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REVIEW OF THE DOCTORAL DISSERTATION OF M.SC. EMILY YI-SHYUAN CHEN
titled: *Life at both edges of the Globe – bipolarity concept tested on pelagic Ostracoda*

This review has been prepared in accordance with Article 13, paragraph 1 of the Act of 14 March 2003 on Academic Degrees and Titles and on Degrees and Titles in the Arts (Journal of Laws 2017, item 1789). Its purpose is to evaluate whether the doctoral dissertation of Ms. Emily Yi-Shyuan Chen, prepared under the supervision of her Advisor, constitutes an original solution to a scientific problem and demonstrates the Candidate's possession of both theoretical knowledge in the discipline of biological sciences and the ability to conduct independent scientific research. I have assessed the following aspects: (1) the selection of the research area, topic, and structure of the dissertation, (2) the formulation of objectives and the applied research methods, (3) the scope of theoretical knowledge demonstrated by the Candidate, (4) the originality and cognitive value of the results obtained, and (5) the ability to conduct independent research.

The dissertation of M.Sc. Emily Yi-Shyuan Chen addresses issues of fundamental importance for contemporary biogeography and ocean ecology. Understanding the distribution patterns of marine organisms is one of the central challenges of modern science, as it provides insight into the mechanisms governing natural systems, particularly in poorly explored marine ecosystems, and contributes to their protection and sustainable use of their natural resources. These studies acquire special significance in the context of rapidly advancing climate change, which affects ecosystem stability and the shaping of biogeographic boundaries. Within this framework, phenomena referred to as bipolarity and antitropicality hold particular importance, describing the occurrence of identical or closely related taxa at both high and low latitudes. Although these concepts were formulated as early as the 19th century, they remain a subject of scientific debate due to ambiguous definitions, as well as difficulties in their empirical verification, not least because of the high costs and extreme logistical challenges of polar research. Against the background of

accelerating climate change, the problem of bipolarity gains renewed relevance. Ms. Chen's dissertation contributes to this discussion by focusing on pelagic Ostracoda, selected as a model research group.

The structure of the dissertation is clear and consists of four scientific publications: three already published and one accepted for publication in peer-reviewed international journals. These are preceded by a brief introductory chapter (Summary) presented in two languages, and the entire dissertation comprises 219 pages. In the following section, I provide a characterization of the individual articles and their assessment.

## CHARACTERIZATION OF THE PAPERS FORMING THE BASIS OF THE DOCTORAL DISSERTATION

Paper 1: **Chen E.Y-S.,** Trudnowska, E., & Błachowiak-Samołyk, K. (2024). Bipolarity and Antitropicality in Marine Taxa: Understanding the Complexities of Latitudinal Distribution. *Journal of Biogeography*, 52(2): 454–466. doi: 10.1111/jbi.15046

The first article serves as the introductory chapter of Ms. Chen's dissertation and represents an ambitious attempt to trace more than two centuries of research and observations on the phenomena of bipolarity and antitropicality, to clarify their definitions, and to confront the existing literature with data derived from Arctic and Antarctic species registers (ARMS, RAMS) as well as the global OBIS database. The Candidate based her analysis on an impressive dataset comprising 665 records from 221 publications, demonstrating that cases of antitropicality (517) markedly outnumber those of bipolarity (148). At the same time, she showed that as many as 44% of descriptions in the literature do not meet the adopted definitional criteria, and that the term "bipolarity" has often been applied arbitrarily. The analysis further highlighted clear taxonomic patterns: antitropicality pertains primarily to vertebrates (fish and marine mammals), whereas bipolarity more frequently refers to invertebrates, particularly planktonic groups. The article provides a systematic clarification of concepts, stresses the necessity of precise use of terminology, underlines the importance of molecular methods in studies of species distributions, and points to the need for better knowledge of poorly investigated groups such as planktonic crustaceans.

