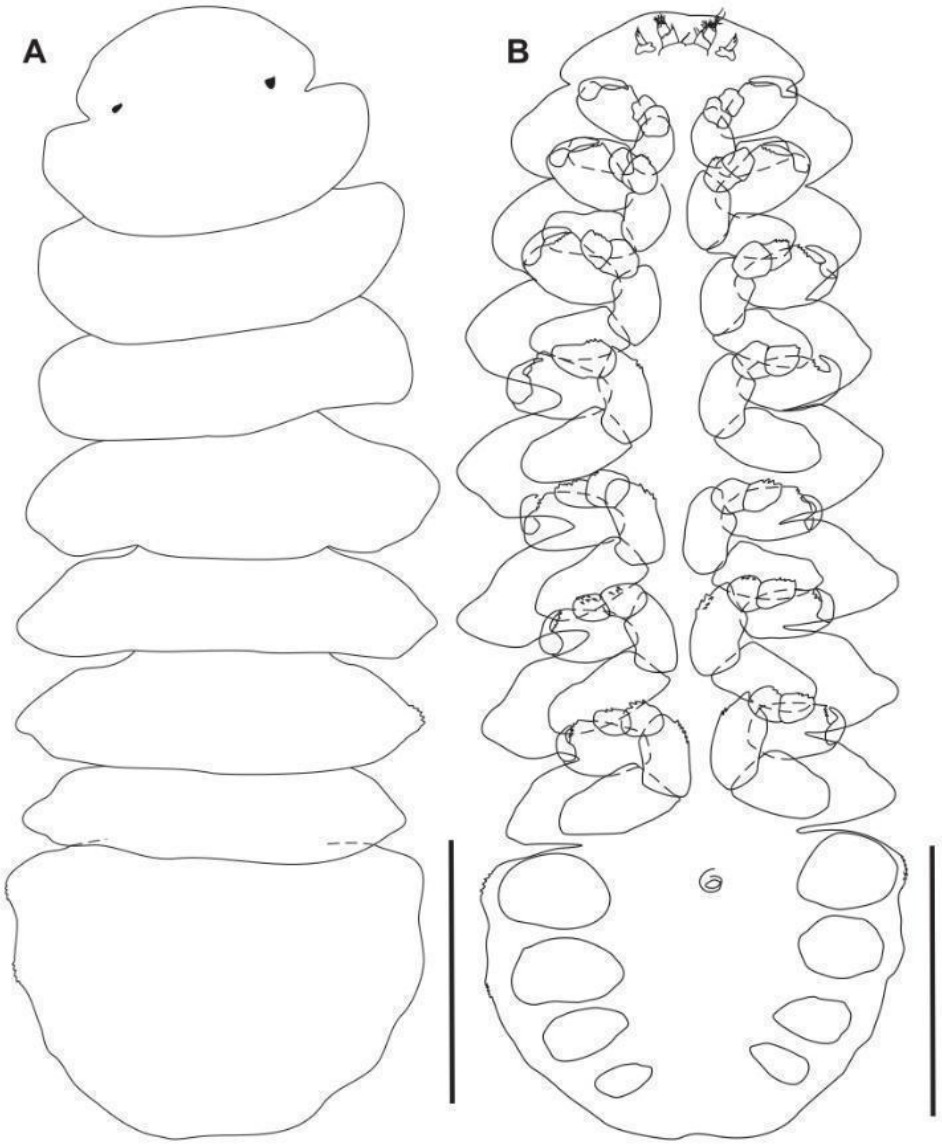

Figure 7. *Parabopyrella richardsonae* adult male. A: habitus dorsal; B: habitus ventral. Scale bars: 0.5 mm.

