

Editorial

Taxonomy and Ecology of Marine Algae

Bum Soo Park ¹  and Zhun Li ^{2,*} 

¹ Marine Ecosystem Research Center, Korea Institute of Ocean Science and Technology, Busan 49111, Korea; parkbs@kiost.ac.kr

² Biological Resource Center/Korean Collection for Type Cultures (KCTC), Korea Research Institute of Bioscience and Biotechnology, Jeongseup 56212, Korea

* Correspondence: lizhun@kribb.re.kr

1. Introduction

The term “algae” refers to a large diversity of unrelated phylogenetic entities, ranging from picoplanktonic cells to macroalgal kelps. Marine algae are an important primary producer in the marine food chain, responsible for the high primary production of coastal areas, providing food resources in situ for many grazing species of gastropods, peracarid crustaceans, sea urchins or fish. The biodiversity of marine algae is enormous, and they represent an almost untapped resource. This Special Issue shows the current worldwide interest in the field of taxonomy and ecology of marine algae, and it will be a very useful tool to support and inspire future studies about this exciting topic. Recent findings indicate that marine environments have rapidly changed due to global warming over the past several decades. This change leads to significant variations in marine algal ecology. For example, a long-term increase in ocean temperatures due to global warming has facilitated the intensification of harmful algal blooms, which adversely impact public health, aquatic organisms, and aquaculture industries. Thus, extensive studies have been conducted, but there is still a knowledge gap in our understanding of the variation of their ecology in accordance with future marine environmental changes. To fill this gap, studies on the taxonomy and ecology of marine algae are highly necessary.

We have invited algologists to submit research articles that enable us to advance our understanding of the taxonomy and ecology of marine algae. The Issue collected fourteen papers that cover different aspects of the taxonomy and ecology of marine algae, including understudied species, interspecific comparisons, and new techniques.

2. Papers Details

Wang and Wu [1] suggested that the significantly enhanced discharge of the Changjiang River since the winter of 2020–2021 was crucial for the outbreak of the *Ulva prolifera* green tides in southwestern Yellow Sea, which could have contributed significantly to the nutrient enrichment of the Subei coast. They demonstrated that these large amounts of nutrient inputs, as an effective supplement, were the reason the green tides emerged sharply as an extensive outbreak in 2021. The easterly wind anomaly during spring 2021 contributed to the landing of *Ulva prolifera* off the Lunan coast.

Lee et al. [2] established an integrated loop-mediated isothermal amplification (LAMP) assay based on *Ostreopsis cf. ovata* and *Amphidinium massartii*. The detection sensitivity of the LAMP assay for *O. cf. ovata* or *A. massartii* was comparable to other molecular assays (PCR and quantitative PCR (qPCR)) and microscopy examination. The detection limit of LAMP was 0.1 cell of *O. cf. ovata* and 1 cell of *A. massartii*. The optimized LAMP assay was successfully applied to detect *O. cf. ovata* and *A. massartii* in field samples. They provided an effective method of detecting target benthic dinoflagellate species and could be further implemented to monitor phytoplankton in field surveys as an alternative.

Lee and Yeh [3] proposed a new endophytic filamentous red algal species from Taiwan based on morphological observations and molecular analysis, named as *Colaconema formosanum*



Citation: Park, B.S.; Li, Z. Taxonomy and Ecology of Marine Algae. *J. Mar. Sci. Eng.* **2022**, *10*, 105. <https://doi.org/10.3390/jmse10010105>

Received: 11 January 2022

Accepted: 12 January 2022

Published: 14 January 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sp. nov. The new species was confirmed based on morphological observations and molecular analysis. Both the large subunit of ribulose-1,5-bisphosphate carboxylase/oxygenase (*rbcL*) and cytochrome c oxidase subunit I (*COI-5P*) genes showed high genetic variation between our sample and related species. Anatomical observations indicated that the new species present asexual reproduction by monospores, cylindrical cells, irregularly branched filaments, a single pyrenoid, and single parietal plastids.

