A new species of the genus *Henricia* (Asteroidea, Spinulosida, Echinasteridae) from South Korea

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Abstract
A new species of the genus *Henricia* Gray, 1840 that belongs to the family Echinasteridae is described from South Korea. *Henricia epiphysialis* sp. nov. has epiphyseal ossicles at the ends of the abactinal and lateral plates, and the abactinal and lateral spines form a hooked crown. The partial sequence of the mitochondrial COXI gene (537 bp) of *H. epiphysialis* sp. nov. was obtained, and the new species was morphologically and genetically compared with other related *Henricia* species.

Keywords
Distribution, DNA barcoding, *Henricia epiphysialis* sp. nov., morphology, taxonomy

Introduction
Echinasteridae Verrill, 1867 is the only family that belongs to the order Spinulosida Perrier, 1884. This family comprises eight accepted genera: *Aleutihenricia* Clark & Jewett, 2010; *Dictyaster* Wood-Mason & Alcock, 1891; *Echinaster* Müller & Troschel, 1840; *Henricia* Gray, 1840; *Metrodira* Gray, 1840; *Odontohenricia* Rowe & Albertson, 1988; *Plectaster* Sladen, 1889; and *Rhopiella* Fisher, 1940 (Mah 2019). Most of the species are found in genera *Echinaster* and *Henricia.*
A total of 11 species that belong to *Aleutihenricia* or *Henricia* have been reported in South Korea: *Aleutihenricia beringiana* Djakonov, 1950 and 10 *Henricia* species, namely, *Henricia anomala* Hayashi, 1973; *Henricia elachys* Clark & Jewett, 2010; *Henricia leviuscula* Stimpson, 1857; *Henricia nipponica* Uchida, 1928; *Henricia ohshimai* Hayashi, 1935; *Henricia pachyderma* Hayashi, 1940; *Henricia pacifica* Hayashi, 1940; *Henricia regularis* Hayashi, 1940; *Henricia reniosa* Hayashi, 1940; and *Henricia sanguinolenta* O.F. Müller, 1776 (Shin 2010; Shin and Ubagan 2015a, b; Ubagan and Shin 2016, 2019a, b, c; Taekjun and Shin 2020). Most species recorded in South Korea including *H. leviuscula*, *H. nipponica*, *H. pachyderma*, *H. regularis*, *H. reniosa*, and *H. sanguinolenta*, are distributed in the East Sea. *Henricia* species can be distinguished by the ratio of arm to disk, shape and number of abactinal spines, and shape of the skeletal plates.

In DNA barcoding, sequence variation in a 658 bp region of the mitochondrial cytochrome *c* oxidase subunit I (*COXI*) gene is used for specimen identification and species discovery (Hebert et al. 2003). An integrative approach to taxonomy (i.e., using morphological characteristics from preserved specimens as well as one to several genes) has become necessary for assessing species diversity and species boundaries (Puillandre et al. 2012).

In this study, we identified a new species that belongs to the genus *Henricia* collected from waters adjacent to the East Sea, South Korea, and performed detailed morphological and molecular mitochondrial sequence analyses. This paper aims to extend the taxonomical insights to *Henricia* species in South Korea by providing a complete description of this new species.

**Materials and methods**

In May and December 2014, sea stars were collected from the East Sea in South Korea by using fishing nets (Fig. 1). The collected specimens were preserved in 95% ethanol and deposited at the National Institute of Biological Resources (NIBR) and Marine Echinoderm Resource Bank of Korea (MERBK), South Korea. The external features of the specimens were observed using a stereomicroscope, and the specimens were identified on the basis of morphological characteristics such as the size of the disk, R/r ratio (R: length of arm; r: radius of the disk), size of the upper and proximal portions of arms, number of abactinal spines, shape of abactinal and actinal skeletons, and number of adambulacral spines. For observing the detailed structures of the specimens such as the shape of the spines and skeletal plates, sodium hypochlorite (5.25% solution) was applied carefully to dissolve the skin (Shin 2010). Then, the specimens were washed with water and observed using the stereomicroscope. The important morphological characteristics of the specimens were photographed using a scanning electron microscope (JEOL JSM-6510), stereomicroscope (Nikon SMZ1000), and digital camera (Nikon D7000). Abbreviations for the measurements were those used by Shin and Ubagan (2015a, b).
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**Figure 1.** Map of Korea showing the collection sites of *Henricia epiphysialis* sp. nov. in the East Sea, South Korea.