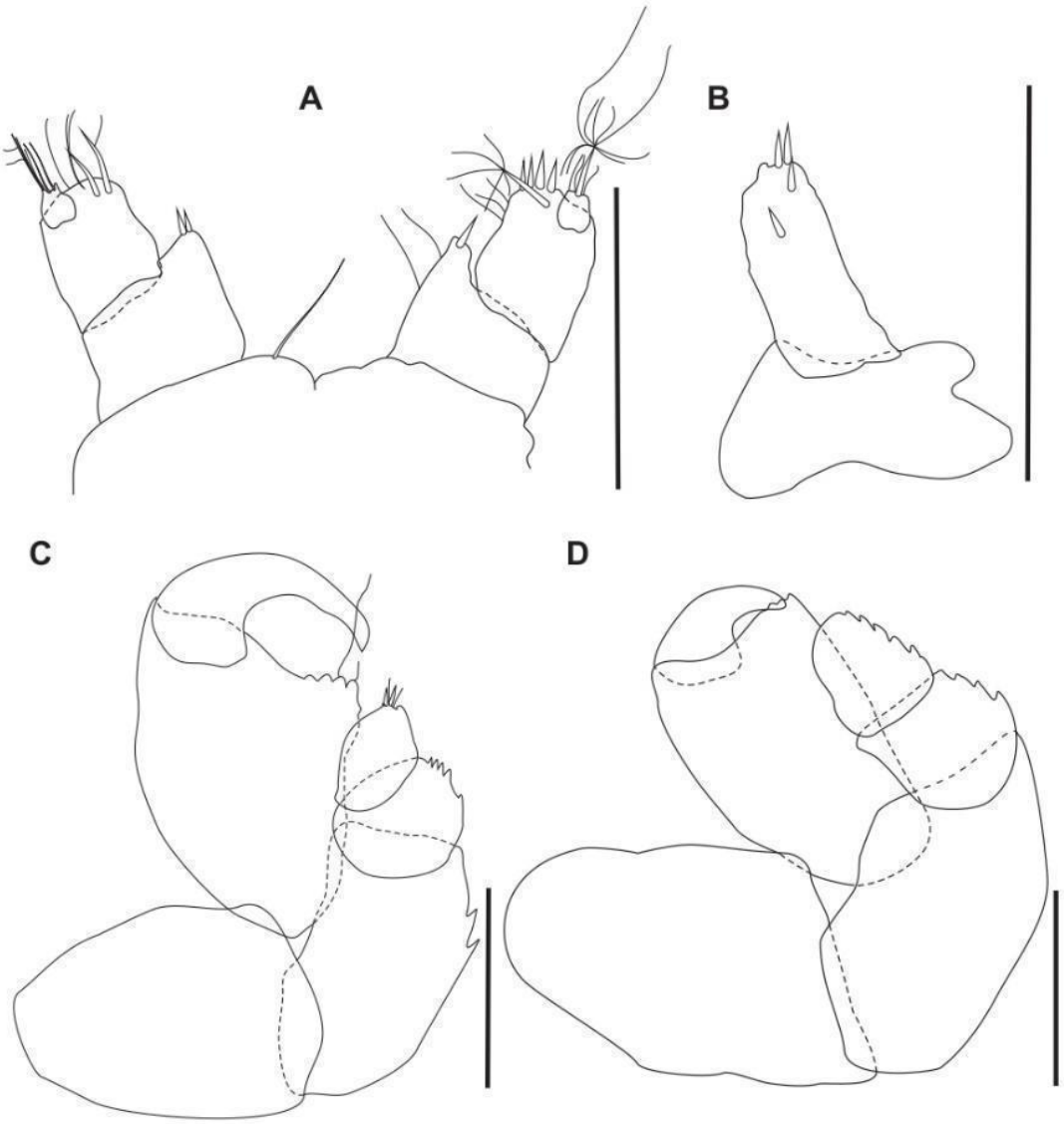

Figure 8. *Parabopyrella richardsonae* adult male. A: antenna 1; B: antenna 2; C: pereiopod 1; D: pereiopod 7. Scale bars: 0.1 mm.

Table 1. Number of specimens and carapace length (CC) of *Alpheus estuariensis* infested by *Parabopyrella richardsonae*, total length (TL) of females and males.

	HOST SHRIMP DATA			PARASITE DATA	
	Sex	**CL (mm)**	**Quantify of Eggs**	**Female TL (mm)**	**Male TL (mm)**
A. estuariensis	Male	9,74		6	
A. estuariensis	Female	8,48		5,69	
A. estuariensis	Male	7,31		5,41	
A. estuariensis	Male	6,99		4,62	1,44
A. estuariensis	Male	9,42		6,5	1,37
A. estuariensis	Female Ovigerous	7,34	10	5,09	1,32
A. estuariensis	Female Ovigerous	6,45	12	4,41	1,26
A. estuariensis	Female Ovigerous	9,01	68	5,94	1,7
A. estuariensis	Male	6,57		4,48	0,86
A. estuariensis	Female Ovigerous	7,79	2	5,45	
A. estuariensis	Male	8,16		6,08	1,78
A. estuariensis	Female Ovigerous	9,18	200	6,88	2,23
A. estuariensis	Female	8,25	55	5,5	1,54

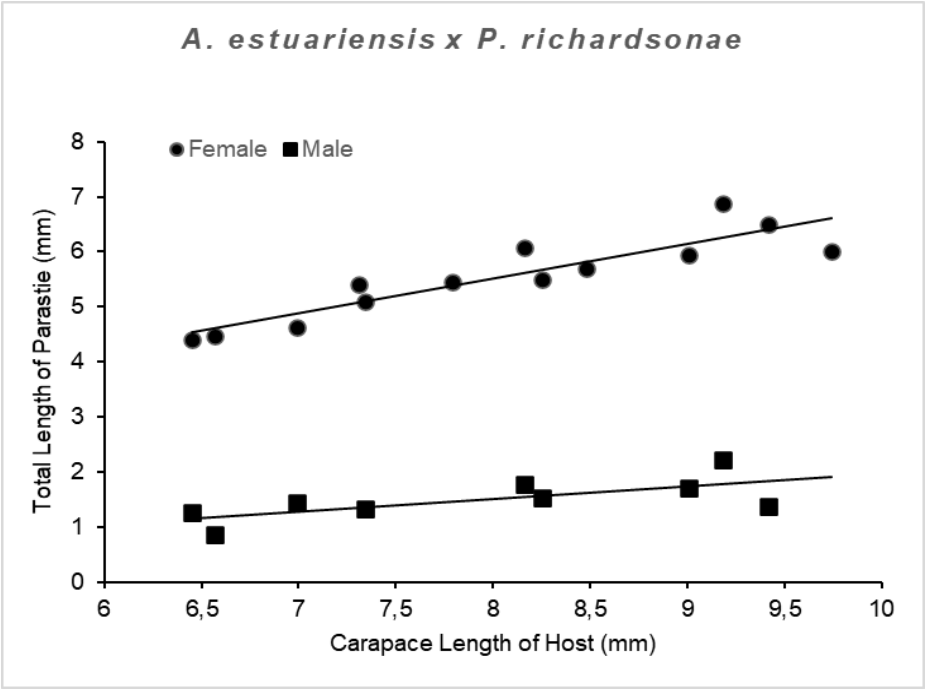

Figure 9. Variation of total length of male and female *Parabopyrella richardsonae* with carapace length of the host, *Alpheus estuariensis*.

5 ARTIGO 2

Artigo científico submetido na Revista **Zootaxa.**

Todas as normas de redação e citação, doravante, atendem as estabelecidas pela referida revista, exceto a posição das imagens, as quais estão localizadas ao longo do texto.

Hiding in the branchia: A new species of the parasitic genus *Ovobopyrus* Markham, 1985 (Isopoda: Bopyridae) associated with a snapping shrimp from Brazil

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Abstract

A new species of parasitic isopod of the genus *Ovobopyrus* Markham, 1985 is described from one parasitized specimen of the snapping shrimp *Alpheus carlae* Anker, 2012, collected from the state of Pernambuco, northeastern Brazil. It is the second species of the genus in the world and the first record of the genus from Brazil. *Ovobopyrus odoya* **sp. nov.** adult female is diagnosed by the head produced into small anterolateral projections; antennule with three articles; maxilliped subquadrate with a non-articulated palp bearing nine long setae; oostegite 1 with digitate ridge with five small lobes; carpi of all pereopods with tufts of setae distally; terminal pleomere bilobed. A comparative table, an identification key and a distribution map

for species of the genus are also provided. In addition, an identification key for all Bopyrinae genera from Brazil is also provided.

Keywords: Alpheidae, *Alpheus carlae*, distribution, parasitism, taxonomy

Introduction

Bopyridae Rafinesque, 1815 is one of the most diverse families of parasitic isopods, being composed by 642 species ectoparasitic species on decapod hosts, which generally differ in host selection, including some species that infest symbiotic hosts, generally differ in host selection (Williams & Boyko 2012; Boyko et al. 2013; Boyko et al. 2024a). Among the nine bopyrid subfamilies, Bopyrinae Rafinesque, 1815 encompass 27 genera and 126 species of branchial parasites of caridean shrimps (An et al. 2015; Boyko et al. 2024b). The genus *Ovobopyrus* Markham, 1985 is monotypic and represented only by *Ovobopyrus alphezemiotes* Markham, 1985, found attached to the lateral surface of the branchial chamber of *Alpheus armillatus* H. Milne Edwards, 1837 collected in the western of Egmont Key Island (27º37'N 83º28'W), Florida, Gulf of Mexico (Markham 1985).

