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A NEW SPECIES OF *EUPELTE* (COPEPODA: HARPACTICOIDA: PELTIDIIDAE) FROM ANCHIALINE CAVES IN BERMUDA

Nueva especie de *Eupelte* (Copepoda: Harpacticoida: Peltidiidae) de cuevas anquihalinas de Bermuda

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ABSTRACT

A new anchialine species of *Eupelte* (Copepoda: Harpacticoida: Peltidiidae) is described from tidal pools and submerged passages in Bermuda caves. It is the sixth anchialine harpacticoid species known from Bermuda and the first anchialine member worldwide of the family Peltidiidae. The genus *Eupelte* currently contains 16 valid species, of which five have been found in the Atlantic Ocean, four in the Pacific Ocean, three in the Indian Ocean, two in the Mediterranean Sea, one in arctic waters and the last one in antarctic waters.

Keywords: subterranean estuary; Copepoda; stygiobiont; anchialine cave.

RESUMEN

Una nueva especie de *Eupelte* (Copepoda: Harpacticoida: Peltidiidae) es descrita de las galerías sumergidas de cuevas en Bermuda. Esta es la sexta especie anquialina de copépodo harpacticoide conocida para Bermuda, y la primera especie anquialina de la familia Peltidiidae. El género *Eupelte* presenta hasta el momento 16 especies válidas, de las cuales cinco especies han sido encontradas en el Océano Atlántico, cuatro en el Océano Pacifico, tres en el Océano Índico, dos en el Mar Mediterráneo, una en aguas árticas y la especie restante en aguas antárcticas.

Palabras clave: estuario subterráneo; Copepoda; estigobio; cueva anquialina.

INTRODUCTION

Harpacticoid copepods makeup a significant component of the world's anchialine (saline or brackish waters with subterranean connections to the sea) cave fauna, with a few planktonic or symbiotic. They represent at least 15 species from eight genera and six families (Table I). The harpacticoid Family Superornatiremidae contains the most, with nine anchialine species

(Huys, 1996; Jaume, 1997). These anchialine harpacticoids were found from submerged limestone and volcanic caves as well as connected groundwater aquifers. They include five species in Bermuda, three in the Balearic Islands, two each in Western Australia and North Vietnam, plus single species in Belize, Bahamas, and Canary Islands.

Bermuda represents an exceptional global hotspot for anchialine cave biodiversity (Iliffe & Calderón-Gutiérrez, 2021) with the Walsingham Cave System containing 78 described anchialine species of which 20 are copepods and five harpacticoids. It is not clear why Bermuda has the highest level of anchialine species, although possible explanations include the island's isolated mid-Atlantic location, Pleistocene age limestone, and fluctuating sea levels which alternately submerged and exposed the anchialine caves.

Currently there are 16 valid species of the Genus *Eupelte* Claus, 1860: *Eupelte acutispinis* Zhang & Li, 1976 (China); *Eupelte aurulenta* Wells & Rao, 1987 (India); *Eupelte beckleyae* Hicks, 1982 (South Africa); *Eupelte bicornis* Claus, 1863 (North Sea); *Eupelte cubensis* Varela & Gomez, 2013 (Cuba); *Eupelte gracilis* Claus, 1860 (Mediterranean Sea); *Eupelte hexaseta* Hicks, 1982 (South Africa), *Eupelte minuta* (Ramirez, 1971) (Argentina); *Eupelte oblonga* Claus, 1886 (Mediterranean Sea); *Eupelte purpurocincta* (Norman, 1869) (Shetland Islands); *Eupelte regalis* Hicks, 1971 (New Zealand); *Eupelte setacauda* Monk, 1941 (California, USA); *Eupelte simile* (Monk, 1941) (California, USA); *Eupelte tristanensis* Wiborg, 1964 (Tristan da Cunha); *Eupelte typica* (Scott T., 1912); *Eupelte villosa* (Brady, 1910) (Tierra del Fuego); *Eupelte oblivia* Scott A., 1909 (South Orkneys) is currently accepted as *Alteuthellopsis oblivia* (Scott A., 1909), (Walter & Boxshall, 2021).