Paper 2: **Chen, E.Y-S.,** Trudnowska, E., & Błachowiak-Samołyk, K. (2023). It's a female's world: Sex ratio of polar pelagic ostracods tested across multiple spatiotemporal scales. *Journal of Plankton Research*, 45(5): 763–776. doi: 10.1093/plankt/fbad038

The second paper presents an empirical study devoted to the sex ratios of polar pelagic ostracods (Halocyprididae). The Candidate set out to examine whether the proportion of males to females within populations remains stable across different spatial and temporal scales. The analysis was based on an extensive dataset comprising 507 plankton samples collected during a series of polar expeditions between 1983 and 2019. In total, the sex of more than 4,000 individuals was determined, representing four Arctic species: *Boroecia maxima, B. borealis, Discoconchoecia elegans*, and *Obtusoecia obtusata*, and three Antarctic species of the genus *Alacia* (*A. belgicae, A. hettacra, A. isocheira*). The results are unequivocal: in all analyzed populations, females consistently and markedly outnumbered males (60–70%), and in the penultimate developmental stage (A-1), the imbalance was even more pronounced, with individuals being almost exclusively female, regardless of latitude (Arctic vs. Antarctic), depth, or season. In summary, the Candidate concludes that female dominance in the pre-adult (A-1) stage may have adaptive significance, enhancing the reproductive potential of populations inhabiting environments with short periods of primary production and variable conditions. She further suggests that such female-biased ratios may facilitate the maintenance of broad geographic ranges of species and could even contribute to the emergence or persistence of bipolar distributions.

ARTYKUŁ 3: Chen E.Y-S., Trudnowska, E., Wold, A., Boehnke, R., & Błachowiak-Samołyk, K. (2025). A decade of reproductive abnormalities in pelagic ostracods observed at the entrance to a changing Arctic. *Marine Biology,* 172: 42. doi: 10.1007/s00227-025-04601-y

The third article is devoted to the analysis of morphological anomalies in the reproductive organs of pelagic ostracods (*Boroecia maxima, B. borealis, Discoconchoecia elegans, Obtusoecia obtusata*). The study was based on an extensive dataset of more than 4,100 individuals collected between 2010 and 2019 in the Fram Strait, a key “gateway” of water exchange between the Arctic and the Atlantic. The observations confirmed the presence of recurring developmental anomalies, the most frequent of which were intersexuality (the occurrence of traits of both sexes within a single individual, such as the coexistence of copulatory organs and an egg chamber), underdevelopment of gonads, as well as various types of asymmetries or duplications of male copulatory structures. Individuals displaying such traits accounted for several to more than ten percent of populations, regardless of location. These atypical features occurred exclusively in the penultimate developmental stage (A-1) and were never observed in adults, which the Candidate interprets as a potential effect of environmental stressors or developmental disturbances. In the discussion, she points to possible causes including the influence of endocrine-disrupting compounds, food limitation, parasitism, as well as processes linked to climate change.

Paper 4: **Chen, E.Y-S.,** Burzyński, A., Śmietanka, B., Lubośny, M., & Błachowiak-Samołyk, K. (Submitted). Mitogenomic organization and diversity of deep-sea pelagic ostracods from both polar regions. *Molecular Ecology.*

The fourth article constitutes the first study of mitochondrial genomes of pelagic ostracods from the family Halocyprididae (*Boroecia maxima, B. borealis, Discoconchoecia elegans, Obtusoecia obtusata*) collected in the Greenland Sea, Fram Strait, Weddell Sea, and the Drake Passage region. Through sequencing, complete mitogenomes were obtained (13 protein-coding genes, 22 tRNAs, and 2 rRNAs), which were subsequently compared in terms of length, organization, and phylogeny. The results revealed: (1) gene rearrangements, particularly within ND3 and tRNA regions, (2) absence of the ATP8 gene in some genomes, (3) mitochondrial genomes shorter than those of other planktonic crustaceans (a compaction process), (4) phylogenetic confirmation of the monophyly of the taxa Boroecia and Discoconchoecia, and (5) a high degree of similarity between Arctic and Antarctic genomes, interpreted as evidence of a relatively recent, Pleistocene separation of biogeographic lineages. Of particular note are the rearrangements within the ND3 gene, which encodes a subunit of Complex I of the respiratory chain—crucial for metabolism under extreme conditions—and within tRNA genes, recognized as the most plastic elements of crustacean mitochondrial DNA.