Total genomic DNA was isolated from ethanol-preserved tube feet tissue by using a DNeasy blood and tissue DNA isolation kit (Qiagen), according to the manufacturer instructions. The genomic DNA quality and concentration were determined using a Nanodrop ND-1000 spectrophotometer (Thermo Fisher Scientific). All
genomic DNA samples were stored at −20 °C until further use. The partial sequence of the mitochondrial COI gene (658 bp) was amplified using a pair of primers, LCO1490 and HCO2198. PCR was performed using a 25 µL reaction mixture containing 2.5 µL of 10× Ex Taq Buffer containing 20 mM MgCl₂ (Clontech), 1 µL of 2.5 mM dNTPs (Clontech), 1 µL of each primer at 10 pmol, 1.5 µL of the template DNA, 0.3 µL of 5 U/µL Taq polymerase (Clontech), and 17.7 µL of distilled water. The PCR conditions were as follows: initial denaturation at 95 °C/3 min, followed by 35 cycles of denaturation at 95 °C/30 s, annealing at 52 °C/90 s, extension at 72 °C/90 s, and a final extension at 72 °C/7 min. The PCR product quality was determined using electrophoresis with a 1.5% agarose gel stained with ethidium bromide. The PCR products were directly sequenced in both directions using ABI Big Dye Terminator kits (Applied Biosystems) and ABI 3730XL DNA Analyzer. To construct a neighbor-joining (NJ) tree, COX1 sequences (189 and 537 bp) from the *Henricia* species dataset, including one sequence of the new species (GenBank accession No. MT086587), were used (Table 1).
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1). Four species of genus *Echinaster* were used as outgroups (Table 1). Pairwise distances were calculated using MEGA 7.0 and the Kimura-2-parameter model (Kumar et al. 2016). The gaps and missing data were removed, and the bootstrap analysis was performed with 1000 replicates.

**Taxonomic results**

**Phylum Echinodermata Bruguière, 1791**

**Class Asteroidea de Blainville, 1830**

**Order Spinulosida Perrier, 1884**

**Family Echinasteridae Verrill, 1867**

**Genus *Henricia* Gray, 1840**

*Henricia epiphysialis* sp. nov.

http://zoobank.org/E50768C6-B625-43ED-82E1-6D581E38975B

Figs 2–4

**Materials examined.**

**Holotype:** South Korea • 1 specimen; waters adjacent to Namae, 37°55'57.31"N, 128°48'45.58"E; 40 m; 28 May 2014; S. Shin and T. Lee; fishing net; MERBK–A–1255.

**Paratypes:** South Korea • 1 specimen; waters adjacent to Jukbyeon, 37°3'32.49"N, 129°26'14.57"E; 100 m; 19 Dec. 2014; S. Shin and T. Lee; fishing net; NIBRIV0000837785. 1 specimen; waters adjacent to Namae, 37°55'57.31"N, 128°48'45.58"E; 40 m; 28 May 2014; S. Shin and T. Lee; fishing net; MERBK–A–1256.

**Diagnosis.** Regular size, R/r = 4.9–5.4, abactinal plates crowded with 11–40 spines, abactinal and lateral spines forming distinct hooked crown, epiphyseal ossicles formed at ends of abactinal and lateral plates, one to three papulae, marginal and ventrolateral series distinguishable, adambulacral plates bearing 10–14 slender spines.

