Natural variation in shell thickness and composition across a latitudinal gradient and over historical time

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Introduction

- Earth’s climate is changing and our ocean are becoming warmer and more acidic.
- Shellfish, such as bivalves, have thick shells that are made up of a high percentage of calcium carbonate. When the pH decreases, the shells dissolve more easily and it is also more difficult to make. As a consequence, there is a reduction of the barrier between the animal and the surrounding environment.
- Understanding how these species regulate shell production in the natural environment is critical to our understanding of how they will fare under climate change. This will improve our ability to predict future shellfish biodiversity and aquaculture production in a rapidly changing world.
- Specifically this work will investigate the natural variability of shell composition in four commercial species across latitude and over historical time.

Experimental design

- The target taxa are the EU’s most important commercially exploited bivalves: Pecten maximus, Mytilus edulis, Cossartinae giga and Mya arenaria.
- Collection areas were selected along European Atlantic  (13 sites) and Mediterranean coastlines (3 sites).
- Sites are characterized by a progressive variation of environmental parameters from low to high latitudes, such as temperature, salinity and pH.

METHODS

The natural variability of shell features will be examined, testing the general hypothesis that calcareous shells are more difficult to maintain in colder waters (increasing latitude). For each species the following aspects will be examined:

- Intraspecific variation of the overall shell thickness and individual shell layer thickness over the current latitudinal range and with different environmental conditions.
- Variability of microstructure, mineralogy (crystallographic alignment) and composition (element analysis, organic content).
- Differences in shell shape, allometry and colouration. These aspects will be investigated through a range of SEM, X-ray diffraction and ion probe techniques.
- The same parameters will be studied in museum collection allowing us to compare historic data over the last 100 years.
- Additional collections of three taxa, which occurred in the Pliocene (Mid Pliocene Warm Period), will provide further information on any evolutionary scale changes in the shell structure and composition over the last 4 million years.

Discussion

- It is known that shell features can vary significantly within species, depending on where they live and these are often linked to the local conditions. By studying the variability of the shells from the same species in different environments, we can identify how local conditions affect shell production.
- Previous works have provided important information on the effect of increasing water acidification and environmental stressors on bivalves’ shell structure, but for small samples or restricted areas only.
- Analysing the natural variability of shell features over their current and past latitudinal range will show the levels of shell production and physiological responses of these species to different environmental parameters, and will enable us to predict how these animals will be affected when the environment changes.

Figure 2. Target species and their shell microstructures: A) Pecten maximus [1], B) Mytilus edulis [2], C) Cassis gigas [3] and D) Mya arenaria [4]. E) Axial pept bone of a longitudinal section of a blue mussel, revealing the radula thickness of each shell layer and the thin micro-structure bands in the calcitic prismatic region [5]. F) Axial pept bone of a longitudinal section of an European flat oyster showing the annual growth lines in the calcitic prismatic region (black arrows) [6]. (Images: photos from the Natural History - Natural Museum Wales).

Figure 3. Electron Backscatter Diffraction (EBSD) analysis of M. edulis shell grown under culture at 380, 750 and 1000 µmol of CO₂ [2]. Left phase maps: calcite in red and aragonite in green; (centre) crystallographic orientation maps and (right) pole figure (001) planes.

Conclusions

- By studying the composition of shells from natural populations in different environments, we can gain an unprecedented understanding of the level of phenotypic plasticity operating in bivalve shell formation.
- We can also identify if there are factors associated with any observed differences in these taxa and understand their level of resilience to environmental perturbation.
- This will enable us to identify potentially resilient populations that can be selected for future aquaculture production.

Literature cited


Acknowledgement

The research leading to these results has received funding from the European Union Seventh Framework Programme under grant agreement n° 608051.