

First record of *Lucicutia gaussae* (Calanoida, Lucicutiidae) from Korean waters

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Two species (*Lucicutia clausi*, *L. flavicornis*) of *Lucicutia* (Lucicutiidae Sars, 1902) have been reported in Korean waters and one species (*L. gaussae*) is newly added the Tsushima Warm Current realm. Specimens from Korean waters are morphologically consistent with previous morphological characteristics of *L. gaussae*, but these differ in the following characteristics: 1) the male antennule with one process on segments XIX-XX, one process on segment XVIII, and three processes on segments XXI-XXIII; 2) in male leg 5, basis of left leg in the Korean specimen with small spine processes on the protrusion; 3) in male leg 5, the third exopodal segment of left leg without an inner marginal spine. In this study, we provide a re-description of *L. gaussae* insufficiently described by previous authors.

Keywords: Copepoda, *Lucicutia*, Lucicutiidae, Korean waters, Tsushima Warm Current

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INTRODUCTION

Family Lucicutiidae Sars, 1902 consisting of one genus *Lucicutia* Giesbrecht, 1898 was initially considered a subfamily Centropagidae Giesbrecht, 1893, but was later established into a family by Sars (1902). The genus *Lucicutia* was first established as *Leuckartia* by Claus (1863), but was replaced by *Lucicutia* by Giesbrecht (1898, in Giesbrecht and Schmeil, 1898). However, Wilson (1924) replaced *Leuckartia* with the generic name *Rudolfia* Wilson, 1924. *Isochaeta* Giesbrecht, 1889 became a synonym for *Lucicutia* by Grice (1963). Later, Hulsemann (1989) proposed removing *Isochaeta* and preserving *Lucicutia*.

In the worldwide ocean, the genus *Lucicutia* is currently composed of 45 species (Walter and Boxshall, 2023) and geographically occurs widely from the tropic to the polar region (Boxshall and Halsey, 2004). Also, *Lucicutia* species are recorded mainly in mesopelagic or bathypelagic oceans, but some species are done in epipelagic or coastal waters.

In this study, *L. gaussae* Grice, 1963 is newly re-described in addition to two *Lucicutia* species (*Lucicutia clausi* (Giesbrecht, 1889), *Lucicutia flavicornis* (Claus, 1863) known so far in Korean waters. The species has not been sufficiently described by previous authors, key traits

for species identification, and the geographical distribution of *L. gaussae*.

MATERIALS AND METHODS

Zooplankton samples were collected from Korean waters (Fig. 1), using a conical net (mesh size 200 µm) with a mouth diameter of 60 cm and Multiple Opening/Closing Net and Environmental Sampling System equipped with a 200 µm mesh size (BESS, USA). After dividing the collected samples, samples were fixed final concentration of 5% with neutralized formaldehyde for morphological description. *Lucicutia gaussae* were sorted out and dissected under a dissecting microscope (SMZ745T; Nikon, Japan) in CMC-10 aqueous mounting medium (Masters, Wood Dale, IL, USA), mounted on slides, and then sealed with high-quality nail varnish. Drawings were generated using a differential interference contrast microscope (ECLIPSE 80i, Nikon, Tokyo, Japan) equipped with a drawing tube and digital pen display (Cintiq 22HD, Wacom, Kazo, Japan). Morphological terminology follows Huys and Boxshall (1991). Voucher specimens were deposited in the National Marine Biodiversity Institute of Korea (MABIK), Seocheon, South Korea.

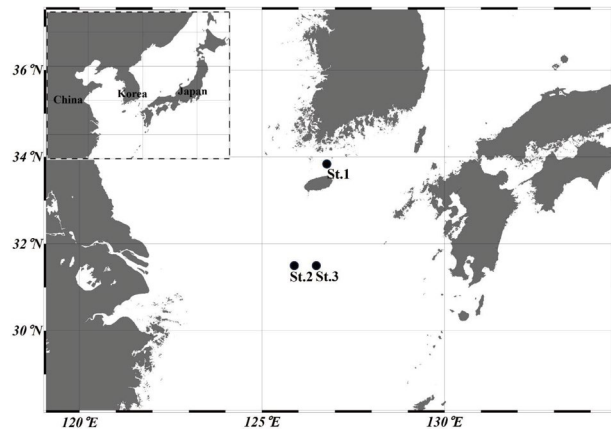


Fig. 1. Map of study area showing sampling location.