Studies with bopyrid fauna in Brazil are still scarce. To date, 29 species of Bopyridae are recorded from Brazil, 12 of which are endemic of the country (Ribeiro & Horch 2023; Horch et al. 2024). Here we describe a new species of *Ovobopyrus* parasitizing the female shrimp *Alpheus carlae* Anker, 2012 from Brazil. It is the second species of the genus in the world, the first in South America and the twelfth record of the subfamily Bopyrinae from Brazil. A comparative table, an identification key and a distribution map are also provided.

Material and methods

Host (shrimp) and parasite (type bopyrid) specimens are deposited in the Crustacean Collection of Museu de Oceanografia Prof. Petrônio Alves Coelho da Universidade Federal de Pernambuco (MOUFPE). Some appendages of the female parasite were dissected, the oostegite 1, the maxilliped and the pereopods 1 and 7 were mounted on semi-permanent slides with glycerin jelly (Crookham & Dapson 1991), after being stained with clorazol black. The specimen was measured for total length (TL), i.e. from the anterior margin of the head to the posterior margin of the pleotelson, maximal width at the broadest pereomere, head length and width, and pleon length. The male parasite dissected antennae, perepods 1 and 7 were mounted on semi-permanent slides. It was measured for total length (TL), maximal width at the broadest

pereomere, head length and width, width and length pleon. During the processing of the material, the male specimen was lost. The shrimp host was measured for carapace length (CL), i.e. from the posterior margin of the ocular orbit to the posterior margin of the carapace. The terminology of genus follows Markham (1985) and the taxonomic classification follows An et al. (2023). Photos were taken on a stereomicroscope ZEISS. Drawings and measurements of parasites were produced with the aid of a *camara lucida* fitted on a stereomicroscope (Leica DME), followed by editing with CorelDRAW. Mapping of the parasite species distribution was created with the QGIS program (Geographic Information System; http://www.qgis.org). The identification keys were based on original descriptions of adult females belonging to the Bopyrinae genera recorded from Brazil and species of *Ovobopyrus*. References are provided for the taxonomic authorities of all parasitic taxa, but not for those of hosts.

Results

Taxonomy

Order Isopoda Latreille, 1817

Suborder Epicaridea Latreille, 1825

Superfamily Bopyroidea Rafinesque, 1815

Family Bopyridae Rafinesque, 1815

Subfamily Bopyrinae Rafinesque, 1815

Genus *Ovobopyrus* Markham, 1985

Type-species: *Ovobopyrus alphezemiotes* Markham, 1985 (by original designation). Gender masculine.

Amended diagnosis (from Markham, 1985)

Female: Head separated from pereon laterally but fused posteriorly; **with or without two large lobes posterior half of dorsal surface**; **reflexed frontal lamina completely across front but not extending to sides. Eyes absent;** maxilliped with irregularly shaped, non-articulating palp **with or without setae; barbula with single, short, unornamented, flaplike lateral projection at each side.** Long sides of pereomeres 1-4 with prominent coxal plates,

dorsolateral bosses, and tergal projections; short sides of same pereomeres with only inconspicuous coxal plates , tergal projections and with or without thin dorsolateral bosses. Pleon with six distinct pleomeres, all separated by large lateral notches; five pairs of flaplike biramous pleopods; no uropods.(characters modified in **bold**).

Male: About twice as long as wide, with irregularly subparallel sides. Head abruptly narrower than pereon, fused medially with first pereomere. Pereopods are large relative to body size. Pleon completely fused; five pairs of discoid sessile pleopods and similar anal cone.

Hosts: Caridean shrimps of the genus *Alpheus* Fabricius, 1798

Remarks

The diagnosis of the genus was expanded to include the new species, *Ovobopyrus odoya* sp. nov., described here.

***Ovobopyrus odoya* sp. nov.**
(Figs. 1–6)

Type material. *Holotype:* female (4.83 mm TL), muddy flat intertidal zone, Suape, Pernambuco, 27/IX/2019 (MOUFPE 22035), infesting female *Alpheus carlae* Anker, 2012 (-6.60 mm CC) (MOUFPE 22037).

Paratype: male (1.59 mm TL), muddy flat intertidal zone, Suape, Pernambuco, 27/IX/2019 (MOUFPE 22036), infesting same host as holotype

Etymology. Named based on the expression “odoyá”, a traditional greeting to Iemanjá, the queen of the waters, of the African-Brazilian religions, derived from the Yoruba language.

Diagnosis based on adult female. Head produced into small anterolateral projections; antennule with three articles; maxilliped subquadrate with non-articulated palp bearing nine long setae; oostegite 1 with digitate ridge with five small lobes; carpi of pereopods with tufts of setae distally; terminal pleomere bilobed.

Description. *Female holotype* (Figs. 1–3): total length 4.83mm, maximal width 3.79mm, distortion angle 50º, head length 1.29mm, head width 1.38mm, pleon length 1.67mm. Body outline suboval, longer than wide, broadest at pereomere 3. No apparent pigmentation.

Head subquadratic and wider than long, deeply set into first pereomere, fused with it

posteriorly but not laterally, and produced into small anterolateral projections (Figs. 1A, 2A). Frontal lamina reflexed across front but not extending to sides. Eyes absent (Figs. 1A, 2A). Antennule (Fig. 2C) with three articles, distal one very small with six short, simple setae distally. Antennae (Fig. 2D) with two articles, distal one smaller with 10 short and simple setae distally. Maxilliped (Fig. 3B) subquadrate with two articles; anterior article with crenulate outer distal margin; non-articulated palp, with nine setae inserted near inner laterodistal margin; spur long and blunt .with four small, simple setae distally. Barbula (Fig. 2E) with single, broad, smooth, flaplike lateral projection at each side, straight margin medially.

