The Effectiveness Of The 'Flexi-chamber' And 3D Photogrammetry To Measure Physiology Of Coral Fragments In The Field

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Background

Corals are increasingly threatened by global climate change and local environmental stressors. Respiration, photosynthesis, and growth are fundamental process in corals that influences the greater reef ecosystem. Traditional methods of measuring physiological rates in situ have been complex, expensive, and destructive. Therefore, finding effective methods to measure these processes in coral fragments is essential. The non-invasive and simpler flexi-chamber and three-dimensional (3D) methods have been verified for coral colonies and have not been tested on small individual coral fragments. This study aimed to determine if these methods can effectively measure respiration, photosynthesis, and growth of small coral fragments of different morphologies and habitats.

Method

Both methods were tested on fragments (n=10) of a massive Anomastraea irregularis and a branching coral species Pocillopora verrucosa in the intertidal and subtidal habitat in Park Rynie, South Africa (30.3167° S, 30.7333° E). Each fragment was stuck onto a cement disk using epoxy putty and stuck back in its habitat of origin. Cement disks without fragments (blanks) were also attached in both habitats. The flexi-chambers were transparent gas-impermeable flexible urine bags with a built-in heat-seamed secured valve. The bottom of the bag was cut to create an opening, and rubber was attached to the opening to create a watertight seal around the cement base. The bags were fastened to the cement bases using two cable ties. Food colouring was syringed into the blank chambers to determine if the connection was indeed watertight. The chambers and surrounding water were monitored for 3 hours to detect any leakage of colour. Temperature (°C)/light (Lux) and acceleration (m.s-2) loggers were placed inside and outside the chambers to determine if the conditions inside the chambers were significantly different outside. Chambers were attached to the corals between 11:00-14:00 to determine the photosynthetic rates of the fragments. Seawater was extracted at the start and the end of the incubations to determine the dissolved oxygen concentrations. Afterwards, the same method was followed but a black plastic bag was placed over the chambers to measure the dark respiration rates. Changes in dissolved oxygen in the blanks during the light and dark incubations corrected for any metabolic activity not due to the corals. Gross photosynthetic rates were obtained by subtracting the oxygen flux during dark incubation (dark respiration) from the oxygen flux during the daylight incubation (net photosynthesis + dark respiration). The rates were normalised to surface area. Short 2–3-minute videos were taken of each fragment covering all angles. Two rulers were placed on either side of each fragment before taking videos to act as a reference for scaling the resulting 3D models. Small wooden and plastic objects

were stuck near the fragments in the intertidal and subtidal habitats. They were videoed in the same manner as the fragments to determine the accuracy of the surface area measurements (cm2) attained from the 3D software (Agisoft Metashape) as opposed to physical measurements attained from Vernier callipers. Mann-Whitney U tests were performed to determine if the temperature, light intensity, and water movement was significantly different inside the chamber compared to outside the chamber. A Wilcoxon Signed Ranks test was done to determine if there was a significant difference in the surface area of the wooden and plastic objects measured physically with a calliper and again using the 3D software. Non-parametric tests were performed because the data were found to be non-parametric (one sample Kolmogorov-Smirnov $p < 0.05$).

Results

No leakage of food colour was witnessed after monitoring the chambers and surrounding seawater. In both the intertidal and subtidal habitat, there was no significant difference in temperature (Mann-Whitney U on intertidal data: n=720, Mann-Whitney U=68236.50, p=0.218; Mann-Whitney U on subtidal data: n=720, Mann-Whitney U=66871.50, p= 0.458), light intensity (Mann-Whitney U on intertidal data: n=720, Mann-Whitney U=63705, p=0.695; Mann-Whitney U on subtidal data: n=720, Mann-Whitney U=62651, p=0.441), acceleration (X plane: Mann-Whitney U on intertidal data: n=21600, Mann-Whitney U=55476262, p=0.057; Mann-Whitney U on subtidal data: n=21600, Mann-Whitney U=88494766, p=0.057), (Y plane: Mann-Whitney U on intertidal data: n=21600, Mann-Whitney U=60946442, p=0.058; Mann-Whitney U on subtidal data: n=21600, Mann-Whitney U=65304433, p=0.058), (Z plane: Mann-Whitney U on intertidal data: n=21600, Mann-Whitney U=43085407, p=0.056; Mann-Whitney U on subtidal data: n=21600, Mann-Whitney U=68187335, p=0.056) between inside and outside of the chamber during the 3-h incubation. The flexi-chamber method was capable of measuring differences in respiration (mg O2 h-1 cm-2) and photosynthetic (mg O2 h-1 cm-2) rates between habitats and species (mean ± standard deviation) intertidal A. irregularis (0.019±0.0007), subtidal A. irregularis (0.021±0.0008), intertidal P. verrucosa (0.006±0.0034) and subtidal P. verrucosa (0.00465±0.0019). The coral fragments did not show any visual signs of stress (excess mucus production or loss of pigmentation) during the 3-hour incubations and an hour after the incubations.

Good quality 3D models were successfully constructed for all fragments and objects. There were no significant differences in the surface area measurements of wooden and plastic objects attained from physical measurements and from the 3D software (Wilcoxon Signed Ranks on intertidal data: n=16, Z=-3.541, p=0.057; Wilcoxon Signed Ranks on subtidal data: n=15, Z=-3.474, p=0.056). The coral surface area measurements (mean ± standard deviation) were intertidal A. irregularis (31.83±0.91), subtidal A. irregularis (31.08±0.56), intertidal P. verrucosa (57.39±0.96) and subtidal P. verrucosa (57.60±0.74).

Conclusion

This study showed that the flexi-chamber and 3D photogrammetry methods can be effectively used to measure the respiration, photosynthesis, and growth of small individual coral fragments of different morphology and habitats. The combination of the two methods permits more knowledge of fundamental physiological processes to be attained at lower financial cost and complexity. This can ultimately aid

conservation of corals by allowing a wider range of coral species to be sampled in situ at more locations thereby generating more knowledge on resilient/susceptible species.