Kwon et al. [4] reported 11 unrecorded diatom species (*Diploneis didyma*, *Mastogloia elliptica*, *Cosmioneis citrifomis*, *Haslea crucigera*, *Pinnularia bertrandii*, *Pinnularia nodosa* var. *percapitata*, *Gyrosigma sinense*, *Gomphonema guaraniarum*, *Gomphonema italicum*, *Navicula freesei*, *Tryblionella littoralis* var. *tergestina*) among samples collected from the Hwajinpo, Hyangho, Maeho, and Gapyeongri wetlands, and Cheonjinho and Gyeongpoho lagoons in Korea, during a survey from 2018–2020. They presented the taxonomic characteristics, ecological information, habitat environmental conditions, and references for these 11 species.

Park et al. [5] reported the marine benthic dinoflagellate *Bysmatrum subsalsum* from Korean Tidal Pools. They identified two ribotypes of *B. subsalsum* based on molecular phylogeny. The Korean isolates were nested within the ribotype B consisting of the isolates from China, Malaysia, and the French Atlantic, whereas the ribotype A included only the isolates from the Mediterranean Sea. These findings support the idea that there is cryptic diversity within *B. subsalsum*.

Park et al. [6] investigated fossil diatoms in Suncheonman Bay and introduced sub-fossil diatoms recorded in Korea. One sedimentary core has been extracted in 2018. They identified 87 diatom taxa from 52 genera in the sediment core sample. Of these, six species represent new records in Korea: *Cymatonitzschia marina*, *Fallacia hodgeana*, *Navicula manni*, *Metascolioneis tumida*, *Surirella recedens*, and *Thalassionema synedriforme*. These six newly recorded diatom species were examined by light microscopy and scanning electron microscopy. The ecological habitats for all the investigated taxa are presented.

Prasath et al. [7] studied these four coagulants combined with algae suppression bacteria for their effect on *G. catenatum* to promote a more efficient and environmentally friendly algae suppression method. The results showed that polyaluminum chloride (PAC) is more efficient than other coagulants when used alone because it had a more substantial inhibitory effect. The PAC and Ba3 broth produced a pronounced algae inhibition effect that effectively hindered the germination of algae cysts. They conclude that this combination provides a scientific reference for the prevention and control of marine red tide. They suggested that designing environmentally friendly methods for the management of harmful algae is quite feasible.

Park et al. [8] investigated the community composition of free-living (FLB) and particle-associated (PAB) bacteria in each growth phase (lag, exponential, stationary, and death) of *Tetraselmis suecica* P039 culture using pyrosequencing. They suggested that the PAB community may have a stronger association with the algal growth than the FLB community. Irrespective of the growth phase, *Roseobacter* clade and genus *Muricauda* were predominant in both FLB and PAB communities, indicating that bacterial communities in *T. suecica* culture may positively affect algae growth, and that they are potentially capable of enhancing the *T. suecica* growth.

Kim et al. [9] investigated the diversity of dinoflagellate genus *Scrippsiella*, a common member of phytoplankton, and their cysts using light and scanning electron microscopy. They observed the Korean isolates of *S. precaria* had two types of the 5'' plate that either contacted the 2a plate or not. Molecular phylogeny based on internal transcribed spacer (ITS) and large subunit (LSU) rDNA sequences revealed that the Korean isolates were nested within the subclade of PRE (*S. precaria* and related species) in the clade of *Scrippsiella* sensu lato and that the PRE subclade had two ribotypes: ribotype 1 consisting of the isolates from Korea, China, and Australia, and ribotype 2 consisting of the isolates from Italy and Greece. They suggested that lineages between isolates of ribotype 1 were likely related to the dispersal by ocean currents and ballast waters from international shipping, and

the two types of spine shapes and locations of the 5'' plates may be a distinct feature of ribotype 1.

Ma et al. [10] proved that the well-known brown-tide-causing pelagophyte *Aureococcus anophagefferens* has a resting stage. They conducted a follow-up study to characterize the resting stage cells (RSCs) of *A. anophagefferens* using the culture CCMP1984. The results indicated that the RSCs of *A. anophagefferens* are a dormant state that differs from vegetative cells morphologically and physiologically, and that RSCs likely enable the species to survive unfavorable conditions, seed annual blooms, and facilitate its cosmopolitan distribution.