Table I. Worldwide anchialine Harpacticoida

Family	**Genus species**	**Authors**	**Location**
Ameiridae	*Nitokra humphreysi*	Karanovic & Pesce, 2002	W. Australia
	Nitokra vietnamensis	Tran & Chang, 2012	North Vietnam
Novocriniidae	*Novocrinia trifida*	Huys & Iliffe, 1998	Belize
Peltidiidae	*Eupelte hughesi* **n. sp**	This paper	Bermuda
Rotundiclipeidae	*Rotundiclipeus canariensis*	Huys, 1988	Canary Islands
Superornatiremidae	*Intercrusia problematica*	Huys, 1996	Bermuda
	Intercrusia garciai	Jaume, 1997	Balearic Islands
	Neoechinophora daltonae	Huys, 1996	Bermuda
	Neoechinophora fosshageni	Huys, 1996	Bermuda
	Neoechinophora jaumei	Huys, 1996	Bermuda
	Neoechinophora xoni	Jaume, 1997	Balearic Islands
	Neoechinophora sp.	Huys, 1996	Bahamas
	Superornatiremis mysticus	Huys, 1996	Bermuda
	Superornatiremis mendai	Jaume, 1997	Balearic Islands
Tachidiidae	*Microarthridion thanhi*	Tran & Chang, 2012	North Vietnam
Tetragonicipitidae	*Phyllopodopsyllus wellsi*	Karanovic, Pesce & Humphreys, 2001	W. Australia

OBJECTIVES

- To describe a new species of copepod from the family Peltidiidae collected in a cave in Bermuda.

MATERIALS AND METHODS

Bermuda Cherry Pit Cave (32° 20.73'N, 64° 42.64'W) consists of a 30 m long by 12 m deep, water-filled fissure in Walsingham's Idwal Hughes Nature Reserve (Fig. 1). Cherry Pit is adjacent and likely connected to the Palm Cave System, a complex series of submerged caverns and collapsed entrances (Iliffe & Calderón-Gutiérrez, 2021). It is located midway across the isthmus separating Harrington Sound and Castle Harbour. Tidal flushing of seawater moves through these caves such that salinity at deeper depths remains close to that of the surrounding ocean. The water level in the entrance pools from the Palm System and adjacent Cherry Pit fluctuate with the tides but with reduced amplitude and a two-hour delay from ocean tides. The surface water in the small entrance pool at Cherry Pit Cave has a salinity of 28.5, increasing to 35.4 at 1 m depth.

Collections from Cherry Pit Cave between 1982 and 1987 used a Deck Plankton Collector (Anderson, 2004) or scuba cave divers with 30 cm diameter, 93 µm mesh hand or plankton net (Iliffe, 2018). Copepoda were the most abundant organisms in these collections, numbering in the hundreds, followed in decreasing order by Ostracoda, Mollusca, Cumacea, Polychaeta, Amphipoda, and Chaetognatha. Among the Copepoda, *Epacteriscus rapax* Fosshagen, 1973 and *Miostephos leamingtonensis* Yeatman, 1980 were plentiful in collections from Cherry Pit Cave, along with a few specimens of a *Metacalanus* species (Fosshagen et al., 2001).

The abbreviations used in the text are: ae, aesthetasc; P1, Leg 1; P2, Leg 2; P3, Leg 3; P4, Leg 4, and P5, Leg 5.

RESULTS

Taxonomic Account

Order Harpacticoida
Family Peltidiidae Claus, 1860
Subfamily Peltidiinae Claus, 1860
Genus *Eupelte* Claus, 1860
(Figs. 2-4)

Eupelte hughesi **sp. nov**.

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Type material

Holotype. Non ovigerous female. 810 µm. BERMUDA. Collected in Cherry Pit Cave, 32° 20.73'N, 64° 42.64'W, 22.iii. 1987. 0-3 meters deep; col. T. Illife. National Museum of Natural History (USNM #1593336). Paratypes: One dissected non ovigerous female on slide (USNM #1593337); 16 non ovigerous females 805 µm (805 µm -810 µm) (USNM #261446).