SYSTEMATIC ACCOUNTS

Order Calanoida Sars G. O., 1903
 Family Lucicutiidae Sars G. O., 1902
 Genus *Lucicutia* Giesbrecht, 1898

***Lucicutia gaussae* Grice, 1963 (Figs. 2–5)**

Korean name: 정타원형가시살갓노벌레 (신칭)

Lucicutia ovalis Wolfenden, 1906: p. 28, pl. 9, figs. 7–10;
 Wolfenden, 1911: p. 319, fig. 61; Mori, 1937(1964):
 p. 72, pl. 36, figs. 6–13; Grice, 1962: p. 222, pl. 24, figs.
 5–9; Chen and Zhang, 1965: p. 84, pl. 33, figs. 7–12.

Lucicutia gaussae Hulsemann, 1966: p. 715, figs. 92, 93,
 122; Ali-Khan and Ali-Khan, 1982: p. 267, figs. 14–18;
 Bradford-Grieve *et al.*, 1999: p. 883, 945, fig. 7.304;

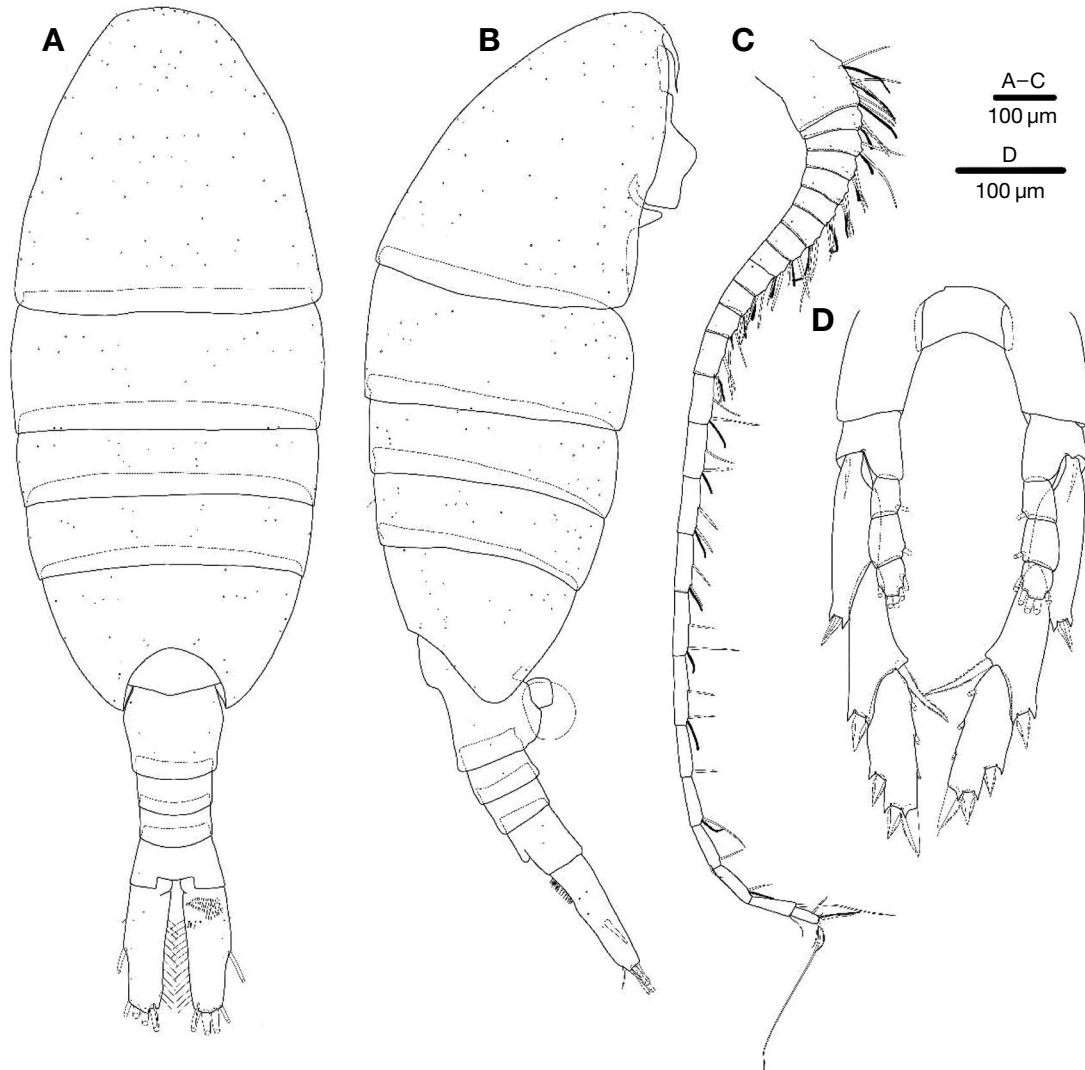


Fig. 2. *Lucicutia gaussae* Grice, 1963, female. A, Habitus, dorsal; B, Habitus, right lateral; C, Antennule; D, Leg 5. Scale bars in μm .

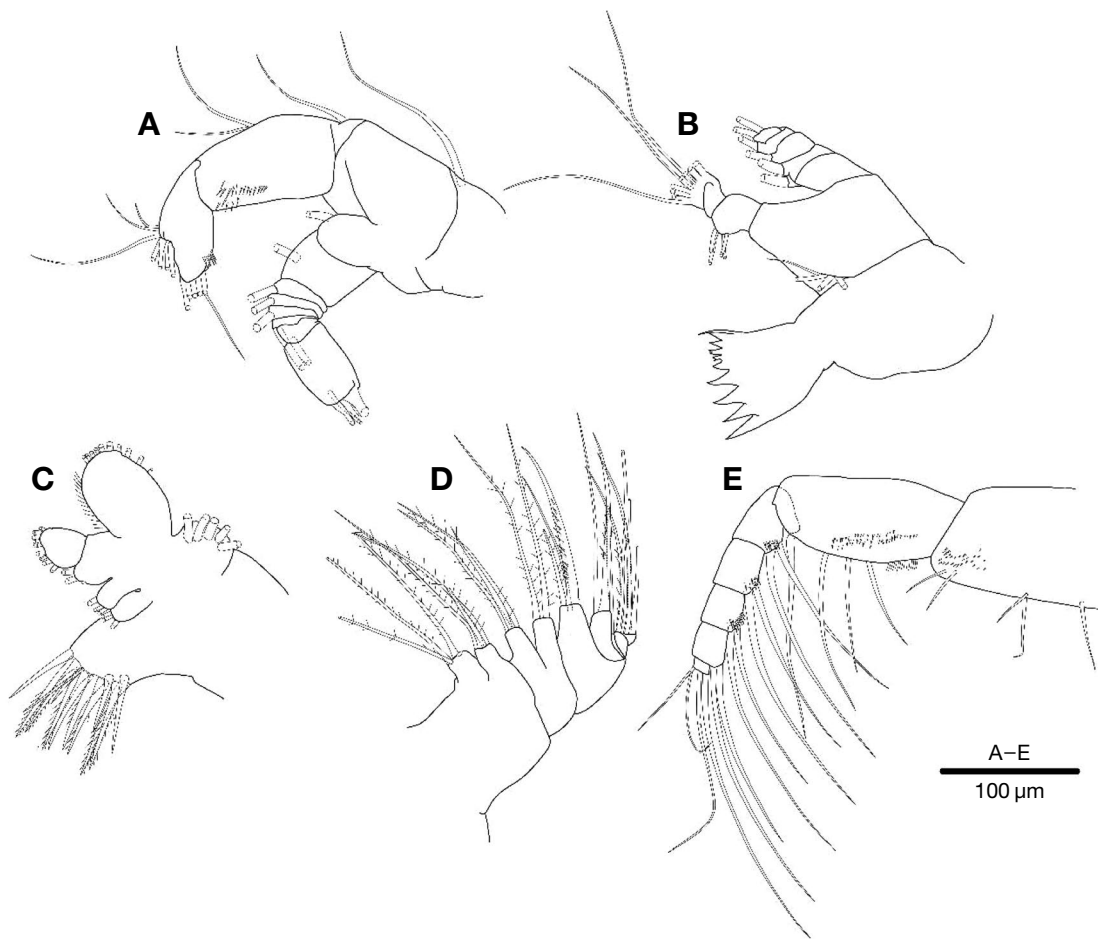


Fig. 3. *Lucicutia gaussae* Grice, 1963, female. A, Antenna; B, Mandible; C, Maxillule; D, Maxilla; E, Maxilliped. Scale bars in μm .