Pereon with seven pereomeres distinctly separated, broadest at pereomere 3. Prominent 1–4 with prominent, elongated coxal plates, slender dorsolateral bosses, and moderately extended tergal projections on the long side of body. On the short side reduced coxal plates on all pereomeresshort tergal projections and thin dorsolateral bosses on first four pereomeres (Figs. 1A, 2A). Oostegites surrounding but not enclosing brood pouch (Figs. 1B, 2B); Oostegite 1 (Fig. 3A) as wide as long, subtriangular in shape; posterolateral point broad and setose, extending straight back; digitate ridge with five small lobes; oostegites 2–5 progressively longer until oostegite 5 over four times as long as wide, with long simple setae posteriorly. Pereopods (Figs. 3C, D) relatively small, posterior ones slightly larger and with smaller dactyli; carpi with tufts of setae distally; meri with scales of external margin.

Pleon of six distinct pleomeres. Lateral plates absent; pleomeres deeply separated by lateral notches. Five pairs of flaplike, biramous pleopods extending out from ventral surface of pleon, partially covering it; exopodites subcircular, larger than respective endopodites and latter elongated (Fig. 2F). Uropods absent; terminal pleomere bilobed with midposterior notch (Figs. 1, 2A, B, F).

Paratype male (Figs. 4,5): total length 1.59mm, maximal width 0.69mm, head length 0.12mm, head width 0.42mm, pleon width 0.70mm, pleon length 0.39mm. Body with sides irregularly subparallel, tapering lightly anteriorly, head abruptly narrower than pereon, broadest at pereomere 4.

Head nearly rectangular, almost straight anteriorly, separated from much broader first pereomere at posterolateral corners, fused medially (Fig. 4A). Eyes small laterally placed (Fig. 4A). Antennule (Fig. 5A) with three articles, decreasing in size, distal and middle articles with foursimple setae both; antenna 2 (Fig. 5B) with three articles, middle article longer and distal article narrower, four simple setae on distal article.

Pereomeres distinct dorsally and laterally, obscurely separated ventrally, varying in width with 3 and 4 being wider (Figs. 4A, B). Pereopods (Figs. 5C,D) large, increasing slightly in size posteriorly, all with setae on carpi and propodi; carpi and meri not distinctly separated with scales.Pleon completely fused, margins sinuous (Figs. 5A, B). Five pairs of uniramous pleopods, discoid and subrectangular in shape; decreasing in size posteriorly. Posterior end of pleon extending out from margin of body, ventrally bearing conspicuous anal cone (Fig. 4B).

Type locality. Rio Massangana (8º21'31.45''S 34º57'42.91''W), Suape, Pernambuco, Brazil (Fig. 6).

Distribution. This species has so far only been recorded for the Southwestern Atlantic, off the coast of Pernambuco in Brazil (Fig. 6).

Remarks. The characters of *Ovobopyrus odoya* **sp. nov.** overall match those proposed by Markham (1985) in the original description of the genus *Ovobopyrus* body outline smoothly oval, nowhere abruptly narrowing; head separated from pereon laterally but fused posteriorly; barbula with single, broad, flaplike lateral projection at each side; and the non-articulating maxilliped palp. This genus currently has only one described species, *Ovobopyrus alphezemiotes* Markham, 1985, infesting *Alpheus armillatus* H. Milne Edwards, 1837, collected from Florida. The female of *Ovobopyrus odoya* **sp. nov.** is similar to *O. alphezemiotes* in the body outline suboval, longer than wide, broadest at pereomere 3; barbula with flaplike lateral projection at each side; on the first four pereomeres. However, they differ mainly in the distortion angle, the two large lobes on the posterior half of the head's dorsal surface; setation of oostegite 1 posterolateral point inner ridge digitated (Table 1). A detailed comparison of *O. odoya* **sp. nov.** and *O. alphezemiotes* can be found in Table 1.

Discussion

The genus *Ovobopyrus* is now composed of two species of parasites: the type-species *O. alphezemiotes* and now Ovobopyrus odoya sp. nov.

However, the genera *Allobopyrus* Bourdon, 1983, *Discorsobopyrus* Boyko, 2004, *Litobopyrus* Markham, 1982, *Ogyridione* Markham, 1988, *Palaemonellione* Markham, 1989, *Parabopyriscus* Markham, 1985, *Parabopyrus* Shiino, 1934, *Probopyrione* Bourdon, 1983, *Probopyriscus* Markham, 1982, *Septembopyrina* An, Boyko & Li, 2015 and *Urobopyrus* Richardson, 1904 still remain monotypic (WoRMS, 2025)

Since new species and new locality and host records records are being discovered in Brazil (Ribeiro et al. 2020; Horch et al. 2024) and Further investigations are needed in terms of sampling, documentation and descriptions to better understand the diversity and phylogenetic relationships within the subfamily Bopyrinae.

Table 1. Comparison of taxonomically important morphological characters for females and males of the species of *Ovobopyrus*.

	Ovobopyrus alphezemiotes Markham, 1985	*Ovobopyrus odoya* sp. nov.
Female		
Distortion angle	34º	50º
Head anterolateral projections	absent	present
Head lobes on dorsal surface of head	Two, posterior half	absent
Antennule with	2articles	3 articles
Antennae distal article one with	single terminal seta	ten small and simple setae
Maxilliped palp	trifurcate, lacking setae	rounded, with nine setae
Pereopods carpi tufts of setae distally	without	with
Pleopods endopodites	larger than respective exopodites	shorter than respective exopodites
Male		
Body (ration length: width)	2.0x	2.5x
Head distal margin	concave	convex
Eyes	large, diffuse,extending onto first pereomere	small, not difuse, not extending onto first pereomere
Antennule middle and	five and three simple setae, respectively	three and four simple setae, respectively

distal articles		
Antenna 2 with	2 articles	3 articles
Pereopod 1-7 with scales of meri and carpi	without	with
Pleomeres	suboval	subrectangular
Pleon (ration length: width)	1.3x	1.6x
Host	*Alpheus armillatus* H. Milne Edwards, 1837	*Alpheus carlae* Anker, 2012
Distribution	Florida, Gulf of Mexico, EUA	Pernambuco, Brazil
Reference	Markham, 1985	present contribution

Key for Bopyrinae genera from Brazil (based on adult females)

1. Uropods tiny or absent ……. 2

1’. Uropods developed ……...……...…… 8

2. Barbula with one pair of projections on each side ……... 3

2’. Barbula with two pairs of projections on each side ……..…….. 5

3. Pleomeres well separated on both sides ……...…… 4

3’. Pleomeres fused in short side ….……...…… *Bopyrina* Kossmann, 1881

4. Maxilliped palp non-articulating ……..…. *Ovobopyrus* Markham, 1985

4’. Maxilliped palp articulating ..…….. *Probopyrinella* Nierstrasz & Brender à Brandis, 1929

