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Amounts and composition of trace elements in the statoliths of loliginid squids: reflection of environmental conditions?

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Introduction

The study of trace elemental composition in cephalopod statoliths is a rapidly developing technique with a variety of potential uses. For example, the trace element uptake is believed to reflect the elemental composition of the environment. As it had been proven that statoliths produce daily increment rings, they may contain valuable information of cephalopod distribution and migration. Major shortcomings of these new techniques in cephalopod research are still the time-consuming, difficult and expensive analytical methods which are involved.

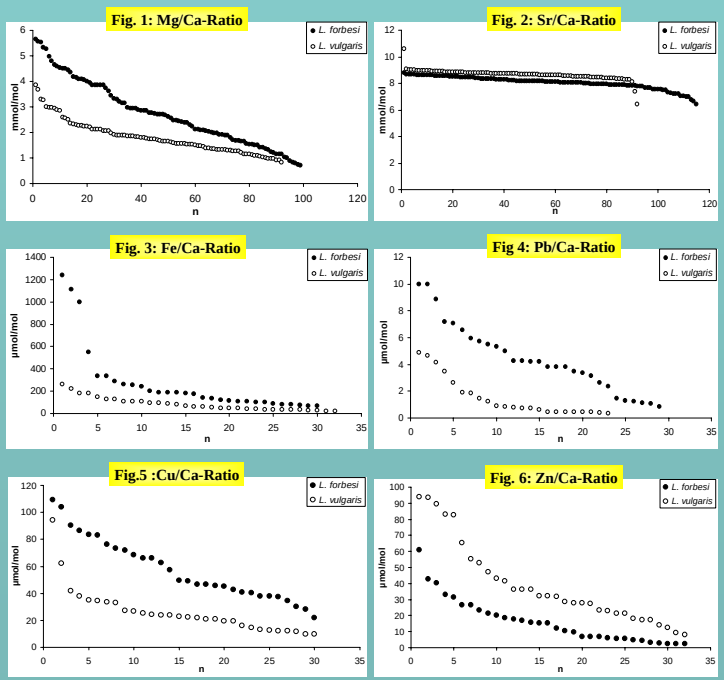
Material and methods

In order to test if this microchemistry technique will be applicable for more detailed life history analyses of oceanic squid species we examined trace elemental composition of two long-finned squids of known different origin: *Loligo forbesi* from the central North Sea (caught in September 1999) and *L. vulgaris* from the Mediterranean Sea (caught off the Sicilian coast in July 2000). The statolith microchemistry included atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry with optical spectrum analysis (ICP-OES). Mapping of statolith Sr, Ca, Mg, Fe and Zn concentrations was further investigated by electron microprobe analyses. Because Ca forms the statolith matrix, all measurements are given in ratios related to Ca which also ensures comparison of the different statoliths of the two squid species considered. Detailed descriptions of the techniques applied are given in the Diploma thesis of the first author.

Results

Microchemistry. The statolith trace elemental composition differed significantly ($p<0.01$) between the two species (Figs. 1-6). Sr/Ca and Zn/Ca ratios of Mediterranean *Loligo vulgaris* statoliths were significantly higher than those in North Sea *L. forbesi* statoliths which was attributed to the higher salinity of the Mediterranean Sea. For all other elements (Mg, Fe, Pb, Cu) the ratios were contrary.

Electron microprobe analysis. The measurements of a *Loligo forbesi* statolith are presented in Figs. 7 to 9. They vary from the results obtained by the microchemistry analysis. The Mg/Ca, Fe/Ca and Zn/Ca ratios are considerably lower, in particular the Mg/Ca ratio; whereas the Sr/Ca ratio is similar in both, microchemistry and electron microprobe analysis. The disper-sion of measurements is lower in the latter analysis.



Figs. 1-6. Trace elemental ratios in statoliths of *Loligo forbesi* and *L. vulgaris* obtained from microchemistry analysis. X-axis represents single measurements which for clarity reasons are ordered by decreasing value of trace elemental ratios.

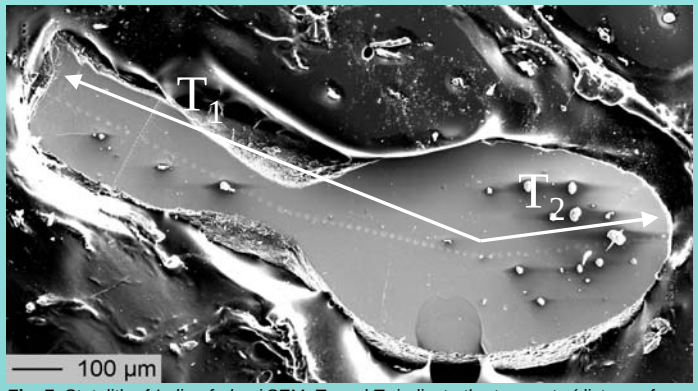


Fig. 7. Statolith of *Loligo forbesi* SEM. T_1 and T_2 indicate the transects (distance from nucleus) shown in Figs. 8 and 9. Below the arrows which indicate the transects the marks of the electron microprobe beams are visible (beam diameter ca. 7 µm).

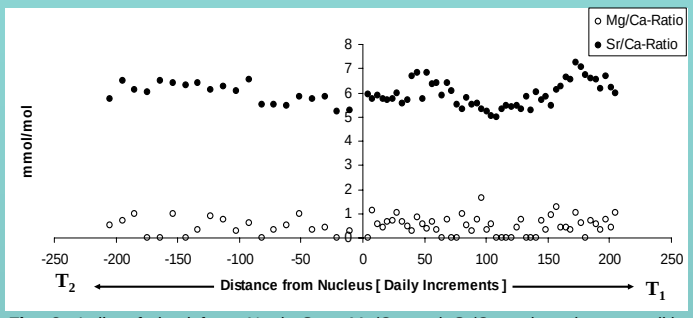


Fig. 8. *Loligo forbesi* from North Sea. Mg/Ca and Sr/Ca ratios along statolith transects T_1 and T_2 of Fig. 7; X-axis: Distance of measurements according to daily increments.

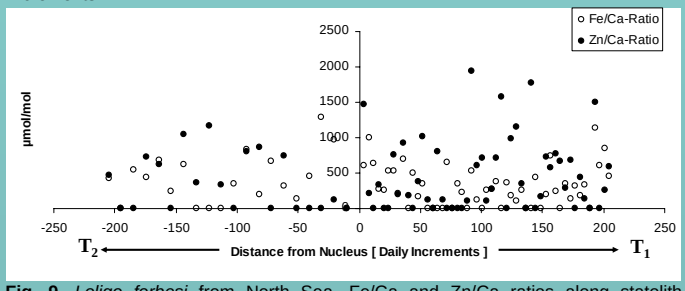


Fig. 9. *Loligo forbesi* from North Sea. Fe/Ca and Zn/Ca ratios along statolith transects T_1 and T_2 of Fig. 7; X-axis: Distance of measurements according to daily increments.

Conclusions

The microchemistry analysis suggests a significant difference of the statolith trace elemental composition between *Loligo forbesi* from the North Sea and *L. vulgaris* from the Mediterranean Sea. The measurements of Sr/Ca ratios show the lowest deviations making this ratio the most reliable one to measure. The electron microprobe analysis reflects changes in the accumulation of Sr in the statolith during the life history of *L. forbesi* which suggests that the animal possibly migrated through different water bodies. Further studies on the trace elemental composition of the ambient water masses are now required for a better mapping of the squid's possible migration as well as a better understanding of the mechanisms which control the amount of trace element accumulation in the statolith.

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