Prusova *et al.*, 2012: p. 173, figs. 166–169.

Material examined. 1 ♀ (MABIK CR00254251) dissected in 12 slides glasses, 1 ♂ (MABIK CR00254252) dissected in 12 slides glasses, 17 ♀♀, 25 ♂♂, South Sea (St. 1), 33°50'21.23"N, 126°46'43.78"E, Oct. 2022; 11 ♀♀, 4 ♂♂, East China Sea (St. 2), 31°30'0"N, 125°53'3"E, Nov. 2022; 3 ♀♀, 1 ♂, East China Sea (St. 3), 31°30'0"N, 126°28'59.88"E, Nov. 2022. 20 individuals were used for length measurement.

Description. Female. Body length 1.35–1.47 mm ($n=10$). Body elongated; cephalosome separated from first pedigerous somite; cephalosome rounded, without protrusions; rostrum with a pair of slender filaments; fourth and fifth pedigerous somites fused; posterolateral corners of fourth pedigerous somite symmetrical and rounded (Fig. 2A, B). Urosome 4-segmented; genital double somite in dorsal view about as wide as long, and in lateral view with ventral protrusion; anal segment slightly long than second and third urosomites; anal segment and caudal rami separated (Fig. 2A, B). Caudal rami symmetrical, slightly long and wide. Caudal rami with 6 setae,

second terminal setae longer than other terminal setae (Fig. 2A, B).

Antennule symmetrical, longer than body length. 25-segmented (Fig. 2C). Fusion pattern and setal formula as follows: I-III-5 + 3ae (aesthetasc), IV-2 + ae, V-2 + ae, VI-2 + ae, VII-2 + ae, VIII-2 + ae, IX-2 + ae, X-2 + ae, XI-2 + ae, XII-2 + ae, XIII-2 + ae, XIV-2 + ae, XV-2 + ae, XVI-2 + ae, XVII-2 + ae, XVIII-2 + ae, XIX-2 + ae, XX-2 + ae, XXI-2 + ae, XXII-1, XXIII-1 + ae, XXIV-1 + 1, XXV-1 + ae, XXVI-1 + 1, XXVII-XXVIII-6 + ae.

Antenna biramous (Fig. 3A), exopod slightly larger than endopod; coxa with 1 seta; basis with 1 seta; endopod 2-segmented, first endopodal segment with 2 setae at about middle, row of spinules on distal; second endopodal segment with 7 and 6 setae on proximal and distal lobes, respectively and row of spinules on distal lobe; exopod 8-segmented with setal formula 1, 1, 1, 1, 1, 1, 1, 4.

Mandible with coxal gnathobase and biramous palp; gnathobase with 9 sharp teeth; basis of mandibular palp with 4 setae; endopod 2-segmented, setal formula 4, 10; exopod 5-segmented, setal formula 1, 1, 1, 1, 2 (Fig. 3B).