SUMMARY AND EVALUATION

Three of the four publications comprising Ms. Emily Yi-Shyuan Chen's dissertation have already been published in reputable international journals, which demonstrates that their scientific value, methodological approach, and interpretation of results have been independently verified through peer review. This fact constitutes clear confirmation of the high quality of the research and of the Candidate's ability to present her scientific achievements within the international academic community. In this context, the Candidate and her co-authors deserve recognition for producing valuable publications, with best wishes that these works will resonate widely within the scientific community and achieve high citation impact. At the same time, my role as reviewer is to evaluate the dissertation as a coherent whole, to assess the degree of independence shown by the Candidate, and to identify areas that may warrant further discussion.

Ms. Chen's dissertation was conceived as an attempt to test the concept of bipolarity in the distribution of marine organisms, using pelagic ostracods as a model group. The first article, in

which the Candidate sought to clarify the concepts of bipolarity and antitropicality and conducted an analysis of extensive literature and open-access databases, is without doubt both valuable and needed within the ongoing scientific debate. Nevertheless, it leaves a certain sense of incompleteness. In my view, the article would have benefitted from a more thorough discussion of the hypotheses concerning the origin of bipolarity (which were only briefly mentioned) as well as of the ecological and evolutionary mechanisms that might account for the observed patterns.

Certain reservations also arise from the adoption of rigid and somewhat arbitrary criteria for defining bipolarity (i.e., occurrence above 66°33′N and below 66°33′S) and antitropicality (distribution outside the tropics), which diverge from the classical approach of Hubbs (1952), based on climatic and oceanographic boundaries. While this methodological choice has the advantage of standardizing and quantifying the data, it overlooks key ecological aspects, namely that species distributions are shaped primarily by ocean currents, fronts, and isotherms. It would therefore be appropriate to clarify the methodological rationale for this choice and to explain why the Candidate did not attempt to incorporate environmental factors, even if their analysis would have posed additional challenges. The study would also have benefitted from analyses at higher taxonomic levels (genera, families) as well as from reference to biological traits that may promote or constrain bipolarity, such as mobility, the ability to form resting stages, or vertical migrations. It should also be emphasized that the work does not directly answer the central question of the dissertation—namely, to what extent pelagic ostracods actually conform to the observed bipolar pattern.

From the perspective of the dissertation's aims, the second and third articles are more closely aligned with the goal of the thesis: to investigate the bipolarity concept. The second article, a pioneering study, clearly demonstrates the pronounced predominance of females over males. However, the discussion of these results is largely confined to the ecological level, and it is regrettable that it does not engage more explicitly with sex ratio theory (Fisher, Hamilton, Charnov). The statistical analyses employed (chi-square goodness-of-fit tests) allowed the assessment of deviations from 1:1 and 1:2 sex ratio models and of seasonal and depth-related differences, while non-parametric tests (Kruskal–Wallis, Wilcoxon), together with post-hoc analyses, enabled evaluation of the influence of season, depth, and developmental stage. This approach was sufficient to demonstrate significant deviations from sex ratio equilibrium and to capture some temporal fluctuations. However, analyzing each factor separately does not allow assessment of potential interactions among ecological variables.

The third article, based on a rich collection of polar ostracods, highlights morphological anomalies in the reproductive system. This analysis remains largely descriptive. The hypotheses linking

observed anomalies to environmental processes are interesting, yet the study lacks a statistical assessment of the relationship between environmental parameters (e.g., temperature) and the frequency of deformities. One might ask whether the Candidate envisaged such an approach and whether any attempts in this direction were undertaken.