**Description.**

**Holotype.** (Figs 2–4) Size. R = 51 mm, r = 10 mm, R/r = 5.1.

Arms five, semi-cylindrical, gradually tapering to tips (Fig. 2A–B). Abactinal paxillae formed in group with evenly spaced spinulation, bearing 11–40 spines with serrated tips (Fig. 2C). Denuded abactinal spines forming hooked crown composed of nine to 11 large hook-shaped spinules enclosing nine to 12 small connected apical tips (Fig. 4A–C). Paxillae on lateral side of arms similar to abactinal paxillae (Fig. 2D). Denuded abactinal plates reniform, usually connected to end of other plate in mid convex part of plate, larger than papular areas, partially enclosing papular area on concave side of plate. Papular areas narrow, containing one to three papulae in an area. Some papular areas divided by small ossicles (Fig. 3A). Almost every skeletal plate aside from adambulacral plates was observed bearing epiphyseal ossicles at ends of plate (Fig. 3A, C, D). Madreporite circular in form, slightly elevated, bearing spines same as adjacent spines (Fig. 3B). Shape of spines on lateral side nearly similar to that of abactinal spines (Fig. 4D–F). Superomarginal, inferomarginal, and ventrolateral plates well defined forming elongated cross shape and arranged in rows show-
Figure 2. External characteristics of *Henricia epiphysialis* sp. nov. A abactinal side B actinal side C abactinal spines D spines on lateral side of arm E adambulacral spines F oral part. Abbreviations: ab abactinal side ls lateral side ss superomarginal spines is inferomarginal spines vs ventrolateral spines as adambulacral spines os oral spines ms marginal spines sos sub-oral spines.

...ing consistent series (Fig. 3D). Superomarginal plates bearing 12–28 spines, bend upward toward base of arm in crescentic form, and reach tip of arm (Figs 3C–D, 4D). Intermarginal plates forming small elongated shape, extending near half of arm (Fig. 3D). Inferomarginal plates longer than superomarginal and ventrolateral plates, bearing 34–45 spines, reaching tip of arm (Figs 3C–D, 4E). Ventrolateral plates...
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**Figure 3.** Denuded skeleton of *Henricia epiphysialis* sp. nov. **A** abactinal plates **B** madreporite (arrow) **C** part of abactinal and lateral side of arm **D** plates on the lateral and actinal side of arm **E** actinal plates **F** oral part. Abbreviations: **ab** abactinal side **ls** lateral side **eo** epiphyseal ossicles **p** papula **s** superomarginal plates **in** intermarginal plates **i** inferomarginal plates **v** ventrolateral plates **a** adambulacral plates **am** ambulacral plates **o** oral plates.

forming a rounded cross shape, bearing 21–25 spines, reaching near tip of arm, epiphyseal ossicles forming a knob-like connection to adambulacral plates, extending to middle part of arm (Figs 3D, 4F). Adambulacral plates forming semi-rounded shape, bearing 10–14 slender, thorny spines, arranged in two transverse series (Figs 3D–E, 4G), articulated with ambulacral plates (Fig. 3E). Furrow spine single, somewhat
curved (Fig. 4H). Oral part bearing two slender, bluntly pointed oral spines, with six or seven marginal spines, and five or six sub-oral spines similar to adambulacral spines (Fig. 2F). Paired oral plates forming a slightly elongated triangular shape, articulated with first pair of adambulacral plates. Plates of inter-radial area slightly compact (Fig. 3F).

**Paratypes.** Size. $R = 39 \text{ mm}, r = 8 \text{ mm}, R/r = 4.9$; $R = 60 \text{ mm}, r = 11 \text{ mm}, R/r = 5.4$. 

**Figure 4.** SEM images of the spines of *Henricia epiphysialis* sp. nov. **A, B, C** abactinal spines **D** superomarginal spines **E** inferomarginal spines **F** ventrolateral spines **G** adambulacral spines **H** furrow spines.
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**Etymology.** The specific name is derived from the Latin “epiphysialis,” which means the end part of a long bone.

