Incorporation of strontium into the skeleton of the zooxanthellate coral *Acropora* sp.

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**INTRODUCTION**

Strontium (Sr²⁺) is a relatively common constituent of seawater and one of the most abundant trace elements (8 mg l⁻¹ or 91 nM). It is chemically similar to calcium (Ca²⁺) and is generally considered to substitute for calcium ions in the aragonite lattice of biogenic carbonate.

Strontium thermometry has been suggested to be a powerful tool for reconstructing seawater surface temperature. In corals, it has been shown that Sr/Ca ratios vary with calcification (vital effect), which in turn is dependent on light and temperature.

**MATERIALS AND METHODS**

Experimental set up

Experiment was performed in the laboratory using the branching zoanthellate scleractinian corals, *Acropora* sp. “Nubbins” were obtained by cutting terminal portions of branches from a single parent colony and then suspended with a nylon mesh in aquaria. After 2 weeks of healing, tissue entirely recovered the exposed skeleton and coral fragments were ready to be used for experiments.

In the first set of experiments, 27 nubbins were distributed in 3 tanks (30 l), and cultivated under 3 light levels: 100 (low light, LL), 200 (medium light, ML), and 400 mmol m⁻² s⁻¹ (high light, HL) for 4 weeks. The temperature was kept constant and equal to 27 °C.

In the second set of experiments, 15 nubbins were distributed in 3 tanks and cultivated at 20, 25, and 29 °C. The light was kept constant (400 mmol m⁻² s⁻¹).

Calcification rate

Coral nubbins were weighed once a week during the two experiments according to the buoyant weight technique, using a Mettler AT 261 balance.

Radioactive measurements

* For the “light experiment”, 5 nubbins from each light level were incubated for 4 h in beakers containing 50 ml of seawater spiked with microcurie quantities of the radiotracer ⁸⁷Sr (carrier-free, obtained from LEA, T₁/₂ = 64.85 days) to reach an activity of 7.052 kBq 1⁻¹. Temperature was kept constant at 27 °C by incubating beakers in a waterbath. The light level was equal to the one set up in the culture conditions (100, 200, and 400 mmol m⁻² s⁻¹).

* For the “temperature experiment”, 5 nubbins from each temperature were incubated for 24 h in beakers containing 50 ml of seawater spiked with the radiotracer ⁸⁷Sr. The light was kept constant to 400 mmol m⁻² s⁻¹.

At the end of the incubation, colonies were rinsed with normal seawater, blotted dry on absorbent paper to eliminate any adhering radioactive medium, then incubated 30 minutes in beakers containing 50 ml of seawater (labeled). This step is necessary to get rid of the labeled seawater contained in the coelenteric cavity of the corals (and therefore radioactivity not incorporated into the tissue or the skeleton). The ⁸⁷Sr biomass accumulation in the tissue and the skeleton was determined by gamma counting, using a well-type NaI detector.

**DISCUSSION**

Since more than 20 years now, the Sr/Ca ratio of coral skeleton has been widely used to determine the temperature of the ancient seas (Swart, 1981; Aharon, 1991). It is therefore important to fully understand the processes involved in coral calcification, in order to have a better interpretation of the Sr/Ca data collected. Up to now, studies on calcification has mainly focused on the incorporation of calcium into the skeleton (Chalker 1976, Tambutte et al. 1996), or on global calcification. It has been shown that calcium is actively transported to the sites of calcification and that the coral itself regulates this incorporation (Tambutte et al. 1996). It has also been shown that calcification depends on several factors, and among them, light (Barnes & Chalker, 1990; Gattuso et al., 1999) and temperature (Clausen & Roth, 1975; Kaiser et al., 1995; How & Marshall, 2002). Few studies have however investigated the incorporation of strontium into corals’ skeleton. Except the work of Ip & Krishna (1991), most of the studies have suggested that the incorporation of strontium is via an active process (reviewed in Ferrier-Pagès et al. 2002), as for coral. We have therefore tested in this work if the incorporation of strontium was also dependent on light and temperature.

We found a strong effect of the “light past history” and the “temperature past history” of the corals on Sr²⁺ uptake. However, this effect is “indirect”. By changing either the light or the temperature, we indeed changed the rates of calcification, which in turn, has affected the Sr²⁺ uptake rates (Figures 3 and 4).

These results suggest that there is a strong vital effect on the incorporation of strontium in coral skeleton that should be taken into account during palaeoclimatology studies. They are in agreement with previous studies, which have found that extension rate has an important control on skeletal Sr/Ca uptake (Webber, 1973; Oomori et al., 1982; de Vittlier et al., 1995). These conclusions are also in agreement with the findings of Cohen et al. (2001). They demonstrated, using a ion microprobe, that the Sr/Ca ratio in the symbiotic coral *Porites lutea* was more related to calcification rates than directly to seawater temperature. They showed that the Sr/Ca content of the day-time skeleton was always lower than the adjacent night-time skeleton.

The following experiments will have to investigate, under laboratory conditions, the long-term effect of light and temperature on the Sr/Ca ratio, since the incorporations of calcium and strontium might vary in parallel or not with light and temperature.