WARSAW
UNIVERSITY
OF LIFE SCIENCES

Warsaw, 09.07.2025

Review of the Doctoral Dissertation of Morgane Dromby, MSc

„Adaptive Skull Shape Changes in Bottlenose Dolphins (Tursiops spp.): Insights from 3D Morphological Analyses"

„Adaptacyjne zmiany kształtu czaszki u delfinów butlonosych (Tursiops spp.): wnioski z analiz morfologicznych 3D"

The formal basis for this review is a letter from the Chairman of the Scientific Council of Biological Sciences at the University of Gdańsk, Prof. dr hab. Joanna N. Izdebska.

Morgane Dromby's dissertation, submitted to the Faculty of Biology at the University of Gdańsk in 2025, examines the 3D skull morphology of bottlenose dolphins (Tursiops truncatus and related species) using advanced geometric morphometrics (GM) techniques. Supervised by dr. hab. Andre E. Moura, the study investigates cranial variation, allometric patterns, and ecological drivers of skull shape differentiation across coastal and offshore populations. Spanning 299 pages, the dissertation is structured into six chapters, supplemented by appendices, R code, and extensive supplementary materials. This review evaluates the dissertation's scientific merit, methodology, structure, clarity, and contribution to cetacean biology.

dr hab. Tomasz Szara
prof. SGGW
Warsaw University of Life Sciences
Department of Morphological Sciences
Nowoursynowska 159 St.
02–787 Warsaw
+48 22 593 6202
tomasz_szara@sggw.edu.pl

This dissertation investigates adaptive skull shape changes in bottlenose dolphins (Tursiops spp.) through 3D morphological analyses. The study aims to elucidate factors driving skull shape variation among populations, focusing on differences between coastal and offshore ecotypes. It employs geometric morphometrics and 3D imaging to analyze skull morphology in relation to ecological and environmental variables. The dissertation addresses four main objectives: (1) to identify 3D skull shape differences between coastal and offshore bottlenose dolphin populations globally; (2) to assess correlations between skull shapes and environmental variables; (3) to examine skull shape variation within the Western North Atlantic (WNA) operational unit; and (4) to explore allometric patterns in skull shape across regional populations.

To achieve these objectives, the author developed a standardized photogrammetry protocol for 3D modeling, detailed in Chapter 2. Chapter 3 introduces Surface Semi-Landmarking (SSL) techniques to address limitations of manual landmarking. Subsequent chapters present core findings, comparing skull shapes across global and regional scales and analyzing environmental influences and allometric patterns. The methodology is robust and meticulously executed. High-resolution DSLR cameras, combined with software such as Meshroom and MeshLab for 3D mesh processing, demonstrate technical proficiency. The study uses substantial sample sizes (N=58 for Chapter 3, N=234 for Chapter 4, N=73 for Chapter 5) and integrates manual and semi-automatic landmarking techniques for robust data collection. Statistical analyses, including Generalized Procrustes Analysis (GPA), Pairwise PERMANOVA, and Random Forest classification, are appropriately applied to test hypotheses on shape variation and environmental correlations. The inclusion of R code in the supplementary materials enhances transparency and reproducibility.

The study examines skull shape differences across 10 coastal operational taxonomic units (OTUs) and their offshore counterparts, identifying distinct morphological patterns linked to ecological and genetic factors. This global perspective addresses a gap in prior studies, which often focused on regional populations. Chapter 1 (Introduction) provides a thorough review of GM in cetacean studies, with figures (e.g., Figure 1.1, p. 28) illustrating publication trends. Objectives are clearly stated (p. 37), establishing a focused research agenda. Chapter 2 (3D Skull Reconstruction) details a replicable workflow with technical descriptions and software settings, enhancing reproducibility and addressing challenges like inconsistent landmarking. This protocol serves as a standalone resource for morphometric researchers.

Chapters 3–5 (Core Analyses) focus on cranial variation (Chapter 3), global shape differentiation (Chapter 4), and allometric patterns (Chapter 5). Results are supported by clear visuals (e.g., Figures 4.4–4.7, pp. 104–109; Figure 5.4, p. 163) and detailed discussions.

