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Crystallinity and microchemistry of *Nassarius reticulatus* (Caenogastropoda) statoliths: Towards their structure stability and homogeneity

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ABSTRACT

Gastropod statoliths are spherical biocarbonates formed during their lifespan. The stability and homogeneity of these structures' mineral matrix was characterised along their radiuses, using *Nassarius reticulatus* as a model. Generally, they were proved to be bimineralic. Two of the three $CaCO_3$ crystalline polymorphs occurring in biocarbonates – aragonite and calcite – coexist along statolith radiuses, aragonite being unequivocally the most abundant phase. The presence of a diffuse organic matrix was also perceived by the detection of a weak Raman band between 2800 and 3000 cm^{-1} consistently observed along radiuses. Beyond the apparent stability and homogeneity, different crystalline orientations were disclosed by Raman spectroscopy. A change in the intensity pattern of the features related to the lattice and bending modes of aragonite between different radiuses give new insights for a possible spherulitic-like growth of these structures. As expected from the relative homogeneity of both mineral and organic signals, there was no pattern on the distribution of Ca, O, Na and S along radiuses. However, a higher concentration of Sr occurs in growth rings (known as winter tags), corroborating the already described negative correlation between the concentration of this element in statoliths and temperature. Despite the apparent stability and homogeneity of the matrix during its lifespan, the periodic distribution of Sr potentially influences a dissimilar incorporation of trace elements in increments and growth rings. Since gastropod statolith elemental fingerprinting was recently suggested as a new tool to monitor marine environmental changes, the pressing need for further studies on the incorporation of traces in these structures is highlighted.

1. Introduction

Statoparticles are biogenic calcified structures located inside most invertebrates' gravireceptors – the statocysts. Their displacement inside the statocysts, owing to the animal's motion, stimulates local sensory cells indicating the body's position in respect to gravity (Chase, 2002), and thus involved in the mechanisms of balance and spatial orientation.

Statoparticles are diverse amongst class Gastropoda, namely regarding type (i.e. multiple statoconia vs. single statolith), shape and microstructure. These features have been addressed over time, mainly as part of studies on the structure (e.g. Chia et al., 1981; Gao and Wiederhold, 1997; Gorgiladze et al., 2010; McKee and Wiederhold, 1974), development (e.g. D'Asaro, 1965; Gao et al., 1997; Salley, 1986; Wiederhold et al., 1990) and function (e.g. Gallin and Wiederhold, 1977; McKee and Wiederhold, 1974; Wiederhold et al., 1989) of gastropod statocysts. However, the scenario is different as regards to their chemical composition. Hardly any reports on gastropods can be found in the literature and those available refer to a minority of species: statoconia in *Helix lucorum* (Gorgiladze, 2002) and *Aplysia californica* (Pedrozo et al., 1997; Wiederhold et al., 1989); statoliths of larvae in *Lobatus gigas* (Salley, 1986), *Concholepas concholepas* (Manríquez et al.,

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