Maxillule praecoxal arthrite with 13 stout setae; coxal

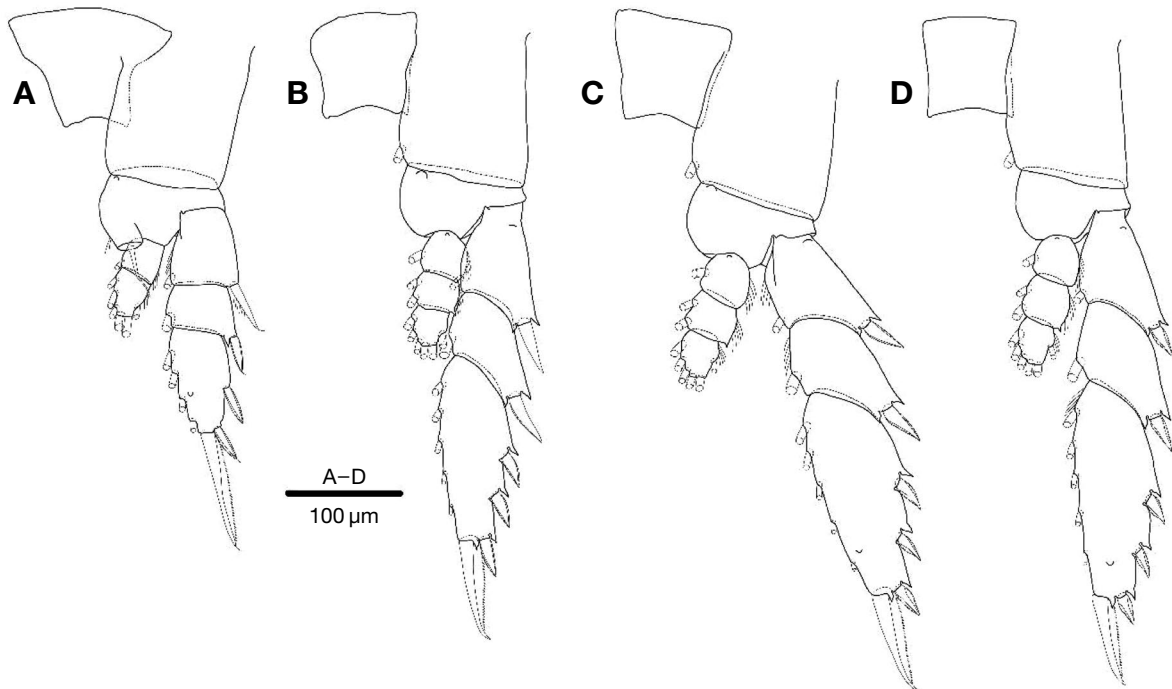


Fig. 4. *Lucicutia gaussae* Grice, 1963, female. A, Leg 1; B, Leg 2; C, Leg 3; D, Leg 4. Scale bars in μm.

endite with 3 setae and epipodite with 5 setae; basis proximal and distal endite with each 3 setae; endopod 1-segmented, with 4 + 5 setae; exopod 1-segmented, with 11 setae (Fig. 3C).

Maxilla 7-segmented; praecoxa with 2 endites, proximal with 4 setae, distal 3 setae; coxa with 2 endites, with each 3 setae; basis with 3 setae; endopod indistinctly 4-segmented, setal formula 2, 1, 2, 3 (Fig. 3D).

Maxilliped 7-segmented; coxa fringed with row of small teeth distally, endite setal formula 0, 1, 2, 2; basis fringed with row of small teeth, small setula distally and with 3 setae; first endopodal segment almost fully incorporated into basis with 2 setae; endopod 5-segmented, segmental setal formula 2, 2, 2, 2, 3 + 1 (Fig. 3F).

Legs 1 to 4 biramous: leg 1 with 2-segmented endopod and 3-segmented exopod, leg 2 to 4 with 3-segmented endopod and 3-segmented exopod (Fig. 4A–D). Coxa of leg 1 without seta; basis with cylindrical process, with slender inner basal seta (Fig. 4A). Coxa of leg 2 to 4 with inner marginal seta (Fig. 4B–D). Setae and spine formula of leg 1 to 4 as follows (spines, Roman numerals; setae, Arabic numerals):

	Coxa	Basis	Exopodal segment	Endopodal segment
Leg 1	0-0	0-1	I-1; I-1; II,I,4	0-1; 1,2,3
Leg 2	0-1	0-0	I-1; I-1; III,I,5	0-1; 0-2; 1,2,3
Leg 3	0-1	0-0	I-1; I-1; III,I,5	0-1; 0-2; 1,2,3
Leg 4	0-1	0-0	I-1; I-1; III,I,5	0-1; 0-2; 1,2,3

Fifth leg symmetrical: coxa without seta, and basis with outer seta; endopod and exopod with each 3-segmented; endopod not reach 1/2 of the second exopodal segment; inner marginal spine of second exopodal segment than about 1/2 length of third exopodal segment; terminal seta of third exopodal segment short, less than about 1/3 length of segment (Fig. 2D).

Male: Body length 1.25–1.41 mm (n = 10). Similar in habitus to female except urosome. Urosome 5-segmented; anal segment almost same length as previous urosomite; anal segment and caudal rami separated (Fig. 5A, B). Leg 1 to 4 similar to female.

Left antennule geniculate, reaching of anal segment. 21-segmented (Fig. 5C, D). Fusion pattern and setal formula as follows: I-III-6 + 3ae (aesthetasc), IV-2 + ae, V-2 + ae, VI-2 + ae, VII-2 + ae, VIII-2 + ae, IX-2 + ae, X-2 + ae, XI-2 + ae, XII-2 + ae, XIII-2 + ae, XIV-2 + ae, XV-2 + ae, XVI-2 + ae, XVII-2 + ae, XVIII-1 + ae, XIX-XX-1 + ae, XXI-XXIII-2 + ae, XXIV-XXV-3 + ae, XXVI-1 + 1, XXVII-XXVIII-6 + ae. Segments XVIII and XIX-XX each with 1 process; segments XXI-XXIII with 3 processes.

