

A Newly Recorded Basket Star of Genus *Gorgonocephalus* (Ophiuroidea: Euryalida: Gorgonocephalidae) from the East Sea, Korea

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ABSTRACT

Euryalid specimens were collected from Gonghyeonjin and Daejin, Gangwon-do in the East Sea, Korea at a depth of 250–300 m by fishing nets on November 2013 and August 2014. They were identified as *Gorgonocephalus arcticus* Leach, 1819 belonging to family Gorgonocephalidae of order Euryalida, which was new to the Korean fauna. Nucleotide sequences of partial mitochondrial cytochrome c oxidase I (mt-COI) gene, which was 569 bp in length, were compared among four *Gorgonocephalus* species, and were subsequently employed to reconstruct phylogenetic trees using the MP, ML, and BI methods. As a result, no sequence difference was found between the *G. arcticus* mt-COI gene sequences from Korea and Canada, and the two made a strong monophyletic group. With the newly recorded *G. arcticus* in Korea, in total, four *Gorgonocephalus* species have been reported in Korea.

Keywords: *Gorgonocephalus arcticus*, taxonomy, molecular phylogenetic analyses, mitochondrial COI gene

INTRODUCTION

Family Gorgonocephalidae, comprising 34 genera, is the largest of three families belonging to order Euryalida (Stöhr, 2015), and its four genera (*Astroboa*, *Astrocladus*, *Astrodrum*, and *Gorgonocephalus*) have been reported in Korean fauna (Shin and Rho, 1996; Shin, 2013). Species of this family have very branched five arms and have rings of little hook-like spines forming bands around the branches of each arm. Almost all *Gorgonocephalus* species are exclusively distributed in deep water and are of worldwide distribution (Piepenburg, 2000). This genus has special features such as the presence of arm spines before the first arm fork of arms, disk and arm covered with small stumps or tubercles, disk often naked interradially (Baker, 1980), and the presence of a row of marginal plates on the interbranchial outer margin (Matsumoto, 1917). A family-level revision of order Euryalida based on sequences from mitochondrial genes (16S rRNA and cytochrome c oxidase I [COI]) and a nuclear gene (18S rRNA) from 83 euryalid ophiuroids including *G. chilensis*, *G. eucnemis*, *G. pustulatum*, and *G. tuberosus* was investigated (Okanishi and Fujita, 2013). Only three (*G. dolichodactylus*, *G. eucnemis*, and *G. tuberosus*) of 10 *Gor-*

gonocephalus species have been reported in Korea based on their morphology (Shin, 2013; Kim and Shin, 2015).

Some basket stars were collected from Gonghyeonjin and Daejin, Gangwon-do in the East Sea, Korea at a depth of 250–300 m by fishing nets on November 2013 and August 2014. The specimens were preserved in 95% ethyl alcohol and identified on the basis of morphological characteristics and molecular analyses. The important morphological characteristics were photographed using a digital camera (Nikon D7000, Tokyo, Japan), stereo-microscope (Nikon SMZ 1000), and scanning electron microscope (JEOL JSM-6510, Tokyo, Japan). The sequences of mitochondrial cytochrome c oxidase I (mt-COI) gene were analyzed with newly intended primers (F-TGRGCYGGVACMRYDGGAAACHGC and R-GGRTCHCKCCHC CHGWDGGRTC) for the accurate molecular identification of Korean *Gorgonocephalus* species. DNA was extracted using DNeasy Tissue and Blood Kits (Qiagen, Hilden, Germany), and PCR and phylogenetic analyses were conducted according to Lee and Shin (2011) with minor revision. The phylogenetic trees were inferred from their alignment sequences by maximum parsimony (MP), maximum likelihood (ML), and Bayesian inference (BI) methods. They were identified as *Gorgonocephalus arcticus*