**Ecology.** This species is found on hard substrates (rocky bottom) from a shallow water of a depth of 40 m to 100 m.

**Distribution.** South Korea (East Sea).

**Molecular results**

We determined the phylogenetic relationships based on two COX1 datasets with 27 and 31 species of the genus *Henricia* respectively, including *H. epiphysialis* sp. nov., on the basis of 189 and 537 bp of the mitochondrial COX1 gene by using the NJ method. All *Henricia* species formed a monophyletic group with congeneric species and were clearly distinguished from the sister taxa (Fig. 5). *Henricia epiphysialis* sp. nov. was clearly monophyletic in the COX1 dataset of 189 bp (Fig. 5A), but the 189 bp COX1 dataset was too short for species-level identification using DNA barcoding analysis. Therefore, we reanalyzed phylogenetic relationships using a longer COX1 dataset (537 bp) including 27 species of *Henricia* (Table 1, Fig. 5B). The phylogenetic tree of the 537 bp dataset also revealed that *H. epiphysialis* sp. nov. presented a monophyletic node according to short and long COX1 datasets analysis (Fig. 5). In addition, each *Henricia* species examined was grouped at the species level. The intra- and inter-specific variations of *Henricia* species from the 537 bp COX1 dataset were calculated by the Kimura 2-parameter model and presented in Table 3. According to the p-distance result, the average value between *Henricia* spp. and *Echinaster* spp. was 0.208 (Table 3). The range of inter-specific distance in the genus *Henricia* was 0.002–0.188, and the average value of inter-specific distance was 0.110 (Table 4). The inter-specific values of *H. kinkasana* and *Henricia* sp. 3–7 was lower than the relationships of other *Henricia* species (Table 3, 4). The range of *Henricia* species, except for *H. kinkasana* and *Henricia* sp. 3–7, was 0.040–0.188 and the average was 0.114 (Table 4). The range and average of *H. epiphysialis* sp. nov. and other *Henricia* species were 0.056–0.154 and 0.098, respectively (Table 4). Therefore, the molecular analysis results show that *H. epiphysialis* sp. nov. is a new species in the genus *Henricia*.

**Discussion**

The diagnostic combination of the morphological characteristics of the genus *Henricia* such as spination of the abactinal (primarily on the disk and proximal portion of the arm), adambulacral, and oral plates was found to be consistent and reliable for determining the species (e.g., Hayashi 1940; Djakonov 1950; Clark and Jewett 2010). The shape of the abactinal spines and plate formation exhibited the distinct morphological characteristics of *Henricia epiphysialis* sp. nov. (Figs 3A, C, D, 4A–C). *Henricia epiphysialis* sp. nov. was compared with nine related *Henricia* species (Table 2). This new species has very peculiar abactinal spines that form a hooked crown and
Figure 5. Phylogenetic trees of *Henricia* species including *Henricia epiphysialis* sp. nov. based on Neighbor joining (NJ) A NJ tree constructed with 189 bp of COX1 dataset B NJ tree constructed with 537 bp of COX1 dataset; K, Knott et al., 2018; L, Lopes et al., 2016; M, Misaki, Kanagawa in Wakita et al., 2019; O, Oshoro, Hokakido in Wakita et al., 2019.

*Henricia epiphysialis* sp. nov. can be compared with the robust, coarse abactinal spines of *H. compacta*, *H. leviuscula*, *H. skorikovi*. *Henricia epiphysialis* sp. nov. is superficially similar to *H. leviuscula* in having short and coarse abactinal spines, but differs mainly in the arrangement of the abactinal paxillae (*H. epiphysialis* sp. nov. has less dense abactinal paxillae, whereas *H. leviuscula* has dense abactinal paxillae) and formation of abactinal spines (*H. epiphysialis* sp. nov. has spines forming a hooked crown with small connected apical tips, whereas *H. leviuscula* has spines with solid glassy tips). *Henricia epiphysialis* sp. nov. is morphologically distinguishable from its congeners primarily by the presence of conspicuous epiphyseal ossicles in almost every plate, and also by the distinctive arrangement of the epiphyseal ossicles of the ventrolateral plates, forming a knob-like connection to the adambulacral plates (Fig. 3D). The knob-like form of epiphyseal ossicles in the ventrolateral plates is rarely seen in related *Henricia* species having slender arms with imbricated plates. Our new species, *H. epiphysialis* sp. nov.
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Table 2. Comparison of the morphological characteristics of *Henricia epiphysialis* sp. nov. with related *Henricia* species. Morphological data derived from the respective original descriptions, the present study, and Xiao et al. (2011).