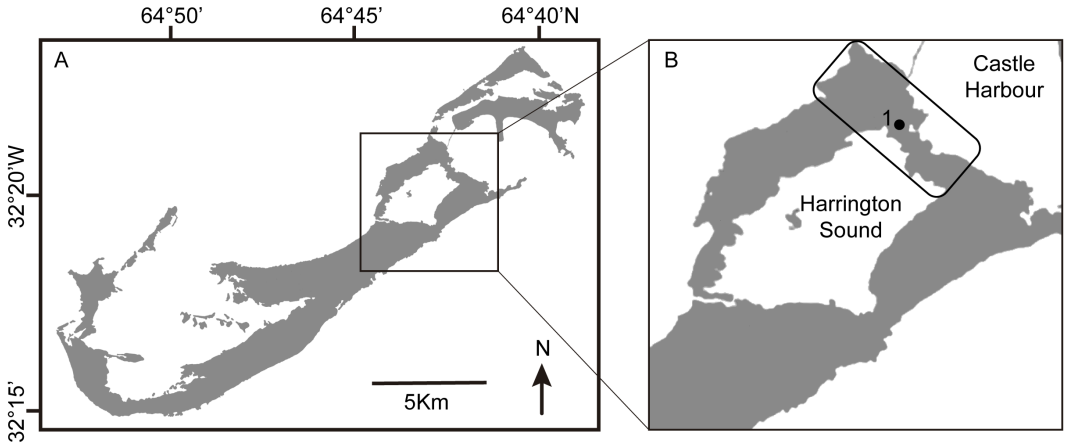

Figure 1. Map of Bermuda. **A)** With cut-away; **B)** showing location of Cherry Pit Cave (#1), located in the isthmus of land between Harrington Sound and Castle Harbour. The rectangle indicates the approximate dimensions of the Walsingham Karst Region. Modified from Iliffe and Calderón Gutiérrez (2021).

Diagnosis (English). *Eupelte hughesi* **n. sp.** is unique with P1 endopod having six distal setae, small pointed projections on the lateral first third of the cephalothorax and four setae on the third article of the endopod of legs P2-P4. These six setae are only shared by *E. hexaseta* Hicks, 1982. Nevertheless, *E. hughesi* **n. sp.**, differs from *E. hexaseta* in the small pointed projections on the lateral first third of the cephalothorax and the four setae on the third article of the endopod of legs P2-P4. In addition, *E. hexaseta* lacks the small pointed projections on the lateral first third of the cephalothorax and having five setae on the third article of the endopod in legs P2-P4. In additon, the female P5 terminal spines are thin and fine, whereas in *E. hexaseta* the are stout and hirsute on all spines.

Diagnosis (Spanish). *Eupelte hughesi*, **n. sp.** es único con el endópodo de P1 con seis setas distales, pequeñas proyecciones puntiagudas en el primer tercio lateral del cefalotórax y cuatro setas en el artejo 3 del endópodo de las patas P2-P4. Estas seis setas en el endópodo de P1, solo las comparte *E. hexaseta* Hicks, 1982. Sin embargo, *E. hughesi* **n. sp.**, se diferencia de *E. hexaseta* en las pequeñas proyecciones puntiagudas en el primer tercio lateral del cefalotórax y las cuatro setas en el tercer artículo del endópodo de las patas P2-P4. Además, *E. hexaseta* carece de las pequeñas proyecciones puntiagudas en el primer tercio lateral del cefalotórax y tiene cinco setas en el artejo 3 del endópodo en las patas P2-P4. Además, las espinas terminales de P5 de la hembra son delgadas y finas, mientras que en *E. hexaseta* estas espinas son robustas e hirsutas.

DESCRIPTION

Female

Total length. 810 µm. Prosome: Urosome ratio (590 µm: 320 µm), including rostrum and caudal rami and width 460 µm at the widest point of prosome. Body flattened dorsoventrally, weakly arched along the midline, ovoid in shape, without a complex pattern of chitinous thickenings

cephalothorax with four somites. Posterior dorsal margins on each somite finely serrated and with a row of tactile hairs, and each lateral corner sharply produced posteriorly, with several lateral setae on each. Rostrum wide and trapezoid, not defined at the dorsal surface, and the tip bends downwards and forwards (Fig. 2D). Urosome consists of four somites. Genital double somite is rectangular and wide, with two large posteriorly directed protrustions at midlength. Second abdominal somite corners spinelike posteriorly directed, third somite is small and narrow and anal somite is almost as wide as the third abdominal somite. Each segment with lateral setae rows and posterior margins finely serrated (Fig. 2A). Caudal rami slightly longer than wide with oblique posterior margin terminating with one long and three short setae, one mediolateral plumose seta and two subdistial surface setae on the back side, medial and lateral margins with spinule rows (Fig. 2E).

