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First record of *Henricia reniossa reniossa* Hayashi, 1940 (Spinulosida: Echinasteridae) from central Honshu, Japan

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Abstract

Henricia reniossa reniossa was first discovered on the coast of Honshu Island, Japan, extending the southern limit of this subspecies to central Japan. This finding suggests that the distributional range of the two subspecies of *Henricia reniossa* presumably overlapped. Herein, we describe the morphology of *Henricia reniossa reniossa* with brief comments regarding its subgeneric classification of *Henricia reniossa*.

Key words: Asteroidea; deep sea; distribution; Niigata; subspecies

Introduction

Henricia Gray, 1840 is a cold-temperate water genus that exhibits a great species diversity in high latitudinal regions and deep-sea settings (Mah and Blake 2012). The genus currently comprises 98 species (Ubagan et al. 2020; Kobayashi et al. 2021) that generally share five slender and subcylindrical arms with a reticulated skeleton bearing numerous minute spines (Clark and Downey 1992). In total, 18 species have been recorded in Japanese waters: *H. anomala* Hayashi, 1973; *H. aspera* Fisher, 1906; *H. densispina* (Sladen, 1879); *H. exigua* Hayashi, 1940; *H. fragilis* Kobayashi et al., 2021; *H. hayashii* Djakonov, 1961; *H. irregularis* Hayashi, 1940; *H. kinkasana* Hayashi, 1940; *H. nipponica* Uchida, 1928; *H. margarethae* Kobayashi et al., 2021; *H. ohshimai* Hayashi, 1935; *H. pachyderma* Hayashi, 1940; *H. pacifica* Hayashi, 1940; *H. reticulata* Hayashi, 1940; *H. regularis* Hayashi, 1940; *H. reniossa* Hayashi, 1940; *H. tumida* Verrill, 1914; and *H. uluudax* Clark & Jewett, 2010 (Sladen 1879; Uchida 1928; Hayashi 1940, 1973; Chichvarkhin 2017; Wakita et al. 2019; Kobayashi et al. 2021). Among the 18 recorded species, *H. reniossa*, a relatively rare bathyal species, has been exclusively observed from northern Japan to Sakhalin Island, Russia (Hayashi 1940; Djakonov 1958, 1961). *Henricia reniossa* was previously categorized into three geographically distinct subspecies (Hayashi 1940; Djakonov 1958, 1961). However, the northernmost subspecies, *H. r. asiatica* Djakonov, 1958, was recently promoted as a distinct species (Chichvarkhin et al. 2019). Consequently, only *H. r. reniossa* in Hokkaido and *H. r. tohokuensis* Hayashi, 1940 in northern Honshu are currently classified under *H. reniossa* (Fig. 1).

Nevertheless, in a survey of the deep-sea benthic fauna in the Sea of Japan, one individual of *H. r. reniossa* was collected in central Honshu, Japan. In this paper, with describing the morphology of *H. r. reniossa*, we comment on its subgeneric classification of *H. reniossa*.

Materials and Methods

A single specimen of *Henricia reniossa reniossa* was collected off Niigata Prefecture, Honshu, Japan using bottom trawling conducted via *Tokiwa-Maru*, the fishing vessel (Fig. 1). The collected specimen was sent to the Misaki Marine Biological Station of the University of Tokyo and housed in a 1,000 L FRP