Fifth leg asymmetrical: coxa without seta (Fig. 5E). Right leg biramous and basis with outer seta; basis smooth with no protrusion; endopod and exopod 2-segmented; second endopodal segment broadly oval-shaped; second exopodal segment curved, setal bundles in medial side; distal margin of segment with spine (Fig. 5E, G). Left leg biramous and basis with outer seta; mediobasal

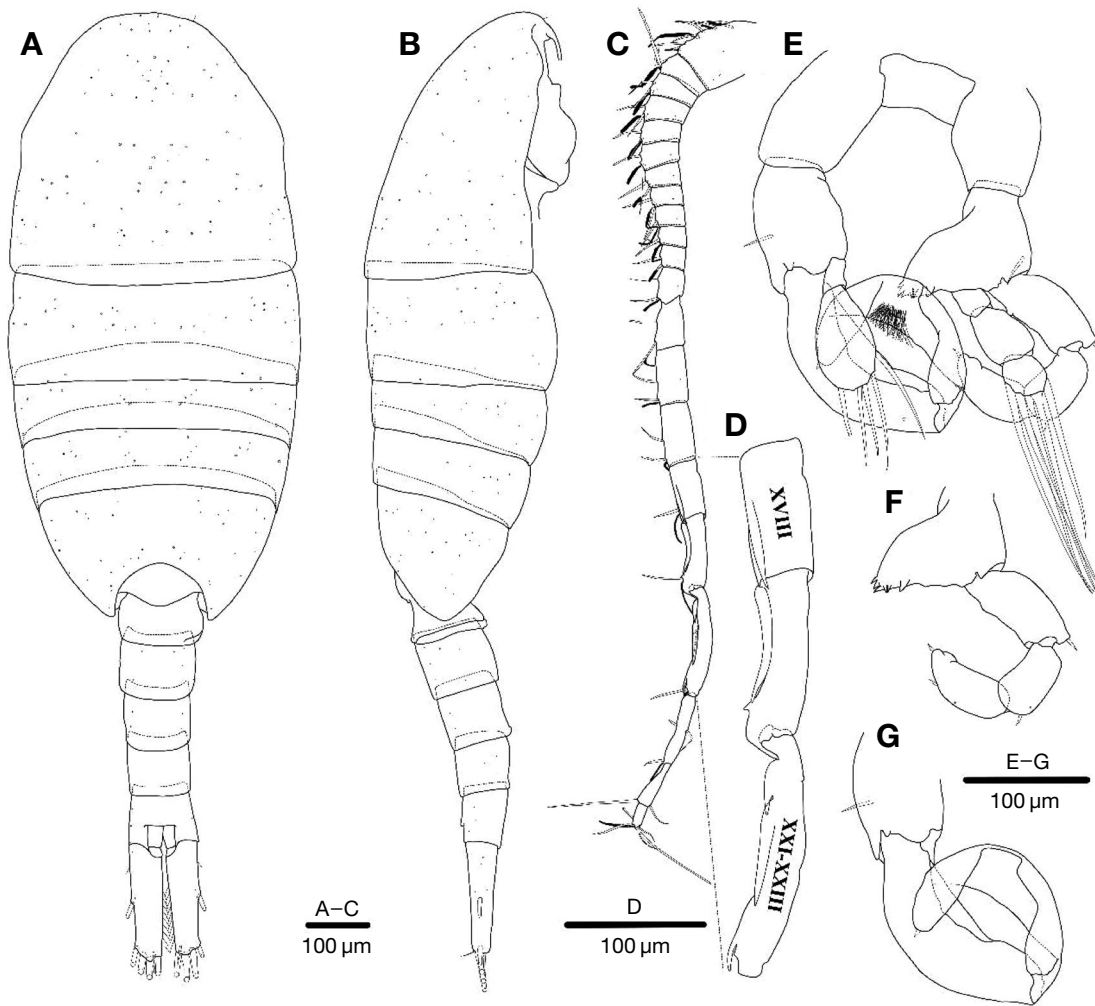


Fig. 5. *Lucicutia gaussae* Grice, 1963, male. A, Habitus, dorsal; B, Habitus, right lateral; C, Left antennule; D, Left antennule XVIII-XXIII segment; E, Leg 5; F, Left leg 5; G, Right leg 5. Scale bars in μm .

margin of basis with large protrusion, adorned small spine processes; endopod and exopod 3-segmented; first and second exopodal segment with outer marginal spine; third exopodal segment with outer marginal spine and terminal spine (Fig. 5E, F).