Antennule. 9-segmented, first article with fine spinules along distolateral surface. Articles four and nine with 4+ae. The setae formula is as follows: 1; 7; 5; 3+ae; 2; 2; 2; 2; 6+ae (Fig. 2B).

Antenna. Rectangular basipod, twice as long as wide, with distolateral seta, a small 2-segmented exopod, first with one terminal seta as long as the basipodite, second segment small rounded with three terminal setae. Endopod 2-segmented, rectangular with medial seta, second segment elongated with two distal setae, and five terminal setae, five are geniculate and one small and simple (Fig. 2C).

Maxillule. With a long narrow and distally directed praecoxapod segment, with seven distomedial strong setae, one terminal strong spine and two setae. Coxopod small with three setae and basipodite with five setae and an unguiform spine. Endopod represented by one seta and exopod with three setae (Fig. 3A).

Maxilla. Praecoxapod flattened and rectangular with three endites, proximal one with one simple and one finely spinulose setae, the medial and distal with two and three, setae respectively. Endopodite reduced and represented by three setae. Basal endite narrow bearing one strong unguiform seta and one simple setae (Fig. 3B).

Mandible. Thin and elongated precoxa with five strong distal spines, three are bidentate and one tridentate, a simple and spinulous seta at internal bulge. Endopod with five spiny setae and small narrow exopod with three simple terminal setae (Fig. 3C).

Maxilliped. Terminally prehensile, slender, basipod narrow elongated with two subterminal medial setae. Exopod 2-segmented, first segment ovoid inflated proximally and slightly concave along medial surface, medial margin with typically 11 stout spines, second segment distally elongated as curved pointed claw with a tiny basal seta (Fig. 2F).

Leg1 with elongated rectangular coxopod. Basipod with a long proximal and a large mediolateral seta with spinules along outer margin. Exopod 3-segmented, the second is the longest of the three with two setae, the first with one seta, the third short, almost as wide as long with four curved strong spines. Endopod 2-segmented, the first with one medial seta and second with six terminal setae (Fig. 3D).

Legs 2-4 with a pair of 3-segmented exopods and endopods swimming legs. The setae and spine formula are as follows: Coxa no spines or spinules. Basis with one terminal setae. Exopod I-1:0; II-1:1; III-3:5 and Endopod I-0:1; II-0:2; III-0:5 (Figs. 3E , 4A, 4B).