Jódar-Pérez et al. [11] studied seven species of *Cystoseira sl* spp. in Cabo de las Huertas (Alicante, SE Spain) and analyzed their distribution using Permutational Analysis of Variance (PERMANOVA) and Principal Component Ordination plots (PCO). The phylogenetic tree supported actual classification, including, for the first-time, *Treptacantha sauvageauana* and *Treptacantha algeriensis* species. These data supported a complex distribution and speciation of *Cystoseira sl* spp. in the Mediterranean, perhaps involving Atlantic clades.

Jo et al. [12] investigated the growth and lipid composition of the algal strain *C. vulgaris* KNUA007. They found that the strain was able to thrive in a wide range of temperatures, from 5 to 30 °C; however, it did not survive at 35 °C. The microalga was tolerant of low temperatures, making it an attractive candidate for the production of biochemicals under cold weather conditions. Therefore, this Antarctic microalga may have potential as an alternative to fish and/or plant oils as a source of omega-3 PUFA. The temperature tolerance and composition of *C. vulgaris* KNUA007 also make the isolate desirable for commercial applications in the pharmaceutical industry.

Li et al. [13] investigated the impacts of different concentrations of cell-free filtrate of the bacteria *Bacillus cereus* BE23 on *Ulva prolifera*. The evidence indicates that the alteration of energy dissipation caused excess cellular ROS accumulation that further induced oxidative damage on the photosynthesis apparatus of the D1 protein. The potential allelochemicals were further isolated by five steps of extraction and insolation (solid phase–liquid phase–open column–UPLC–preHPLC) and identified as N-phenethylacetamide, cyclo (L-Pro-L-Val), and cyclo (L-Pro-L-Pro) by HR-ESI-MS and NMR spectra. The dike-topiperazines derivative, cyclo (L-Pro-L-Pro), exhibited the highest inhibition on *U. prolifera* and may be a good candidate as an algicidal product for green algae bloom control.

Yang et al. [14] reviewed *Karlodinium* due to their representative features as mixoplankton and harmful algal blooms (HABs)-causing dinoflagellates. Their phagotrophy exhibits multiple characteristics: (1) omnivory, i.e., they can ingest a variety of preys in many forms; (2) flexibility in phagotrophic mechanisms, i.e., they can ingest small preys by direct engulfment and much bigger preys by myzocytosis using a peduncle; (3) cannibalism, i.e., species including at least *K. veneficum* can ingest the dead cells of their own species. They suggested that mixotrophy of *Karlodinium* plays a significant role in the population dynamics and the formation of HABs in many ways, which thus deserves further investigation in the aspects of physiological ecology, environmental triggers (e.g., levels of inorganic nutrients and/or presence of preys), energetics, molecular (genes and gene expression regulations) and biochemical (e.g., relevant enzymes and signal molecules) bases, origins, and evaluation of the advantages of being a phagotroph.

Author Contributions: Conceptualization, B.S.P. and Z.L.; writing—original draft preparation, B.S.P. and Z.L.; writing—review and editing, B.S.P. and Z.L.; supervision, B.S.P. and Z.L.; project administration, B.S.P. and Z.L.; funding acquisition, B.S.P. and Z.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by grant from the Korea Research Institute of Bioscience and Biotechnology (KRIBB) Research Initiative Program and the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2021R1C1C1008377 and NRF-2020R1C1C1011466).