5. All pleomeres fused …… *Bopyrella* Bonnier, 1900

5’. Pleomeres distinctly separated …… 6

6. Head distinctly extended into anterolateral horns ……. 7

6’. Head not anterolaterally extended …… *Probopyrus* Giard & Bonnier, 1888

7. Coxal plates absent …… *Capitetragonia* Pearse, 1953

7’. Coxal plates present …… *Parabopyrella* Markham, 1985

8. Uropods uniramous …… *Parapleurocrypta* Chopra, 1923
8’. Uropods birramous ..... *Urobopyrus* Chopra, 1923

Key to all species of *Ovobopyrus* (based on adult females)

1. Head with two large lobes on posterior half of dorsal surface; maxilliped produced into irregulary shaped, non-articulating palp lacking setae; first oostegite with smoothinner ridge ..... *Ovobopyrus alphezemiotes* Markham, 1985
1’. Head without large lobes on posterior half of dorsal surface; maxilliped produced into non-articulating palp with nine long setae; first oostegite with five small projections on internal ridge ..... *Ovobopyrus odoya* **sp. nov.**

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Figure Legends

Figure 1. *Ovobopyrus odoya* **sp. nov.**, female holotype 4.83 mm (MOUFPE 22035). A = dorsal view, B = ventral view. Scale bars = 1 mm.

Figure 2. *Ovobopyrus odoya* **sp. nov.**, female holotype 4.83 mm (MOUFPE 22035). A, habitus dorsal; B, habitus ventral; C, right antennule; D, right antenna; E, barbula; F, pleon. Scale bars = 0.05 mm.

Figure 3. *Ovobopyrus odoya* **sp. nov.**, female holotype 4.83 mm (MOUFPE 22035). A, left oostegite; B, left maxilliped; C, right pereopod 1; D, right pereopod 7. Scale bars: A and B = 0.5 mm; C and D = 0.1 mm;

Figure 4. *Ovobopyrus odoya* **sp. nov.**, male paratype, 1.59 mm (MOUFPE 22036). A, habitus dorsal; B, habitus ventral. Scale bars = 0.5 mm.

Figure 5. *Ovobopyrus odoya* **sp. nov**., male paratype, 1.59 mm (MOUFPE 22036). A,right antennule; B, right antenna; C, right pereopod 1; D, right pereopod 7. Scale bars: 0.1 mm.

Figure 6. Distribution map of *Ovobopyrus odoya* **sp. nov.** in northeastern Brazil.

Figures

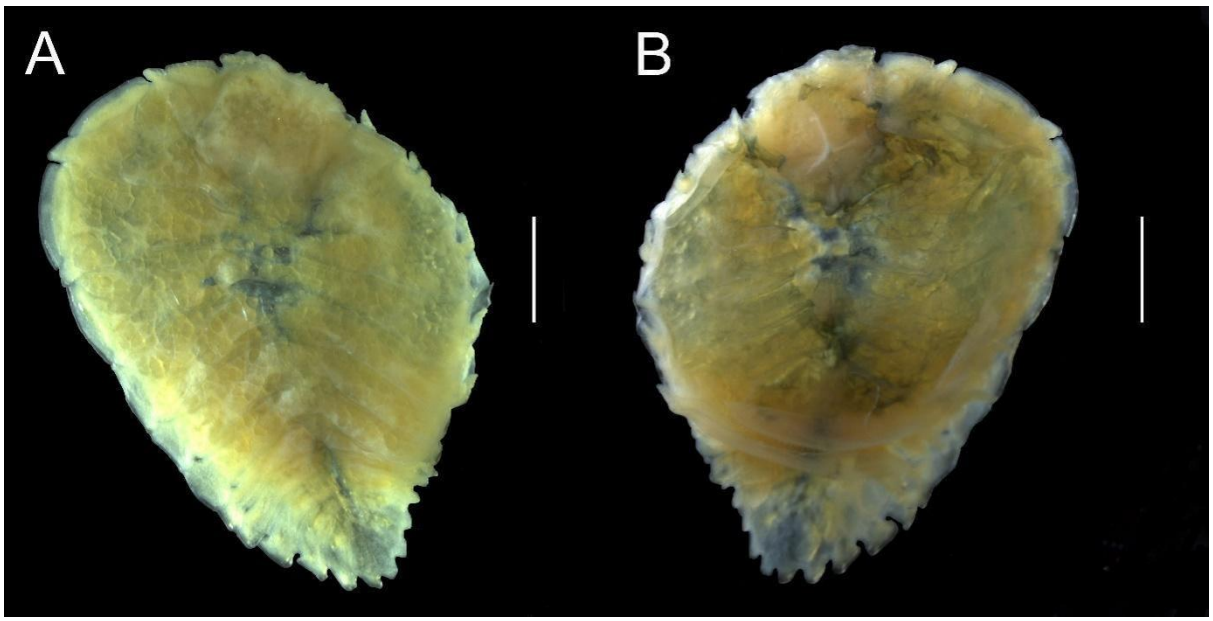

Figure 1. *Ovobopyrus* **sp. nov.**, female holotype, 4.83 mm TL (MOUFPE 22035). A = dorsal view, B = ventral view. Scale bars = 1 mm.