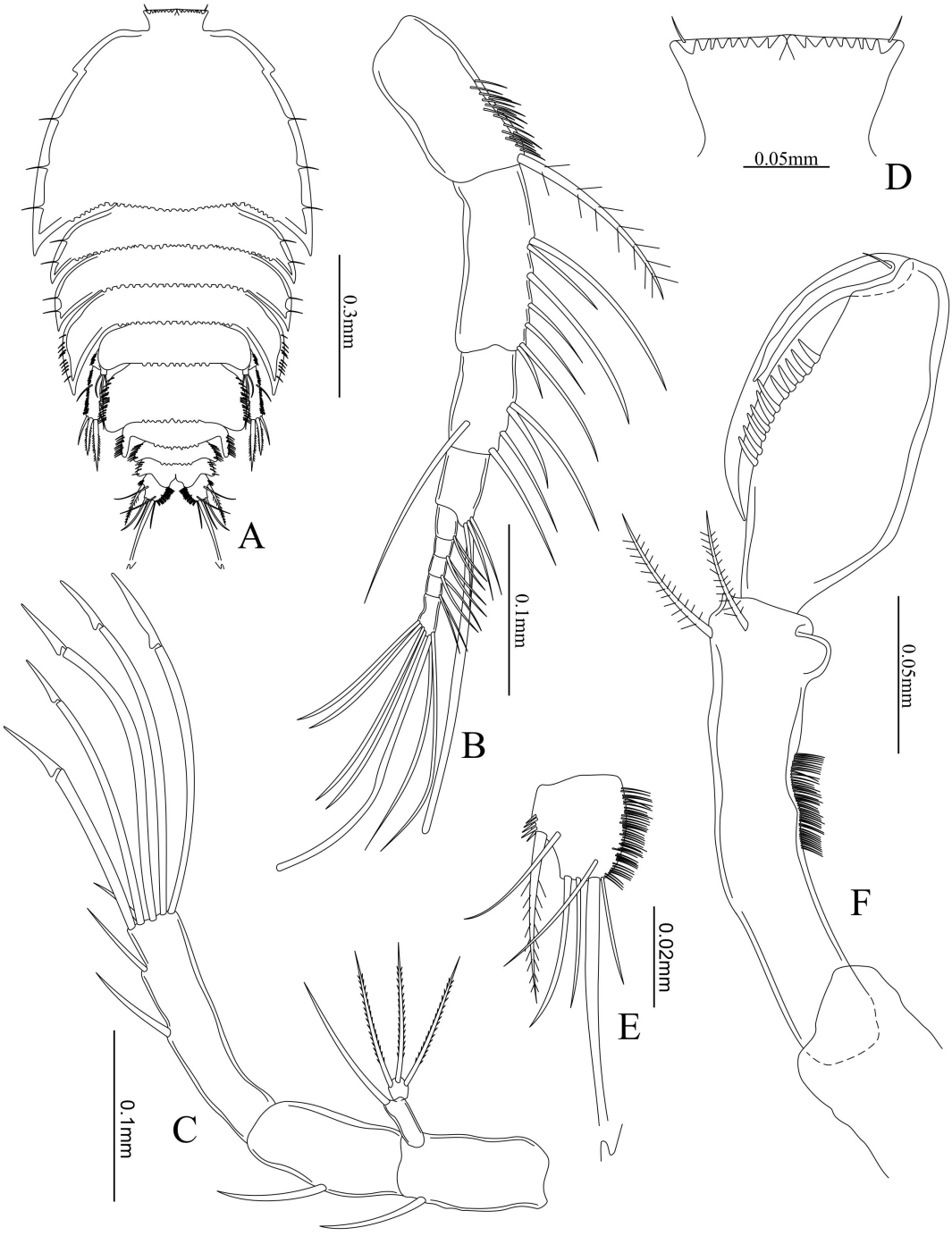

Figure 2. Eupelte hughesi **sp. nov.**, female holotype. **A)** Dorsal view; **B)** antennule; **C)** antenna; **D)** rostrum; **E)** caudal ramus; **F)** maxilliped.