Distribution. *Lucicutia gaussae* was recorded in the Atlantic Ocean (Wolfenden, 1906; 1911), East China Sea (Mori, 1937(1964)), Pacific Ocean (Grice, 1962), North Atlantic Ocean (Grice, 1963), and Arabian Sea (Ali-Khan and Ali-Khan, 1982; Prusova *et al.*, 2012).

Remarks. The morphological description of *Lucicutia gaussae* was not detailed in previous records. The male antennule of Lucicutiidae family has 1 process on segments XIX and XX, 2 processes on segment XXI, and has morphological characteristics with or without process on segments XXII-XXIII (Boxshall and Hasley, 2004). The male antennule of the Korean specimen has 1 process on segments XIX-XX and 3 processes on segments

XXI-XXIII, similar to the morphological characteristics of males of the Lucicutiidae family, but additionally has 1 process on segment XVIII. The right leg basis of male leg 5 is smooth form and is not similar to other *Lucicutia* species. The basis of the left leg 5 of the male in the Korean specimen has small spine processes on the protrusion, but in previous records (Hulsemann, 1966; Ali-Khan and Ali-Khan, 1982; Bradford-Grieve *et al.*, 1999; Prusova *et al.*, 2012) the protrusion has a pointed shape in the distal direction. In the third exopodal segment of the left leg, an inner marginal spine was present in previous records (Hulsemann, 1966; Ali-Khan and Ali-Khan, 1982; Prusova *et al.*, 2012), but it was not present in the Korean specimen. In female, an individual that appears to have morphological variation was collected from the Korean specimen. The female's right caudal ramus partially adorned with small spines at part adjacent to anal segment. In leg 5, the endopod extends beyond the first exopodal segment,

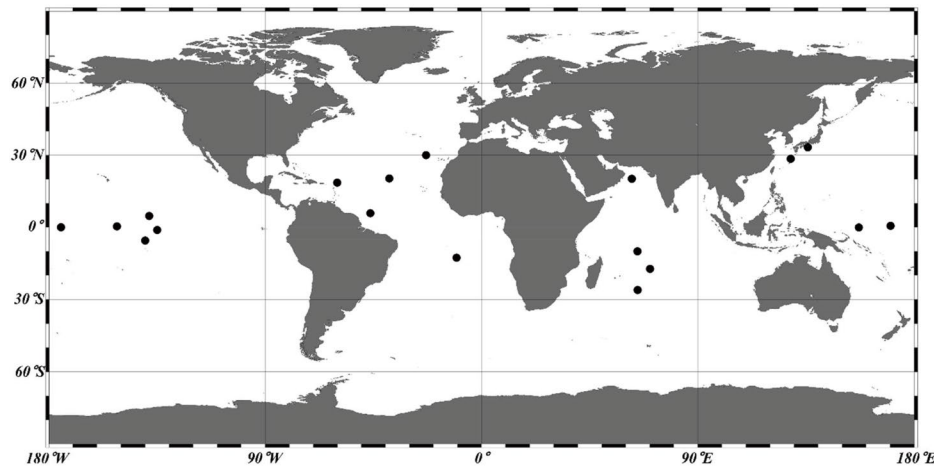


Fig. 6. Distribution of *Lucicutia gaussae* Grice, 1963 based on previous records and on the present study. References are as follows: Wolfenden (1911), Mori (1937), Grice (1962), Hulsemann (1966), Prusova *et al.* (2012).

consistent with previous records, but in the record by Ali-Khan and Ali-Khan (1982), the endopod reaches halfway to the second exopodal segment.

Key to species of genus *Lucicutia* in Korean waters

1. Endopod 3-segmented in leg 1 *L. flavicornis*
- 1a. Endopod 2-segmented in leg 1 2
2. Cephalosome with strong spinelike process on each side *L. clausi*
- 2a. Cephalosome smoothly rounded *L. gaussae*

CONFLICTS OF INTEREST

The author of this paper has no affiliation with any interests and is solely responsible for the paper.

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