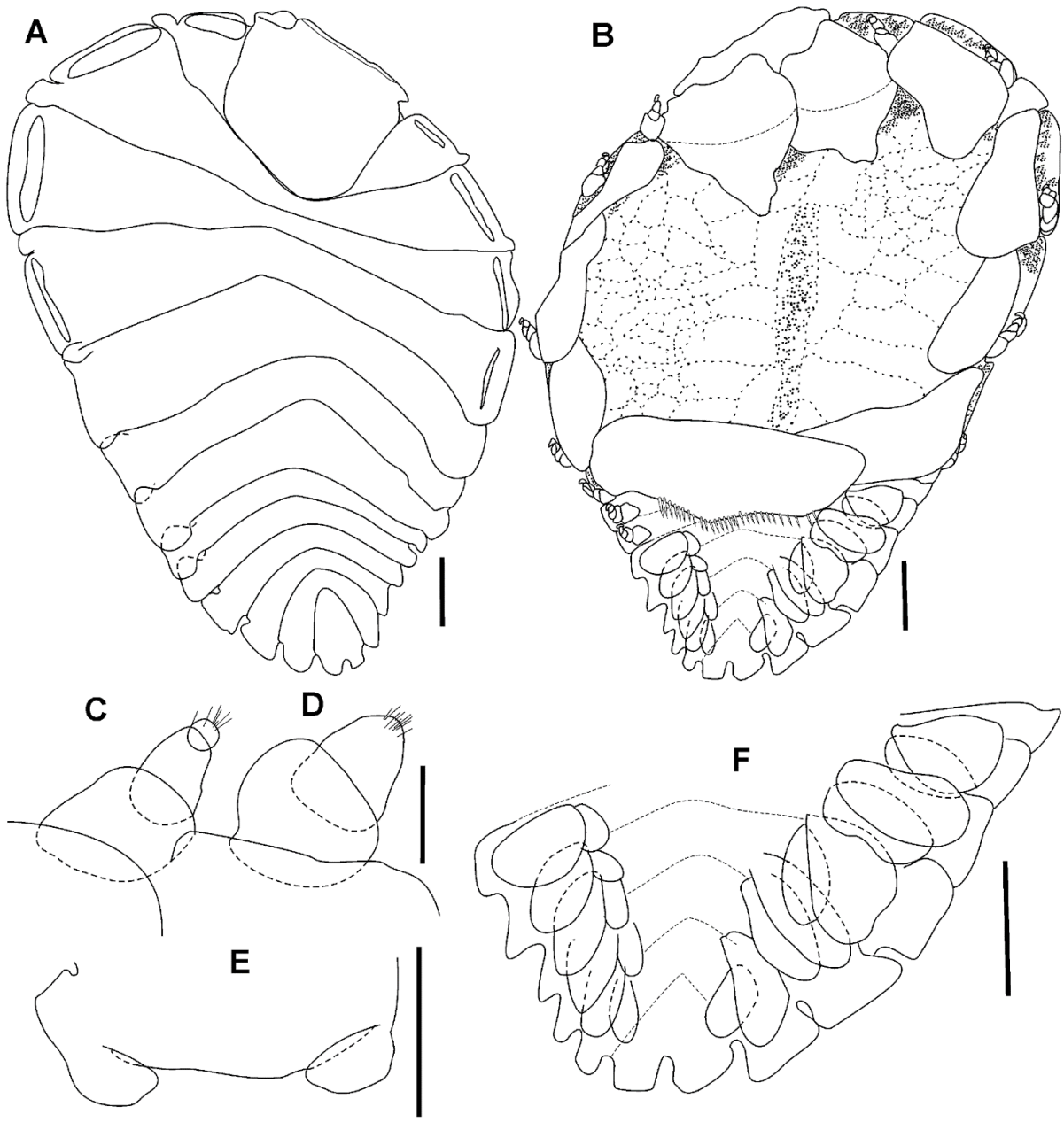

Figure 2. *Ovobopyrus* **sp. nov.**, female holotype, 4.83 mm TL (MOUFPE 22035). A, habitus dorsal; B, habitus ventral; C, antenna 1; D, antenna 2; E, barbula; F, pleon. Scale bars = 0.05 mm.

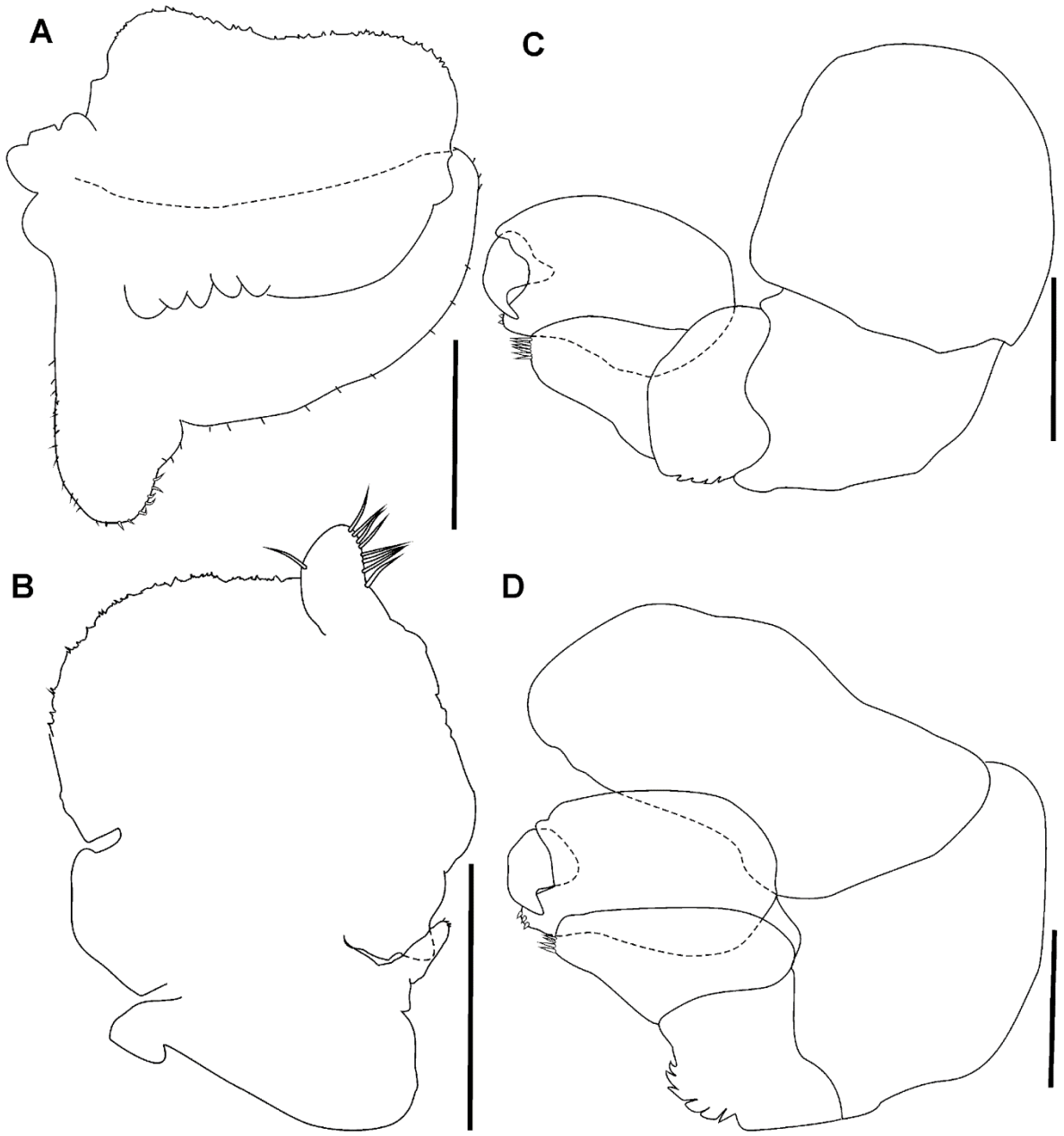

Figure 3. *Ovobopyrus* **sp. nov.**, female holotype, 4.83 mm TL (MOUFPE 22035). A, Oostegite; B, Maxilliped; C, pereopod 1; D, pereopod 7. Scale bars: A and B = 0.5 mm; C and D = 0.1 mm;