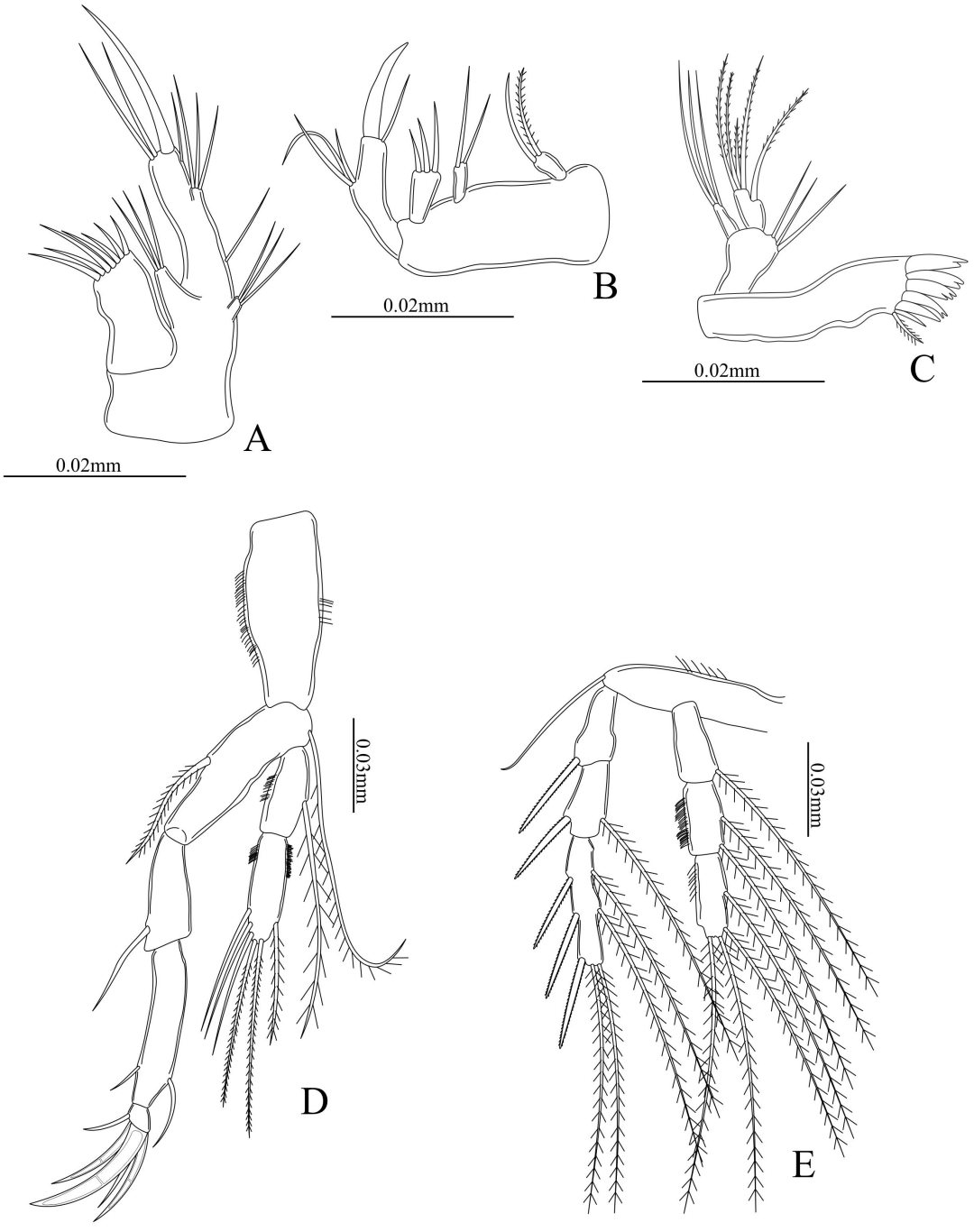

Figure 3. Eupelte hughesi **sp. nov.**, female holotype. **A)** Maxillule; **B)** maxila; **C)** mandible; **D)** Leg 1; **E)** leg 2.