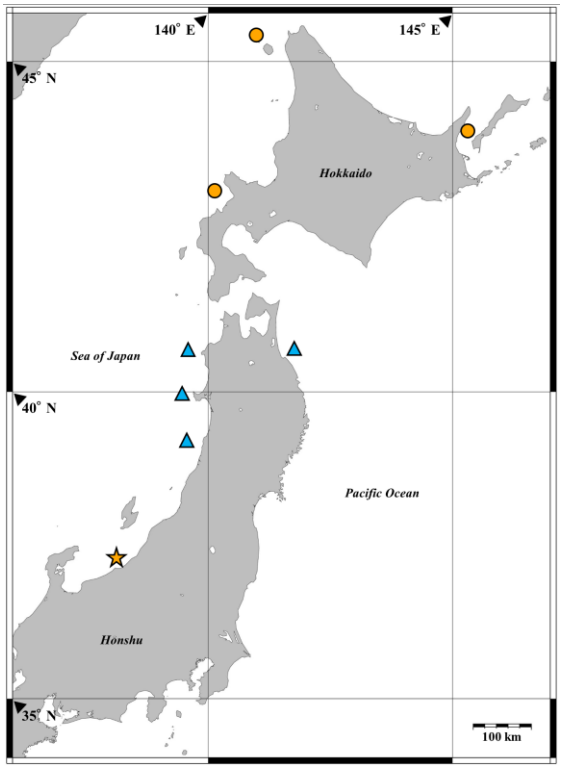

Fig. 1. Sampling site of *Henricia reniossa reniossa* (indicated by the orange star) along with the previous records of *H. r. reniossa* (indicated by orange circles) and *H. r. tohokuensis* (indicated by blue triangles) based on Hayashi (1940) and Wakita et al. (2019).

tank at about 11 °C. After taking images of this live specimen, we fixed and preserved it in 99.5 % ethanol.

The prepared specimen was observed under a Swift S7 stereoscopic microscope (Swift Optical Instruments, USA). To expose the underlying plates, integuments and spines were removed from the arms by applying commercial bleach containing sodium hypochlorite (ca. 5 %). The detached abactinal spines were collected for observation under a scanning electron microscope (SEM). The collected spines were thoroughly washed with purified water to remove any residual bleach. Following cleaning, the spines were mounted on 12 × 15 mm aluminum plates and dried in air. To enhance conductivity, the mounted spines were coated with gold–palladium using an ion coater (Eiko IB-3; Eiko Engineering, Ibaraki, Japan). The samples were observed using SEM (JSM-5510LV; JEOL Ltd., Tokyo, Japan).

After this study, the specimen was deposited in the National Museum of Nature and Science, Tsukuba (NSMT).

Results

Taxonomic account

Family Echinasteridae Verrill, 1867

Genus *Henricia* Gray, 1840

Henricia reniossa reniossa Hayashi, 1940

[New Japanese name: Ori-hime-hitode]

Henricia reniossa Hayashi, 1940: 132–134, pl. 8 figs. 16, 17

Material examined

NSMT E-14623, off Niigata Prefecture, Honshu Island, Japan, ca. 250 m, on March 12, 2023, R = 67.6 mm, r = 9.4 mm.

Diagnosis

The abactinal skeleton is a close meshwork. The abactinal plates display an irregular yet consistent arrangement at abactinolateral arm base. Papular areas, smaller in size compared to the abactinal plates, typically contain one or occasionally two papulae. The pseudopaxillae are narrowly spaced apart. Abactinal spines are straight, clavate, laterally smooth, and serrated by splayed thorns on the tip. Each of abactinal, superomarginal, inferomarginal, actinal, and adambulacral plates has more than 30 spines at maximum. The intermarginal series is confined within 1/3 of R. The actinal series is single on each side of the arm. Subambulacral spines are arranged in more than three rows. Furrow spines are single on most adambulacral plates.

Description

Arms are five, subcylindrical, slender, and gradually taper toward the tip (Fig. 2A). The abactinal skeleton is an irregular close meshwork, constituted by many quadrilobate or stellate abactinal plates (Fig. 2B).

