Evolution of 3D marine worm galleries

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Aims

Bioturbation is an ecological process where living organisms transport particles and solutes from the surface water to the sediment compartment, and vice-versa, enhancing the survival of several other species and contributing to the local biodiversity [1]. Bioturbation may occur mainly through the construction and ventilation of tubes and galleries by benthic organisms. The burrowing and tube-dwelling behaviours permit more surface water penetrating in deeper layers of sediment, increasing the oxygenation at sub-surface, as well as generating a depth gradient of dissolved and particulate nutrients. In this sense, the influence of bioturbators on local community will depend on their behaviour and on the physical characteristics of their tubes and galleries. [1, 2, 3, 4]. Therefore, it is fundamental to estimate the galleries properties, such as volume and their evolution along time, to better understand the mechanisms by which bioturbation influences local biodiversity.

However, to evaluate the gallery properties, a combination of lab experiments with a quantitative non-destructive method are needed. Recent advances in microtomography can produce 3D images with high resolution of the sediment column [5]. In this context, the goals of this work were (1) to evaluate the use of microtomography and optimal experimental conditions (corer size and drying time of samples) to study marine worm 3D galleries and (2) to evaluate the 3D gallery construction behaviour of a marine worm through time and the galleries’ physical properties.

Method

The marine worm Laeonereis acuta is one of the most abundant species on tropical muddy flats, occurring in mangroves and soft-bottoms of the Western Atlantic South coast. This species is known for constructs U or I shaped tubes [6]. The individuals used in this work were collected at mangrove’s margin of Itaipu lagoon (22°57’44’’S; 43°02’22’’O; RJ-Brazil). The specimens with similar body size and weight were kept in the lab and allowed to construct galleries during at maximum 48 hours. The cores were scanned at distinct moments on time (1h, 17h and 48h) in order to evaluate galleries shape and volume variations. To obtain the optimal images, several corers drying times and sizes were tested. It was used a desktop µCt equipment (Skyscan-Bruker, model 1173), which was calibrated to operate at 130 kV and 61 µA. In the results presented in this work, 1 x 1 pixel binning was used in order to obtain images with pixel size of 25 µm and 30 µm. Custom processing plug in, such as unsharp mask filter, despeckle and opening/erosion morphological operations were used in order to investigate the behavior of the 3D galleries by Laeonereis acuta.

Results

For cores with 5 cm height (4.5 cm internal diameter), the optimal images were obtained with a drying time of 4 h, at ambient temperature. On the other hand, a drying time of 24 h is suggested for 10 cm height (4.5 cm internal diameter).

The time series of the 3D galleries volumes showed that the gallery shape of L. acuta is time dependent. The galleries showed a U shape at the beginning of the experiment, evolving to a several connected galleries with Y shape (fig. 1). Further, the preliminary quantitative result indicates that the gallery construction rate decreases with time (table 1) and
perhaps the gallery volume might achieve a plateau. However, further studies with a longer time series are being done to confirm this hypothesis.

![Image of time series of 3D galleries](image)

Figure 1: Time series of 3D galleries constructed by the marine worm *Laeonereis acuta*.

<table>
<thead>
<tr>
<th>Time</th>
<th>Core volume (mm$^3$)</th>
<th>Gallery volume (mm$^3$)</th>
<th>Gallery volume percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1h</td>
<td>65347.98</td>
<td>161.87</td>
<td>0.24</td>
</tr>
<tr>
<td>17h</td>
<td>57024.74</td>
<td>408.96</td>
<td>0.71</td>
</tr>
<tr>
<td>48h</td>
<td>66217.30</td>
<td>616.86</td>
<td>0.93</td>
</tr>
</tbody>
</table>

*L. acuta* is more active until approximately 5cm depth (fig. 2). Also, the water density inside the gallery varied positively with a depth gradient (fig. 2), indicating that the galleries constructed by *L. acuta* may play an important role on the local transport of water and particles within sediment.
Figure 2: Marine worm *Laeonereis acuta* 3D galleries in a depth gradient. Colors show differences on gallery water content tomography intensity, with lower values (blue) at the top.

**Conclusions**

*Laeonereis acuta* may be considered a gallery biodiffusor species, with more than 2 gallery opening at the surface, and may play an important role on bioturbation processes. Gallery physical properties, such as shape and volume, are time dependent and the water's density depth gradient found inside the galleries indicates that *L. acuta* can influence the transport of particles and solutes. Further studies are being done to correlate the galleries properties with solute and particle transport. Finally, the μCT is capable of studying sediments samples in a non-destructive way, which allows following the evolution of the constructed galleries on time.

**References:**