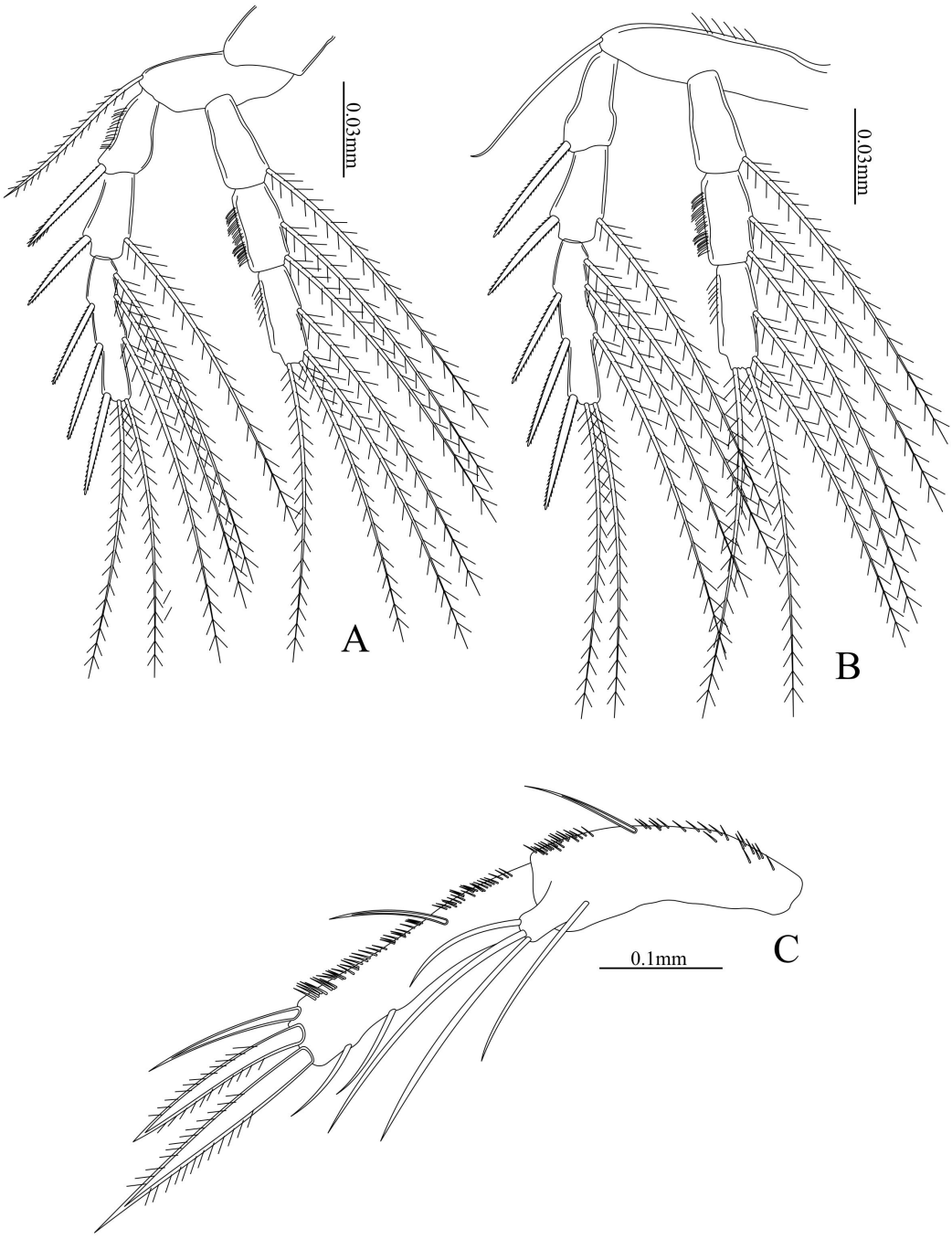

Figure 4. Eupelte hughesi **sp. nov.**, female holotype. **A)** Leg 3; **B)** leg 4; **C)** leg 5.

The seta and spine formula are as follows:

Leg	Exopod	Endopod
P2	0: 1: 223	1: 2: 220
P3	0: 1: 323	1: 2: 220
P4	0: 1: 323	1: 2: 220

Leg 5 with baseoendopod bilobed. Outer lobe with one seta and a row of spines on the outer margin. Inner lobe short, inserted on anterior surface of baseoendopod, with a large simple seta near its base and three longer setae distally. Exopod elongate, with two outer, two inner and one larger terminal hairy setae. Outer margin with minute spines (Fig. 4C).

Male: unknown.

Etymology. Eupelte hughesi is named in recognition of the Idwal Hughes Nature Reserve, the type locality for this species.

Remarks. *Eupelte hughesi* **n. sp.** presents a combination of two characters that are unique in the genus *Eupelte*. The P1 endopod having six distal setae only shared by *E. hexaseta* Hicks, 1982 and the presence of small pointed projections on the lateral first third of the cephalothorax, character only shared by *E. gracilis* Claus, 1860. *Eupelte hughesi* **n. sp.** has P1 endopod having six distal setae, small pointed projections on the lateral first third of the cephalothorax and four setae on the third article of the endopod of legs P2-P4. These six distal setae on P1 endopod are only shared by *E. hexaseta*. Nevertheless *E. hughesi* **n. sp.**, differs from *E. hexaseta* in the small pointed projections on the lateral first third of the cephalothorax and the four setae on the third article of the endopod of legs P2-P4. In addition, *E. hexaseta* lacks the small pointed projections on the lateral first third of the cephalothorax and having five setae on the third article of the endopod in legs P2-P4. In additon, the female P5 terminal spines are thin and fine, whereas in *E. hexaseta* the are stout and hirsute on all spines. *Eupelte gracilis* Claus, 1860, present the small pointed projections on the lateral first third of the cephalotorax. This species has been redescribed on several occasions but some of the diagnostic characters of those redescriptions sometimes don't match, this suggests that it may be a species complex (Varela & Gomez, 2013). Nevertheless, *E. hughesi* **n. sp.** presents the P1 endopod having six distal setae and the leg 5 of the female present 5 setae on the basoendopod and 6 setae on the exopod (5:6) and *E. gracilis* present the P1 endopod having four distal setae and a different armature in the leg 5 of the female.These differences presented here are sufficient to justify the recognition of a new species.

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