|                         | *Henricia epiphysialis* sp. nov. | *H. compacta* (Sladen, 1889) | *H. densispina* (Sladen, 1878) | *H. djakonovi* Chichvarkhin, 2017 | *H. exigua* Hayashi, 1940 | *H. kinkasana* Hayashi, 1940 | *H. leviuscula* (Stimpson, 1857) | *H. regularis* Hayashi, 1940 | *H. reniossa* Hayashi, 1940 | *H. skorikovi* Djakonov, 1950 |
|-------------------------|----------------------------------|------------------------------|-------------------------------|-------------------------------|-----------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|
| **R/r**                 | 4.9–5.4                          | 4.4–7.5                      | 2.9–5.5                       | 4.7–5.0                       | 4.2–4.5                     | 4.0–4.8                       | 5.0–6.0                       | 3.1–5.0                       | 5.5–8.0                       | 3.6–5.0                      |
| **Number of spines of abactinal plates** | 11–40                            | up to 45                     | 30 or more                    | 20–30                         | 5–13                        | 5–18                          | 40–60                         | 9–20                          | 15–60 or more                 | up to 16                     |
| **Shape of abactinal spines** | hooked crown                     | stout                        | granular                      | slender, barrel               | slender, pointed tip         | fine, slender, pointed tip   | short, granular, solid glassy tip | slender, pointed tip single   | very fine, rough tip 1 or 2   | short, robust, thorny tip 2–6 |
| **Number of abactinal papulae** | 1–3                              | 1–3                          | 1–3, rarely 5                 | 1 or 2                        | 1–3                        | 1–3                          | 1–3                          | 1–3                          | 1–3                          | 1–3                          |
| **Shape of abactinal plates** | reniform with conspicuous epiphyseal ossicle rounded cross, elongated cross single | crescentic, compact          | subtriangular                 | cross, oval, triangular, irregular square pillow | elliptic, quasi-triangular, quasi-quadrate rounded cross, elongated cross single | crescentic | elliptic, reniform, subquadrate elongated cross, small rod-like single | subquadrate | reformed | slender, rod-like |
| **Shape of actinal plates** | quadrilobed, squarish single      | elongated cross single        | single                        | single                        | single                      | single                        | single                        | single                        | single                        | single                        |
| **Number of actinal papulae** | 10–14                            | 5 or 6                       | 11–16                         | 10 or 11                      | 8–12                       | 15–18                         | 9–13                          | 15–25                         | 7–12                          |
| **Number of adambulacral spines** | single                           | 2 or 3                       | single                        | double                        | single                      | single                        | single or double              | single                        | single                        | single                        |
| **Number of furrow spines** | 1 long, 2 slender, bluntly pointed + 4–6 slightly shorter | 2 or 3 prominent + 4–6 sharply shorter | 2 or 3 larger + 4–11 slightly shorter | 1 long, 2 spatulate + 4–15 shorter | 1 long, 2 slender, bluntly pointed + 4–12 slightly shorter | 1 long, 3 stout + 5–18 slightly shorter | 1 long, 2 slender, bluntly pointed + 4–13 slightly shorter | 1 long, 5 slender + 7–25 slightly shorter | 1 long, 2 coarse + 4–12 slightly shorter | 1 long, 2 coarse + 4–12 slightly shorter |
| **Pattern of adambulacral spines (near ambulacral furrow) + near ventrolateral plate)** | Korea (East Sea), southern Australia | Bohai Sea, Yellow Sea, Korea Strait, Tatar Strait, Kurile Island, Japan, Philippines | Rudnaya Bay, Kievka Bay | southern Japan, East China Sea | Japan (off Kinkasan) | Korea (East Sea), Alaska (Kadiak) | East China Sea, Korea (East Sea, Korea Strait, Jeju Island), Japan (Goto Island, Uraga Channel) | Korea (East Sea), Japan (Yezo Strait) | White Sea, Barents Sea, Chesha Bay | Korea (East Sea), White Sea |
Table 3. Pairwise genetic comparison for 537 bp of the mitochondrial COXI gene in 27 species of Henricia including *Henricia epiphysialis* sp. nov.