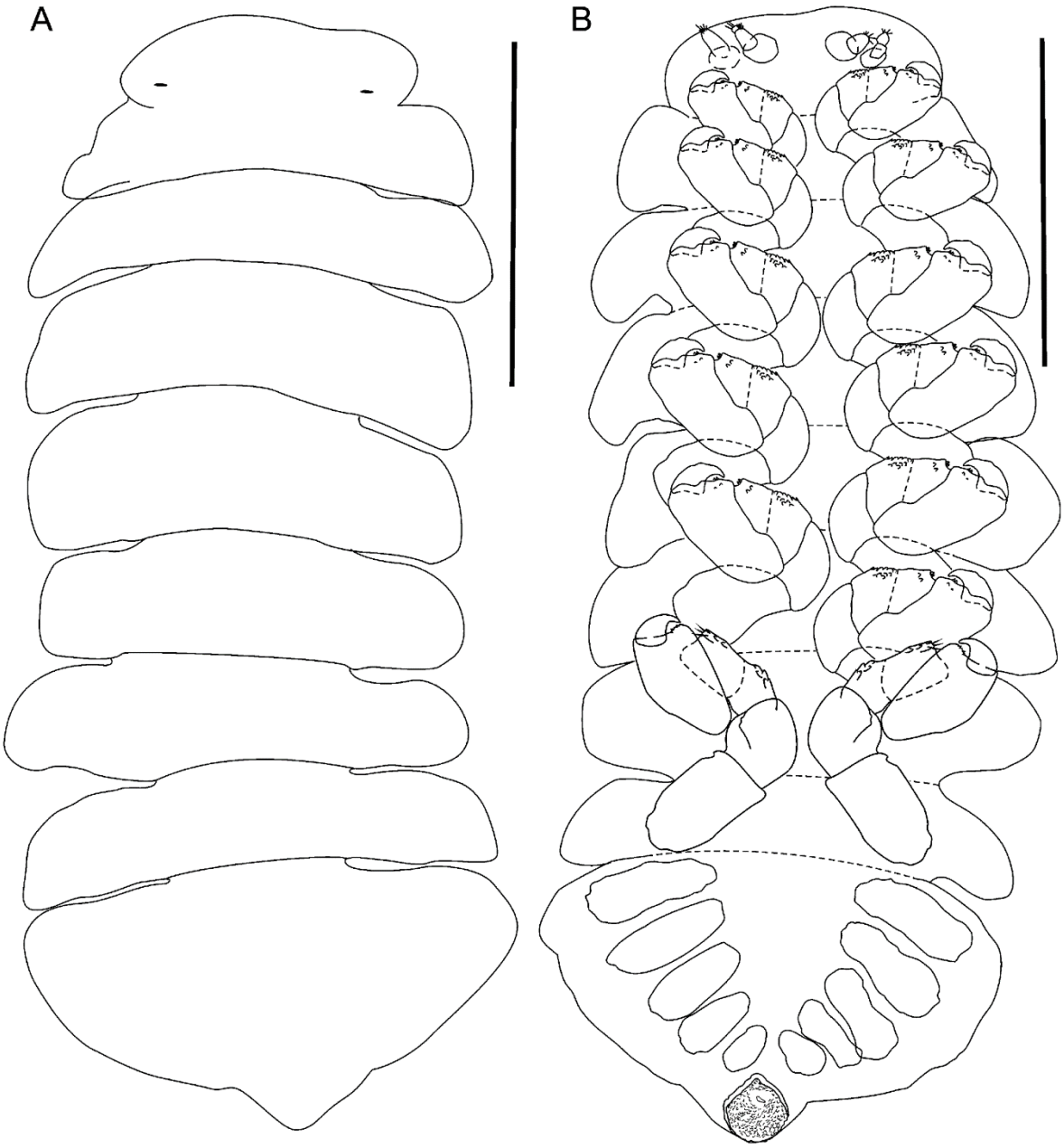

Figure 4. *Ovobopyrus* **sp. nov.**, male paratype, 1.59 mm TL (MOUFPE 22036). A, habitus dorsal; B, habitus ventral. Scale bars = 0.5 mm.