Although both of these studies are undoubtedly of scientific value, they do not directly address the central hypothesis of the dissertation, namely the verification of bipolarity. The description of reproductive peculiarities and female dominance in Arctic ostracod populations is linked by the Author to climate-related processes. Climate change is, of course, a reality, but its relationship with the concept of bipolarity is not straightforward. Rather, the underlying mechanisms should be sought in historical factors (as captured in the fourth article) or in biological traits such as dispersal ability. In this context, the fourth article corresponds most fully to the overarching aim of the dissertation. By applying modern mitochondrial genomics, it does not confirm the existence of genuinely bipolar taxa in the present, but instead reveals distinct evolutionary trajectories of the studied lineages and points to historical processes underlying the apparent bipolarity.

The analysis of co-author statements clearly indicates that in all four publications the Candidate played a leading role. She was responsible for data collection and analysis, laboratory and bioinformatic work, as well as preparing the first drafts of the manuscripts, that is, the most labor-intensive and crucial stages of the research. Her contribution was therefore both essential and integrative. The co-authors, in turn, provided important conceptual, expert, and technical input, ranging from the acquisition of material to supervision of analyses and specialized support in taxonomy and bioinformatics. This organization of work demonstrates the Candidate's research maturity and her ability to collaborate effectively within interdisciplinary teams.

The publication of three articles and the preparation of one additional manuscript leave no doubt that the preparing of this dissertation required the Candidate to possess extensive and in-depth knowledge of the literature in the fields of ostracod biology, plankton ecology and evolution, and the functioning of polar ecosystems. The scope of theoretical knowledge presented in the dissertation meets the requirements expected of a doctoral thesis and confirms the scientific maturity of the Candidate.

From a formal perspective, the dissertation is distinguished by a clear and logical composition, with the individual articles fitting well into the overall line of argument. A certain shortcoming, however, is the absence of a final discussion that would integrate the dissertation as a whole, summarize the findings, indicate the areas in which the hypothesis has been confirmed and those that remain open, and outline directions for further research. The introductory section would also

have benefitted from a more explicit characterization of the study object (pelagic ostracods) to better justify the choice of this group as a model for analyzing biogeographic and evolutionary processes.

In summary, despite the critical remarks presented above, I assess all aspects of the dissertation very highly. The results are original, scientifically relevant, and the research was conducted with great care. The subject of the dissertation is both timely and well aligned with current scientific challenges, while also being based on a rich body of material. Particularly noteworthy is the contribution to knowledge of the biology of planktonic ostracods, an important element in the assessment and monitoring of climate change. Conducting the research, processing the extensive material, preparing scientific documentation, and performing advanced analyses demanded significant effort, time, and determination on the part of the Candidate. The fact that three of the four publications have already appeared in prestigious international journals confirms not only the high scientific quality of the dissertation but also the Candidate's maturity as a researcher and her ability to formulate and present results to the international scientific community. Although the dissertation does not include a concluding discussion tying together all articles, nor does it explicitly address the methodological limitations that the Candidate undoubtedly had to confront, this does not affect my overall very positive evaluation of the work. In my opinion, the dissertation is a valuable, coherent piece of research and constitutes a significant contribution to the advancement of knowledge on the biogeography of marine organisms.

In conclusion, I state that the doctoral dissertation of M.Sc. Emily Yi-Shyuan Chen meets the criteria of Article 13 of the Act of 14 March 2003 on Academic Degrees and Titles and on Degrees and Titles in the Arts (Journal of Laws 2017, item 1789). I therefore recommend to the Scientific Council of the Institute of Oceanology, Polish Academy of Sciences, that the dissertation of M.Sc. Emily Yi-Shyuan Chen be recognized as fulfilling the requirements for doctoral theses and that the Candidate be admitted to the subsequent stages of the doctoral procedure.

Signature Not Verified

Dokument podpisany przez
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