| Species                        | H. epiphysialis sp. nov. | H. hayashi | H. kinokoana | H. leviuscula | H. lua | H. nipponica | H. ocellata | H. abnormis 1 | H. abnormis 2 | H. pachyderma | H. peronata | H. pertusa | H. regiolaris | H. renissa | H. reticulata | H. sanguiolens | H. spongiosa | H. tunide | H. Henricia sp. 1 | H. Henricia sp. 2 | H. Henricia sp. 3 | H. Henricia sp. 4 | H. Henricia sp. 5 | H. Henricia sp. 6 | H. Henricia sp. 7 | H. Henricia sp. 8 | H. Henricia sp. 9 | E. brasiliensis | E. cephalotes |
|--------------------------------|--------------------------|------------|--------------|---------------|-------|-------------|-------------|---------------|---------------|---------------|-------------|----------|-------------|-----------|--------------|----------------|---------------|---------|-------------------|-------------------|------------------|-------------------|------------------|-----------------|--------------------|-------------------|-----------------|-----------------|
|                                |                          |            |              |               |       |             |             |               |               |               |             |          |             |           |              |                |               |         |                   |                   |                  |                   |                   |                  |                   |                  |                   |                   |                   |                   |
|                                | 1                        | 2          | 3            | 4             | 5     | 6           | 7           | 8              | 9              | 10             | 11          | 12        | 13           | 14         | 15            | 16              | 17             | 18       | 19                | 20                | 21                | 22                | 23                | 24                | 25                | 26                | 27                | 28                |
A new species of the genus *Henricia* is morphologically closer to *H. reniossa*: they share similar reniform abactinal plates, elongated cross shaped actinal plates, but *H. epiphysialis* sp. nov. possessed well-developed epiphyseal ossicles in both abactinal and actinal plates. The molecular analysis supports the morphological similarity by showing both species in the same clade (Fig. 5B).

Other morphological characteristics of *H. epiphysialis* sp. nov., such as the ratio of arm to disk and number of adambulacral spines, are similar to those of *H. kinkasana* which is a slender-rayed species; however, this new species differs mainly in the number of abactinal spines and shape of both abactinal and lateral spines. *Henricia epiphysialis* sp. nov. has 11–40 robust abactinal spines on the abactinal plate, whereas *H. kinkasana* has five to 18 fine, delicate abactinal spines. Moreover, the conspicuous epiphyseal ossicles at the ends of the abactinal and lateral plates are exclusively present in *H. epiphysialis* sp. nov. Therefore, the extension of ossicles in the plate and hooked crown shape of the spines are diagnostic characteristics for this new species.

In this study, we identify a new *Henricia* species based on its morphological characteristics and DNA barcoding. *Henricia epiphysialis* sp. nov. has distinct morphological features and was classified as a new species after comparison with related species. Moreover, the molecular analysis showed that *H. epiphysialis* sp. nov. clearly formed a monophyletic node in a large clade of the genus *Henricia* species (Fig. 5), and the minimum value for the inter-specific distance was significantly higher than the inter-specific distance reported in a previous asteroid DNA barcoding study (Table 3) (Ward et al. 2008). Therefore, the molecular analysis clearly supported the diagnostic morphological identification of *H. epiphysialis* sp. nov. as a new species under the genus *Henricia*. The mitochondrial *COX1* gene is especially useful and effective for the DNA barcoding analyses of *Henricia* species.

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| Group                                | Range        | Average | Range        | Average |
|---------------------------------------|--------------|---------|--------------|---------|
| *H. epiphysialis*–other *Henricia* sp. | 0.056–0.154  | 0.098   | 0.002–0.188  | 0.110   |
| All of *Henricia* species             |              |         | 0.040–0.188  | 0.114   |
| All *Henricia* species except for *H. kinkasana* and *Henricia* sp.3–sp.7 |             |         |              |         |

Table 4. The range and average p-distance values of *Henricia* species examined in this study.
References

Clark RN, Jewett SC (2010) A new genus and thirteen new species of sea stars (Asteroidea: Echinasteridae) from the Aleutian Island Archipelago. Zootaxa 2571: 1–36. https://doi.org/10.11646/zootaxa.2571.1.1

Djakonov AM (1950) Keys to the fauna of the USSR. Sea stars (Asteroids) of the USSR seas. Zoological Institute of the Academy of Sciences of the USSR (translated 1968 by Israel Program for Scientific Translations, Jerusalem) 34: 1–183.

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 5294–299.

Hayashi R (1940) Contributions to the classification of the sea-stars of Japan I. Spinulosa. Journal of the Faculty of Science, Hokkaido Imperial University 7: 107–204.