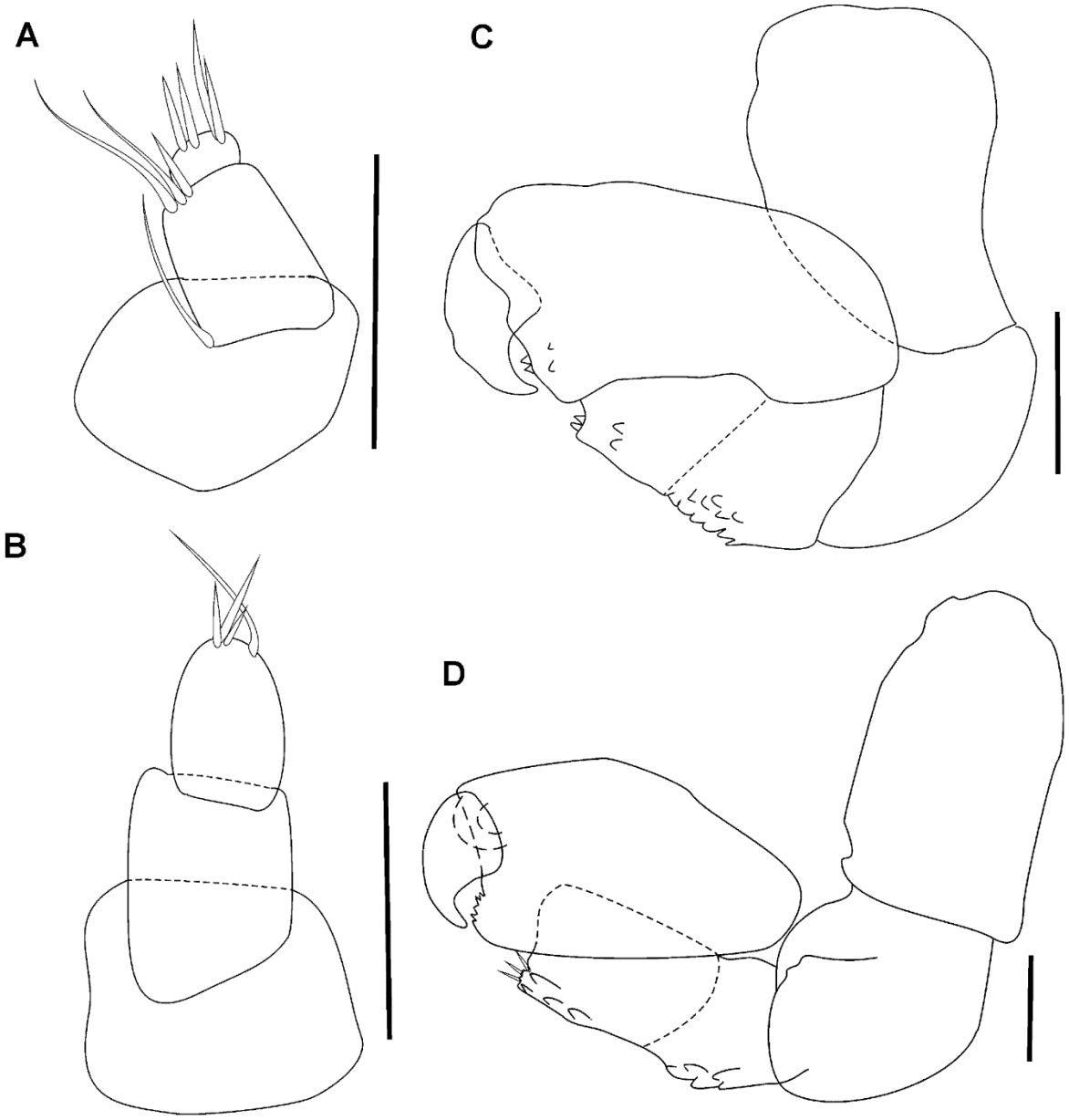

Figure 5. *Ovobopyrus* **sp. nov**., male paratype, 1.59 mm (MOUFPE 22036). A, antenna 1; B, antenna 2; C, pereopod 1; D, pereopod 7. Scale bars: 0.1 mm.

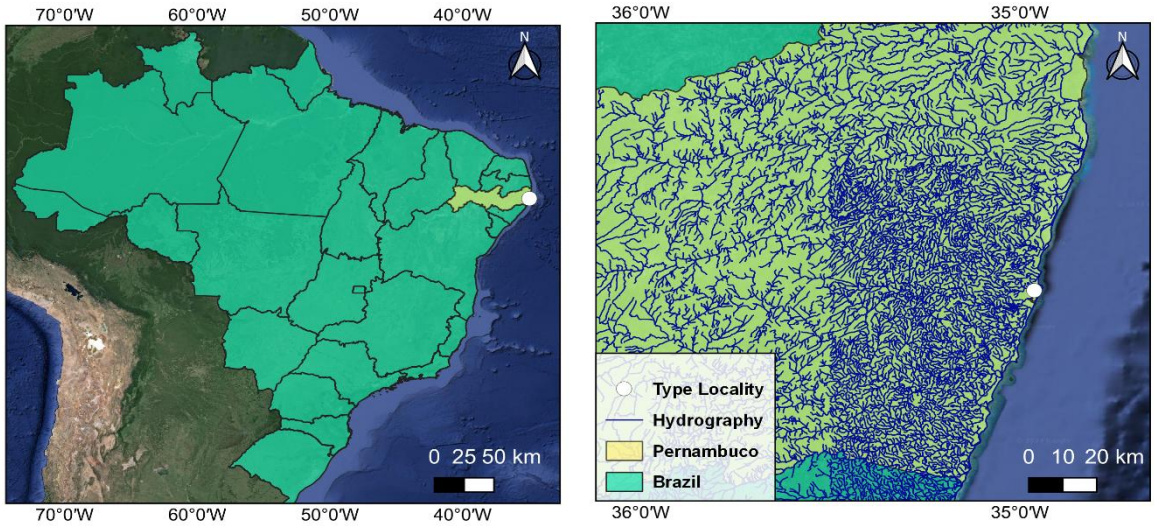

Figure 6. Distribution map of *Ovobopyrus* **sp. nov.** in northeastern Brazil.

6 CONSIDERAÇÕES FINAIS

Neste trabalho descrevemos o novo registro da espécie *Parabopyrella richardsonae* parasitando três camarões da família Alpheidae, *Alpheus estuariensis*, *Salmoneus carvachoi* e *Alpheus formosus* e uma nova espécie do gênero *Ovobopyrus* parasitando também um camarão alfeídeo, *Alpheus carlae*. Apresentamos chaves dicotômicas de identificação dos gêneros da família Bopyridae ocorrentes no Brasil e de comparação entre as duas espécies de *Ovobopyrus* e de *P.richardsonae* com *P.lata,* únicas representantes do gênero no Brasil. Estes resultados ampliam o número de espécies registradas da família Bopyridae, de 29 para 31 aumentando também a sua distribuição geográfica com novos registros para a América do Sul. Foi possível quantificar a prevalência dos parasitos correlacionando a população parasitada com a não parasitada das espécies *A. estuariensis* e *S.carvachoi*, ambas apresentaram um valor menor que 1%, corroborando com outros trabalhos da literatura. As análises de relação entre o tamanho do parasito fêmea e o tamanho da carapaça do hospedeiro foi positiva, enquanto que não houve diferença significativa entre o tamanho da carapaça da população parasitada, da não parasitada de *A. estuariensis*. Em relação aos camarões fêmeas, quando comparamos a quantidade de ovos dos dois grupos houve diferença significativa, indicando que a presença do parasito dificulta a produção e manutenção de ovos no pléon dos camarões. Estes resultados biológicos indicam que o parasito possui certa influencia na biologia dos seus hospedeiros e que estudos mais específicos são necessários para esclarecer essas lacunas.