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wang, B.; Wu, L. Numerical Study on the Massive Outbreak of the *Ulva prolifera* Green Tides in the Southwestern Yellow Sea in 2021. *J. Mar. Sci. Eng.* **2021**, *9*, 1167. [[CrossRef](#)]
2. Lee, E.S.; Hwang, J.; Hyung, J.-H.; Park, J. Detection of the Benthic Dinoflagellates, *Ostreopsis* cf. *ovata* and *Amphidinium massartii* (Dinophyceae), Using Loop-Mediated Isothermal Amplification. *J. Mar. Sci. Eng.* **2021**, *9*, 885. [[CrossRef](#)]
3. Lee, M.-C.; Yeh, H.-Y. Molecular and Morphological Characterization of *Colaconema formosanum* sp. nov. (Colaconemataceae, Rhodophyta)—A New Endophytic Filamentous Red Algal Species from Taiwan. *J. Mar. Sci. Eng.* **2021**, *9*, 809. [[CrossRef](#)]
4. Kwon, D.; Park, M.; Lee, C.S.; Park, C.; Lee, S.D. New Records of the Diatoms (Bacillariophyceae) from the Coastal Lagoons in Korea. *J. Mar. Sci. Eng.* **2021**, *9*, 694. [[CrossRef](#)]
5. Park, J.S.; Li, Z.; Kim, H.J.; Kim, K.H.; Lee, K.W.; Youn, J.Y.; Kwak, K.Y.; Shin, H.-H. First Report of the Marine Benthic Dinoflagellate *Bysmatrum subsalsum* from Korean Tidal Pools. *J. Mar. Sci. Eng.* **2021**, *9*, 649. [[CrossRef](#)]
6. Park, M.; Lee, S.D.; Lee, H.; Lee, J.-Y.; Kwon, D.; Choi, J.-M. Identification of New Sub-Fossil Diatoms Flora in the Sediments of Suncheonman Bay, Korea. *J. Mar. Sci. Eng.* **2021**, *9*, 591. [[CrossRef](#)]
7. Balaji Prasath, B.; Wang, Y.; Su, Y.; Zheng, W.; Lin, H.; Yang, H. Coagulant Plus *Bacillus nitratreducens* Fermentation Broth Technique Provides a Rapid Algicidal Effect of Toxic Red Tide Dinoflagellate. *J. Mar. Sci. Eng.* **2021**, *9*, 395. [[CrossRef](#)]
8. Park, B.S.; Choi, W.-J.; Guo, R.; Kim, H.; Ki, J.-S. Changes in Free-Living and Particle-Associated Bacterial Communities Depending on the Growth Phases of Marine Green Algae, *Tetraselmis suecica*. *J. Mar. Sci. Eng.* **2021**, *9*, 171. [[CrossRef](#)]
9. Kim, H.J.; Li, Z.; Kang, N.S.; Gu, H.; Kim, D.; Seo, M.H.; Lee, S.D.; Yun, S.M.; Oh, S.-J.; Shin, H.H. Morphology and Phylogeny of *Scrippsiella precaria* Montresor & Zingone (Thoracosphaerales, Dinophyceae) from Korean Coastal Waters. *J. Mar. Sci. Eng.* **2021**, *9*, 154.
10. Ma, Z.; Hu, Z.; Deng, Y.; Shang, L.; Gobler, C.J.; Tang, Y.Z. Laboratory Culture-Based Characterization of the Resting Stage Cells of the Brown-Tide-Causing Pelagophyte, *Aureococcus anophagefferens*. *J. Mar. Sci. Eng.* **2020**, *8*, 1027. [[CrossRef](#)]
11. Jódar-Pérez, A.B.; Terradas-Fernández, M.; López-Moya, F.; Asensio-Berbegal, L.; López-Llorca, L.V. Multidisciplinary Analysis of *Cystoseira* sensu lato (SE Spain) Suggest a Complex Colonization of the Mediterranean. *J. Mar. Sci. Eng.* **2020**, *8*, 961. [[CrossRef](#)]
12. Jo, S.-W.; Do, J.-M.; Kang, N.S.; Park, J.M.; Lee, J.H.; Kim, H.S.; Hong, J.W.; Yoon, H.-S. Isolation, Identification, and Biochemical Characteristics of a Cold-Tolerant *Chlorella vulgaris* KNUA007 Isolated from King George Island, Antarctica. *J. Mar. Sci. Eng.* **2020**, *8*, 935. [[CrossRef](#)]
13. Li, N.; Zhang, J.; Zhao, X.; Wang, P.; Tong, M.; Glibert, P.M. Allelopathic Inhibition by the Bacteria *Bacillus cereus* BE23 on Growth and Photosynthesis of the Macroalga *Ulva prolifera*. *J. Mar. Sci. Eng.* **2020**, *8*, 718. [[CrossRef](#)]
14. Yang, H.; Hu, Z.; Tang, Y.Z. Plasticity and Multiplicity of Trophic Modes in the Dinoflagellate *Karlodinium* and Their Pertinence to Population Maintenance and Bloom Dynamics. *J. Mar. Sci. Eng.* **2021**, *9*, 51. [[CrossRef](#)]