

## CHARACTER EVOLUTION OF THE BENTHIC THECATE DINOFLAGELLATE, *GAMBIERDISCUS* (DINOPHYCEAE), WITH AN INTRODUCTION OF THE INTERACTIVE KEY TO SPECIES

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**ABSTRACT** The genus *Gambierdiscus* is one of the benthic marine dinoflagellates that are known to produce biotoxins, causing ciguatera food poisoning (CFP) in humans after consuming the contaminated marine fishes. These benthic marine dinoflagellates are commonly found in the warm tropical and subtropical waters. The phenomena associated with high cell abundance or “blooms” is referred to Benthic Harmful Algal Blooms (BHABs). Precise species identification is crucial as not all of the species in the genus are toxic. In this study, morphological characteristics of *Gambierdiscus* species widely used in species identification were analyzed, and the character states coded. Taxon sampling on the large subunit (LSU) rDNA of all *Gambierdiscus* species were carried out, and used for the phylogenetic reconstruction. The character states were mapped onto the Maximum Parsimony (MP) tree to investigate the character state evolution of *Gambierdiscus* species. Morphological information and the distribution of the 13 species were used to develop a comprehensive taxonomic database of *Gambierdiscus*, a web-based interactive identification key for species identification is presented.

**ABSTRACT** Genus *Gambierdiscus* adalah salah satu dinoflagelat benthik marin yang menghasilkan biotoksin penyebab keracunan ikan ciguatera (CFP) pada manusia akibat termakan ikan marin yang tercemar. Dinoflagelat ini biasanya ditemui di perairan tropika dan subtropika yang panas. Fenomena ini yang berkaitan dengan kepadatan sel yang tinggi atau ledakan adalah dirujuk sebagai “Benthic Harmful Algal Bloom (BHAB)”. Pengecaman spesis yang tepat adalah penting kerana tidak semua spesis dalam genus ini adalah beracun. Dalam kajian ini, ciri-ciri morfologi digunakan secara meluas dalam pengecaman spesis *Gambierdiscus* telah dianalisa, dan pengkodan keadaan ciri-ciri ditentukan. Persampelan takson jujukan ribosomal subunit besar (LSU) rDNA semua spesis *Gambierdiscus* telah dijalankan, dan digunakan untuk pembinaan semula filogenetik. Keadaan ciri-ciri telah dipetakan ke atas pokok kekikiran maksimum (MP) untuk mengkaji evolusi keadaan ciri morfologi spesis *Gambierdiscus*. Maklumat morfologi 13 spesis dan taburan mereka telah digunakan untuk menghasilkan pangkalan data taksonomi *Gambierdiscus* yang komprehensif. Kekunci pengecaman spesis interaktif sesawang untuk tujuan pengecaman dibentangkan.

**(Keywords:** Benthic dinoflagellates; ciguatera; harmful; interactive key; morphological characters)

### INTRODUCTION

Harmful benthic dinoflagellates are microalgae that live on the surfaces of marine substrates (e.g. sediments, seaweeds, coral rubbles etc.), and some are associated with the production of marine biotoxins. These biotoxins are capable of causing harmful effects to fish, human and other wildlife [1]. Several other species of BHABs in the genera of *Gambierdiscus* [2], *Ostreopsis* [3], *Coolia* [4], *Prorocentrum* [3] and *Amphidinium* [5] are also harmful [6]. The most well-known human intoxication due to benthic dinoflagellates is ciguatera fish poisoning (CFP), where the responsible toxins are produced by some species of *Gambierdiscus* [7]. It is a common fish poisoning especially in the tropical and subtropical regions [8], with the first

case reported from Mauritius, Indian Ocean in 1973 [9]. The biotoxins lipid soluble ciguatoxins and water soluble maitotoxins produced by the toxic *Gambierdiscus* species accumulate via food chains transfer from herbivorous to carnivorous fishes to the higher tropic levels [9, 10].

Early symptoms of CFP occur within hours of fish consumption, with gastrointestinal, neurologic and cardiovascular symptoms observed [7]. CFP has become a world health threat as the reef fish such as barracuda, grouper and snapper are increasingly exported for consumption [8].

The genus *Gambierdiscus* is relatively easy to identify under light microscope (LM). Most of the species are disc-shaped and antero-posteriorly