A project for analyzing the ecology and phylogeny of western Pacific echinoids

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Abstract

In 2017 we started a project to analyze the ecology and phylogeny of western Pacific echinoids. As the first step, we are establishing methods to infer their phylogenetic relationships using molecular data; we developed effective methods to obtain complete mitochondrial DNA sequences, and determined their effectiveness in phylogenetic analysis. We have also been gathering data concerning the ecology and systematics of Japanese extant echinoids, which arguably has among the highest genus-level diversities in the West Pacific or perhaps even in the world. We have collected 58 species from middle and southern Japan representing 48 genera. In the next year, we will collect sea urchins from northern Japan, and within 2 years we will finish collecting data on ecology and systematics of Japanese echinoids, and provide a set of standardized data that will be useful for many researchers studying western Pacific echinoids. At that time, we will start comparative analyses of echinoid faunas distributed in the western Pacific.

Key words: echinoid, Pacific, ecology, phylogeny

Introduction

The western Pacific Ocean extending from the Kamchatka Peninsula to Australia is a fascinating region for echinoid researchers, because there is a variety of environments with subarctic to tropical climates, and strong warm and cold currents. Geological variation, forearc islands, basins, volcanic islands, and trenches produce various geomorphologies such as coral reefs, sand beaches, and rocky shores, resulting in the most diverse echinoid fauna in the world. The western Pacific sea urchins have been studied since the first half of the 19th century (Agassiz 1872–74, 1879, 1881; Agassiz and Clark 1907a–b, 1908, 1909; Clark 1912, 1914, 1917; Mortensen 1928, 1935, 1940, 1943a–b, 1950, 1951). An overview of western Pacific echinoid faunas can be derived from the echinoid species described in the great monograph of Mortensen (1928–1951). Since his work, however, no comprehensive study on the western Pacific echinoids has been done until today, though several regional studies for some restricted areas were carried out; e.g. Fell (1963) for New Zealand; Nisiyama (1966, 1968) and Shigei (1986) for Japan; Lane et al. (2000) for South China; Miskelly (2002) for Australia; van Noordenburg (2008) and Mooi & Munguia (2014) for the Philippines. Mooi & Munguia (2014) showed high species richness of the Philippines echinoid fauna; according to their estimates, only half the number of species seen in the Philippines have been recorded from India, Malaysia, and Indonesia combined, and there are more than twice as many echinoid species in the Philippines as in the Gulf of Mexico and Caribbean Sea together. The Philippines fauna includes representatives of every extant order and over 70% of the extant families in the world. They suggest that this provides support for the idea that the Philippines is a center of overlap for many echinoid species occurring in the Philippines (Gaither and Rocha 2013).
Since the 1990s, phylogenetic relationships of echinoids have been analyzed based on molecular data that often encouraged evolutionary discussion in terms of developmental biology. For the western Pacific echinoids, some interesting findings have been reported, for example, speciation in *Echinometra mathaei* living in the Tropical Pacific (Matsuoka & Hatanaka 1991; Palumbi et al. 1997); close relationship between *Acanthocidaris* from Japan and *Heliocidaris* from Australia (Kinjo et al. 2008), phylogeny and evolution of temnopleurid echinoids (Jeffery et al. 2003). The timing is good to re-examine the phylogenetic relationships of the western Pacific echinoids based on molecular data.

**Project on the western Pacific sea urchins**

In 2017, we started a project to analyze the ecology and phylogenetics of western Pacific echinoids. In the first step, we are establishing methods to infer the phylogenetic relationships among families or genera using molecular data. To do this, we developed effective methods for DNA extraction and PCR to obtain complete mitochondrial DNA sequences, and determined the effectiveness of phylogenetic analyses based on complete mitochondrial DNA sequences. The preliminary result is presented by Wakayama et al. in this proceedings volume. In addition, we are assessing the ecology and systematics of Japanese extant echinoids, characteristics of which are mentioned below. For many sea urchins, their ecology can be observed while collecting the specimens by scuba. A preliminary report on 58 species from 22 families of 9 orders from middle and southern Japan is presented by Saitoh et al. in this proceedings volume.

In the next year, we will collect sea urchins from northern Japan, and within 2 years we will finish analyzing Japanese echinoids for their ecology and phylogeny, and provide a set of standardized data that will be useful for many researchers studying western Pacific echinoids. We will then start comparative analyses of echinoid faunas distributed in the western Pacific. Anyone who is interested in this project and would like to join it is welcome.

**Sea urchins around Japan**


The number of species in Japan is about half of the Philippines, but interestingly, the Japanese fauna has 7 more genera than occur in the Philippines. This difference might be caused by the level of knowledge of the taxonomic relationships among these taxa; in tropical regions such as the Philippines, the taxa are much more poorly known (Mooi personal comm. 2018). However, it might be ascribed to the geographic location of Japan. Japan is located from 20 to 46 degrees north latitude—the distance between the northern and southern limits is about 4000 km. The northernmost region is situated in the subarctic zone. In the south, the climate changes from cold temperate to warm temperate to subtropical. Off the Pacific side of Honshu Island, the main island of Japan, the Japan Trench reaches a depth of 8020 m, and two strong ocean currents, the cold Oyashio Current from the north and the warm Kuroshio Current from the South collide. Corresponding to these varied environmental conditions, four elements in Japanese echinoid fauna can be recognized. Northern elements are represented by *Strongylocentrotus intermedius* and *Echinarchinus parma*; sea urchins of these genera can also be found in Russia and Alaska. Endemic elements include *Pseudocentrotus depressus*, *Hemicentrotus pulcherrimus*, and *Scaphechinus mirabilis*; they appear to have speciated around Japan, based on their fossil record. Deep-sea elements are mainly composed of cidarids like *Stereocidaris sertiferoides* and *Goniocidaris mikado*, and echinothurioids such as *Phormosoma bursarium* and *Hygorosoma hoplacantha*. Southern elements contain the genera common to the Philippines. Because of this rich diversity, it is assumed that a comprehensive study of Japanese echinoids carried out by this project will contribute to understanding the western Pacific echinoids as well.
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