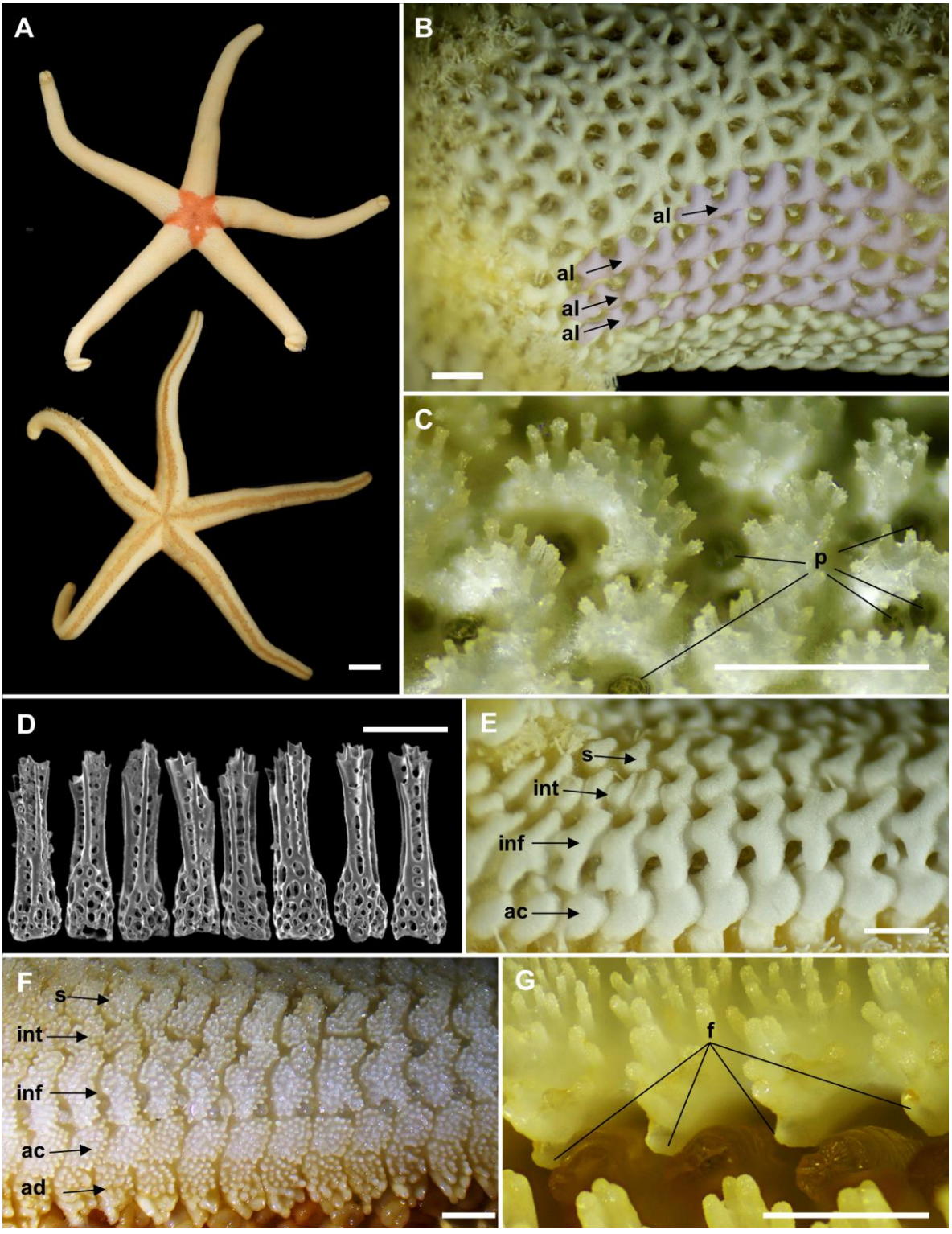

Fig. 2. *Henricia reniossa reniossa*, NSMT E-14623. A, live specimen, abactinal (top) and actinal (bottom) views; B, denuded abactinal surface of the arm base; C, abactinal surface of the arm base; D, SEM images of abactinal spines; E, denuded actinolateral surface of the arm base; F, actinolateral surface of the arm base; G, actinal surface of arm base. Abbreviations: ac, actinal series; ad, adambulacral series; al, abactinolateral series; f, furrow spine; inf, inferomarginal series; int, intermarginal series; p, papula; s, superomarginal series. Scale bars indicate 10 mm for A; 1 mm for B, C, E–G; and 0.1 mm for D.

The abactinal plates are partially imbricated with each other. Each abactinal papular area is smaller than the surrounding plates, containing one or occasionally two papulae and often one secondary abactinal plate. Each abactinal plate bears 1–58 abactinal spines (Fig. 2C). The abactinal spines are arranged irregularly and grouped to form ovoid to crescent pseudopaxillae. Each pseudopaxilla is secluded from adjacent one by sunken papular areas or narrow exposed spaces, maintaining a clear separation without touching other pseudopaxillae. Abactinal plates are mostly arranged irregularly; however, the plates in the proximal abactinolateral portion of the arms are regularly arranged in several longitudinal series (Fig. 2B). These abactinal series extend proximal one-sixth of the arm length. A madreporite is located at the margin of the disk with 71 spines on its surface.