Hebert PDN, Cywinska A, Ball SL, deWaard JR (2003) Biological identifications through DNA barcodes. Proceedings of the Royal Society of Biological Sciences 270: 313–321. https://doi.org/10.1098/rspb.2002.2218

Knott KE, Ringvold H, Blicher ME (2018) Morphological and molecular analysis of Henricia Gray, 1840 (Asteroidea: Echinodermata) from the Northern Atlantic Ocean. Zoological Journal of the Linnean Society 182: 791–807. https://doi.org/10.1093/zoolinnean/zlx066

Kumar S, Stecher G, Tamura K (2016) MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. Molecular Biology and Evolution 33(7): 1870–1874. https://doi.org/10.1093/molbev/msw054

Layton KKS, Corstorphine EA, Hubert PDN (2016) Exploring Canadian Echinoderm Diversity through DNA Barcodes. Plos ONE, 11(11): e0166118. https://doi.org/10.1371/journal.pone.0166118

Lopes EM, Pérez-Portela R, Paiva PC, Ventura CRR (2016) The molecular phylogeny of the sea star Echinaster (Asteroidea: Echinasteridae) provides insights for genus taxonomy. Invertebrate Biology 135: 235–244. https://doi.org/10.1111/ivb.12135

Mah CL (2019) World Asteroidea Database. Echinasteridae Verrill, 1867. World Register of Marine Species. http://www.marinenspecies.org [Accessed 22 Jun. 2019]

Puillandre N, Lambert A, Brouillet S, Achaz G (2012) ADBG, Automatic Barcode Gap Discovery for primary species delimitation. Molecular Ecology 21: 1864–1877. https://doi.org/10.1111/j.1365-294X.2011.05239.x

Shin S (2010) Sea stars: Invertebrate fauna of Korea. National Institute of Biological Resources, Korea, 32: 150.

Shin S, Ubagan MD (2015a) A newly recorded sea star of genus Henricia (Asteroidea: Spinulosida: Echinasteridae) from the East Sea of Korea. Korean Journal of Environmental Biology 33(2): 197–200. https://doi.org/10.11626/KJEB.2015.33.2.197

Shin S, Ubagan MD (2015b) A newly recorded sea star of genus Henricia (Asteroidea: Spinulosida: Echinasteridae) from Jeju Island, Korea. Korean Journal of Environmental Biology 33(4): 390–393. https://doi.org/10.11626/KJEB.2015.33.4.390
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Taekjun L, Shin S (2020) Complete mitochondrial genome of *Henricia pachyderma* (Asteroida, Spinulosida, Echinasteridae) and phylogenetic analysis. Mitochondrial DNA Part B 5(2): 1483–1484. https://doi.org/10.1080/23802359.2020.1742231

Ubagan MD, Shin S (2016) A new record sea star of genus *Henricia* (Asteroida: Spinulosida: Echinasteridae) from Jeju Island, Korea. Journal of Species Research 5(3): 351–354. https://doi.org/10.12651/JSR.2016.5.3.351

Ubagan MD, Shin S (2019a) A newly recorded sea star of genus *Henricia* (Asteroida: Spinulosida: Echinasteridae) from the East Sea of Korea. Journal of Species Research 8(1): 109–112. https://doi.org/10.11626/KJEB.2019.37.1.068

Ubagan MD, Shin S (2019b) New record of a sea star of genus *Henricia* (Asteroida: Spinulosida: Echinasteridae) from Jeju Island, Korea. Korean Journal of Environmental Biology 37(1): 68–71. https://doi.org/10.11626/KJEB.2019.37.1.068

Ubagan MD, Shin S (2019c) A newly recorded sea star of genus *Aleutihenricia* (Asteroida: Spinulosida: Echinasteridae) from East Sea, Korea. Animal Systematics, Evolution Diversity 35(2): 91–94.

Wakita D, Fujita T, Kajihara H (2019) Molecular systematics and morphological analyses of the subgenus *Setihenricia* (Echinodermata: Asteroida: *Henricia*) from Japan. Species Diversity 24:119–135. https://doi.org/10.12782/specdiv.24.119

Ward RD, Holmes BH, O’Hara TD (2008) DNA barcoding discriminates echinoderm species. Molecular Ecology Resources 8(6): 1202–1211. https://doi.org/10.1111/j.1755-0998.2008.02332.x

Xiao N, Liao Y, Liu R (2011) Records of the genus *Henricia* Gray, 1840 (Echinodermata: Asteroida: Echinasteridae) from Chinese waters. Zootaxa 3115(1): 1–20. https://doi.org/10.11646/zootaxa.3115.1.1