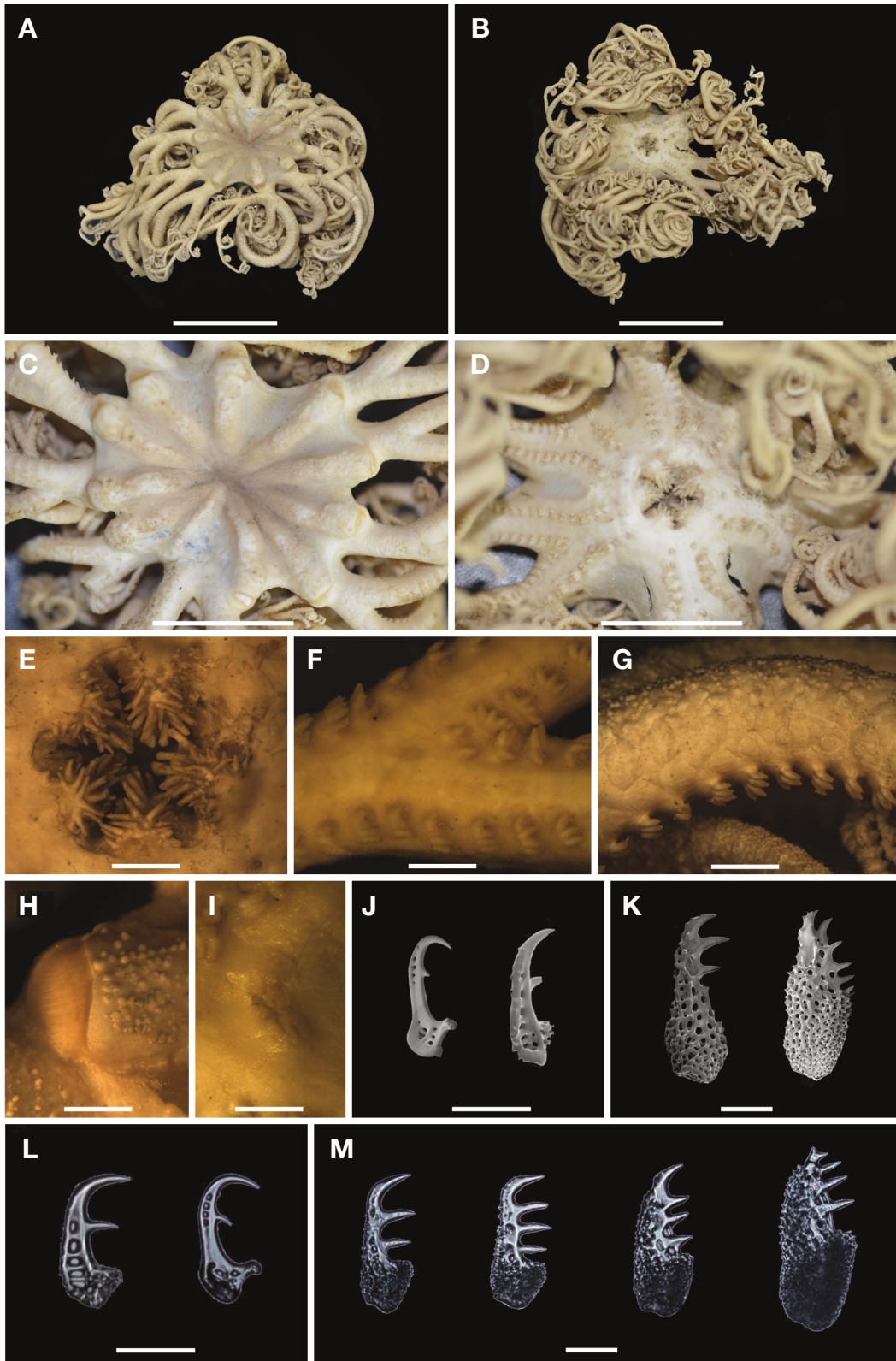


Fig. 1. *Gorgonocephalus arcticus*. A, C, Dorsal view; B, D, Ventral view; E, Oral part; F, Ventral side of arm; G, Lateral side of arm; H, Distal part of radial shield; I, Madreporite; J, K, Arm spines under scanning electron microscope; L, M, Arm spines under light microscope. Scale bars: A, B=2.5 cm, C, D=1.4 cm, E-I=3 mm, J-M=50 μ m.

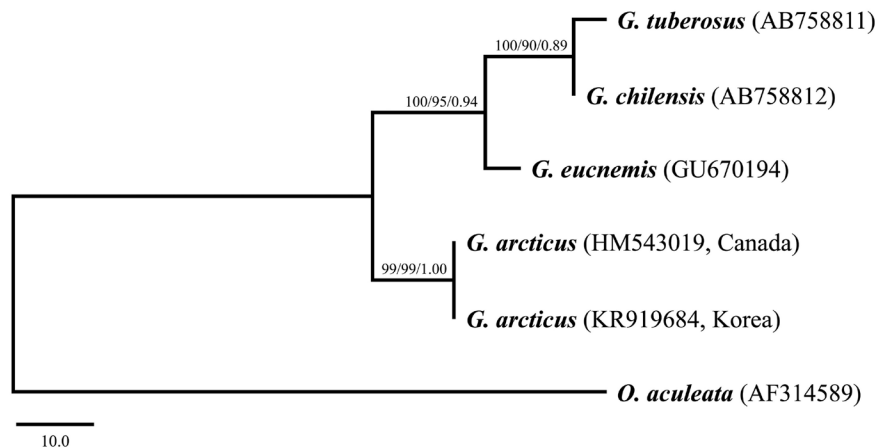


Fig. 2. Maximum parsimony tree inferred from mt-COI, showing phylogenetic relationships among four *Gorgonocephalus* species. Bootstrapping values obtained from maximum parsimony, maximum likelihood, and Bayesian inference methods are shown in each node in order. *G. Gorgonocephalus*; *O. Ophiopholis*.

is characterized having a smooth and thick body, distinctly upwelled disk, and acute spiniform teeth.

Molecular analysis. A total of 569 base pairs (bp) of mt-COI DNA were obtained from Korean *G. arcticus* (GenBank accession number: KR919684), and perfectly correspond to *G. arcticus* sequence data obtained from NCBI (GenBank HM543019, Canada). There were partial sequence gaps comparing to each sequence of other *Gorgonocephalus* species obtained from NCBI: difference as 36 bp from *G. tuberosus* (GenBank AB758811), difference as 32 bp from *G. chilensis* (GenBank AB758812), and difference as 25 bp from *G. eucnemis* (GenBank GU670194) (Table 1). We appointed *Ophiopholis aculeata* as the outgroup, and analyzed the sequence of *G. arcticus* from Korea with those of *G. arcticus*, *G. chilensis*, *G. eucnemis*, and *G. tuberosus* obtained from NCBI. The phylogenetic trees inferred from their alignment sequences by the MP, ML, and BI methods are very similar to each other, with only minor differences (Fig. 2). All trees confirm that the Korean species is clearly different from *G. tuberosus*, *G. eucnemis*, and *G. chilensis*, and Korean *G. arcticus* data are coincident with *G. arcticus* of NCBI data of family Gorgonocephalidae.

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