# Multidisciplinary evidence suggest new coral divergence within extant blue coral species (*Heliopora coerulea*) in Japan

Hiroki Taninaka[1], Haruko Kurihara[2], Hiroshi Yamashita[3], Satoshi Nagai[4], Mitsuhiro Ueno[5], Taisei Kikuchi[6] and Nina Yasuda[7]

[1]Interdisciplinary Graduate School of Agriculture and Engineering, University of Miyazaki

[2]Faculty of Science, University of the Ryukyus

[3]Research Center for Subtropical Fisheries, Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency

[4]Japan Fisheries Research and Education Agency, National Research Institute of Fisheries Science, Research Center for Bioinformatics and Biosciences Environmental genomics group

[5]Coral Reef Research in Sekisei Lagoon

[6]Parasitology, Faculty of Medicine, University of Miyazaki

[7]Department of Marine Biology and Environmental Sciences, Faculty of Agriculture, University of Miyazaki

## Abstract

High biodiversity of reef-building corals, the foundation species of coral reefs facilitate the high biodiversity of the ecosystem. This high biodiversity can be caused several factors such as physical segregation of populations and various types of ecological speciation including sympatric populations. The patterns of speciation of the coral species are, however, poorly understood because corals show phenotypic plasticity and high degree of gene flow among closely related species. Thus, multi-disciplinary approach is required to examine species boundaries of corals. The blue coral genus *Heliopora* is an important reef-building taxa and *Heliopora* colonies show a high degree of morphological variation across the Indo-Pacific Ocean. Up until 2018 *Heliopora coerulea* was regarded as the sole surviving extant species, however a recent genetic study has described a new species in Western Australia. Also in the Kuroshio region, previous genetic studies indicated at least two distinct lineages of *Heliopora coerulea* (HC-A and B) are distributed. Although traditional genetic approach such as microsatellite, ITS, and *mt*DNA could not discriminate, HC-A lineage appears to

include two difference growth forms (encrusting and stick) in the field. The purpose of this study is to exam possible speciation in HC-A lineage with two morphological variations by multi-disciplinary approach including population genomic analyses, physiological experiments, and morphological observations.

A total of 586 samples of HC-A from 35 sites were collected along the Kuroshio Current in Japan. Based on MIG-seq data relating to 216 Single Nucleotide Polymorphisms (SNPs), STRUCTURE and Principle Coordinate Analysis successfully detected genetic differences among two different growth form (HC-A1 and A2), though possible hybrid colonies exist between the two lineages. These results indicate occasional contemporary gene flow caused by incomplete reproductive isolation between two lineages within sympatric habitats. In addition, we found physiological differences between the two including cell densities of symbiont algae, light and dark net calcification, gross photosynthesis, and respiration rate. Microscopic morphological differences further corroborate the difference between the lineages. To summarize, we considered HC-A1 and A2 are undergoing ecological speciation with clear physiological and morphological differences, and relatively weak genetic difference. This study underpinned that integrated multi-disciplinary approach is important to understand the species boundaries and patterns of speciation of corals. We also demonstrate the effectiveness and necessity of using genome-wide population genomic analysis to delineate hidden species of corals in the Indo-Pacific Ocean.