Abactinal spines are 0.21–0.27 mm in length. The spines are straight, clavate, laterally smooth, and serrated by splayed thorns on the tip (Fig. 2D).

Supero- and inferomarginal plates are quadrilobate or stellate; they are arranged in longitudinal series (Fig. 2E). These plates gradually decrease in size toward the arm tips. Each superomarginal plate bears 37–52 spines, and each inferomarginal plate bears 29–77 spines. The supero- and inferomarginal spines are arranged in more than three transverse rows (Fig. 2F). Beginning proximally, the supero- and inferomarginal series are separated from one another by up to one-sixth of the arm length. The superomarginal series progressively approaches the inferomarginal series toward the arm tips, eventually making contact (Fig. 2E). Intermarginal plates are ovoid or quadrilobate; they are arranged in one regular longitudinal series extending proximal one-sixth of the arm length. Papulae are present between these marginal series.

Actinal plates are ovoid to quadrilobate; they are regularly arranged in one longitudinal series (Fig. 2E, F). The actinal series extends almost to the tip of the arm but does not contact with the terminal plate. Each actinal plate bears 21–44 spines arranged in more than three irregular rows (Fig. 2F). Papulae are present between the inferomarginal and actinal series but absent between the actinal and adambulacral series.

Most adambulacral plates bear a single furrow spine deep in the furrow (Fig. 2F, G) and 13–35 subambulacral spines. Furrow spines and the adradial-most subambulacral spines are arranged in a vertical row on the adradial surface of the adambulacral plate, and the remaining subambulacral spines are arranged in more than three irregular transverse rows on the adambulacral plate's actinal surface.

The color in life is yellow with a stellate orange area on the abactinal side of the disk (Fig. 2A).

Distribution

Nemuro Strait, off Rebun Island, and off Iwanai, around Hokkaido, Japan (Hayashi 1940), and the Sea of Japan side of the central Honshu, Japan (this study). The bathymetric range is 157–347 m in depth.

Etymology

The new Japanese name "ori" originates from the Tanabata myth featuring princess "Ori-hime" who was separated from her husband by the Milky Way. Similar to this legend, *Henricia reniossa* displays a regular abactinal series divided into both sides of the arms by irregularly arranged abactinal plates. Furthermore, "hime-hitode" is a commonly used species name of the genus *Henricia* in Japan.

Discussion

The observed specimen aligns with the original description of *Henricia reniossa* (Hayashi 1940), with abactinal plates arranged regularly in several longitudinal series exclusively at the proximal abactinolateral section of the arms (Fig. 2B). This morphology is unique among the 18 Japanese *Henricia* species (Hayashi 1940; Kobayashi et al.

2021). Our observed specimen was distinctly identified as *H. r. reniossa* because it had narrower abactinal meshes than the surrounding plates (Fig. 2B). This feature differed from *H. r. tohokuensis* that had wider abactinal meshes than the surrounding plates (Hayashi 1940). Moreover, the number of papulae was different between the observed specimen and *H. r. tohokuensis*. The observed specimen typically had one papula per abactinal mesh, akin to *H. r. reniossa*, whereas *H. r. tohokuensis* had up to five papulae per mesh (Hayashi 1940).

This marks the first occurrence record of *H. r. reniossa* from Honshu Island, extending its southernmost distributional range to the Sea of Japan side in central Japan (Fig. 1). This finding suggests the possibility of an overlap in distribution between the two subspecies in this region. Traditionally, subspecies are defined as geographically distinct fractions of species (Wilson and Brown 1953). Therefore, if the sympatric distribution of the two subspecies is confirmed, there appears to be no reason why *H. r. reniossa* and *H. r. tohokuensis* are ranked as subspecies in the same species. Further collection of specimens from different locations and analysis of DNA sequences are required to confirm whether these two subspecies are distinct species.

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