The publication of Chapter 3 in the Zoological Journal of the Linnean Society (Dromby et al., 2023) underscores its peer-reviewed impact. However, reliance on existing data rather than generating new evidence slightly limits originality in this aspect. It would be preferable to cite this publication rather than include it as an integral chapter. Chapters 4 and 5 explore environmental influences (e.g., bathymetry, salinity) and allometric diversification, revealing correlations between skull shape and feeding strategies, swimming mechanics, and habitat heterogeneity. The identification of distinct allometric patterns in coastal versus offshore populations is particularly novel. Chapter 6 (Main Discussion) synthesizes findings, linking morphological variation to ecological and social factors. While comprehensive, it occasionally repeats points from earlier chapters (e.g., p. 182 vs. p. 121). Supplementary materials, including extensive tables (e.g., Table S4.2.1, p. 216) and R code (pp. 269–299), enhance transparency, though their volume may overwhelm some readers.

The dissertation's primary strength lies in its innovative application of 3D geometric morphometrics to study bottlenose dolphin skulls. By integrating photogrammetry, 3D modeling (using software like 3DSlicer and Blender), and advanced statistical tools (e.g., Principal Component Analysis, Random Forest, Redundancy Analysis), the study provides a robust framework for analyzing cranial variation. The focus on coastal and offshore populations across diverse regions (e.g., Western North Atlantic, Mediterranean, Japan, West Africa) adds a global perspective, addressing ecological and evolutionary drivers of morphological diversity. The thesis identifies distinct skull shape patterns, such as broader rostrums in coastal populations and more streamlined skulls in offshore ones, linked to ecological factors like diet, habitat heterogeneity, and founder effects. The exploration of allometric patterns (Chapter 5) is particularly noteworthy, revealing subtle intraspecific differences in cranial scaling, contributing to discussions on population differentiation and phenotypic plasticity. These findings are novel and build upon existing literature, offering new insights into cetacean cranial evolution. The standardized 3D reconstruction protocol (Chapter 2) is a significant contribution, addressing methodological challenges in GM, such as inconsistent landmarking and imaging artifacts, and enhancing reproducibility for future morphometric studies.

Despite these merits, certain shortcomings must be noted.

The Polish abstract contains significant linguistic errors, likely due to automatic translation. Terms such as "czaszki wewnątrzgatunkowej" (intraspecific skull), "region czołowy" (instead of "okolica czołowa"), "dimorfizm" (instead of "dymorfizm"), and "rozbieżność kształtu" (instead of "zmienność kształtu") distort meaning. Repetitions like "badania te badają" and ambiguous phrases like "delfiny morskie" (implying inland dolphins) or "wody morskie" (suggesting the Gulf of Guayaquil and Mediterranean are not seas) reduce clarity. English abbreviations are explained in the Polish abstract, but their full names should appear in the English version. The abstract requires thorough revision by a native Polish speaker with expertise in zoology and geometric morphometrics to meet doctoral standards.
In the main text, the term "geometric morphometric" is occasionally used instead of "geometric morphometrics." The reference to "South Pacific" and "North Pacific Oceans" as separate entities is inaccurate, as they are parts of the Pacific Ocean.
The claim that contours are lost in 2D projection lacks supporting references and should be substantiated or removed.
The photogrammetric protocol, while detailed, omits the standard distance between the camera and the skull, which could affect reproducibility.
Including a published paper as Chapter 3 introduces redundancy, as Chapters 4 and 5 revisit similar questions with expanded data. A more cohesive structure could integrate these findings to reduce overlap. The inclusion of one publication in a dissertation edited as a monograph also complicates the review process, as this chapter has already undergone peer review and should not be re-evaluated in terms of its content, unlike the other sections.
The division of the reference list by chapter leads to unnecessary repetition; a consolidated list would be more efficient.

These criticisms do not diminish the dissertation's overall scientific merit, as the English text is clear and well-written, and the methodological and analytical contributions are substantial.

In conclusion, this dissertation offers valuable insights into the interplay of ecological, evolutionary, and developmental factors that influence skull morphology in bottlenose dolphins. The findings enhance our understanding of cetacean evolution, adaptation, and diversification, with implications for conservation, as they identify distinct populations that require specific management strategies. The methodological advancements and comprehensive dataset will serve as a valuable resource for future research. The dissertation meets the requirements of Article 187, Section 1 of the Polish Law on Higher Education and Science (Journal of Laws of 2018, item 1668, as amended), demonstrating the candidate's ability to conduct independent, high-quality research. Its originality, rigorous methodology, and novel findings fulfill Section 2, advancing knowledge of bottlenose dolphin cranial morphology and its ecological drivers. I request that the Scientific Council for Biological Sciences at the University of Gdańsk admit Morgane Dromby, MSc, to the next stages of her doctoral proceedings.

dr hab. Tomasz Szara, prof. SGGW