Investigating the Effects of Internal Waves on Growth, Reproduction and Spatial Distribution Pattern of Coral Barnacle at Dongsha Atoll

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Background

Coral barnacles (Cirripedia: Pyrgomatidae) are filter-feeding sessile organisms whose adults are symbiotic with various scleractinian and fire corals at subtidal zones. There are around 24 genera and 70 species worldwide, and can reflect long-term dynamics of environment in coral reef ecosystem, especially in Taiwan where 39 species from 11 genera have been found to date (Chan et al., 2013).

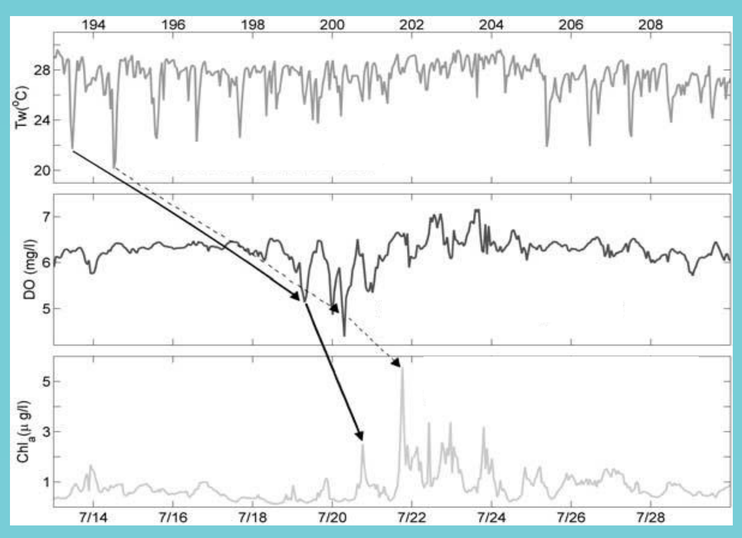


Fig.1 Time series plots at Dongsha Atoll after NLIW arrived.
The internal waves carry out cold nutrient-rich water (above), and after bacterial decomposition, the concentration of dissolved oxygen drop (middle). The upwelling brought up nutrients and were associated with the phytoplankton blooms (chlorophyll peak) (bottom). (modified from Wang et el., 2007)

The nonlinear internal waves (NLIW) has received much attention in decades due to its unique physical properties. Bountiful nutrition of sea water at Dongsha Atoll seems to associate with NLIW **(Fig.1)**. However, the impacts of NLIW to marine organisms remain largely unknown. The eastern outer reef directly faces the NLIW transporting from the western Pacific into the South China Sea (SCS). As a result, we hypothesized that the internal waves may have positive impacts on the growth and productivity of sessile organisms, as well as the cluster spatial distribution in the eastern outer reef owing to plenty of larvae resources.

In the present study we examine the relationship among growth, reproduction and spatial distribution pattern of coral barnacles and the environmental features of NLIW at Dongsha Atoll.

Methods

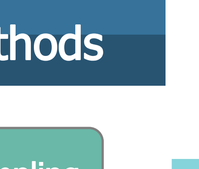
Sampling

- Randomly collected from host corals *Favites* sp. by SCUBA diving at around 10m depth at outer reef of Dongsha Atoll.
- Stored in RNAlater within 5 hours after collection.
- During 3 trips in Oct. 2018, April and Oct. 2019.

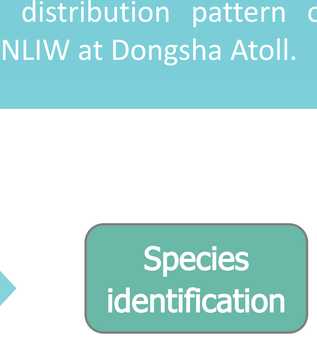
Species identification

- DNA were extracted from barnacle tissues by Tissue & Cell Genomic DNA Purification Kit.
- The 12S rRNA sequences were amplified by PCR (primers: FB, R2).
- *Galkinia equus* were identified by phylogenetic tree reconstructed based on 12S rRNA with coral barnacle sequences from Genbank.

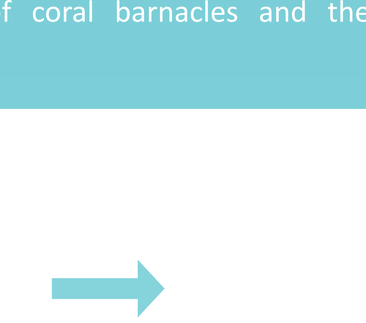
Biological parameter (P_{bio}) collection



- **Body wet weight**: blot dried → weighed with a digital analytical scale.
- **Lipids**: free fatty acids, triacylglycerols, cholesteral and wax ester were analyzed by HPTLC.



- **Carino-rostral diameter**, CD: measured by imageJ soft ware.
- **Basal depth**, BD: measured indirectly with tooth sticks.



- **Egg volume**: took pictures under anatomic microscope → calculated with 'Egg Tools' imageJ plugin (Troscianko, 2014).
- **Egg-possessed individual**

Environmental parameter (P_{env}) collection

SST, salinity, chlorophyll *a*, pH, DO, PIC, POC, Fe, silicate, nitrate and phosphate at each site were retrieved from the NASA's Giovanni, OceanColor Web and Copernicus Marine Environment Monitoring Service (CMEMS) from Jan 2017 to Dec. 2019.

Spatial point pattern analysis

The Ripley's K function was performed with spatstat packages → orientation of barnacle distribution were calculated by CircStats in R.

Statistic analysis

The Pearson correlation between P_{bio} and P_{env} were evaluated → the P_{env} with significant correlation were further analyzed with PCA.

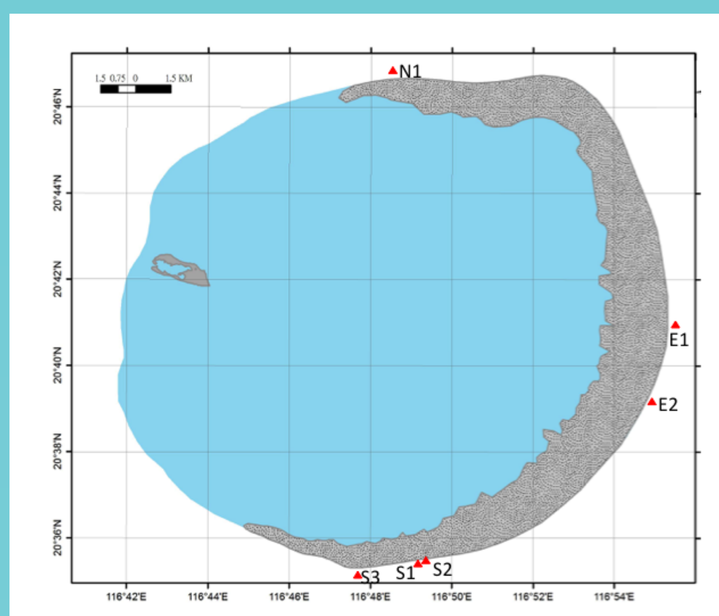


Fig.2 Sampling sites at Dongsha Atoll.
Potential internal wave impacted (east: E1 and E2) and less-impacted (north: N1 and south: S1, S2, S3) zones.

Preliminary Results

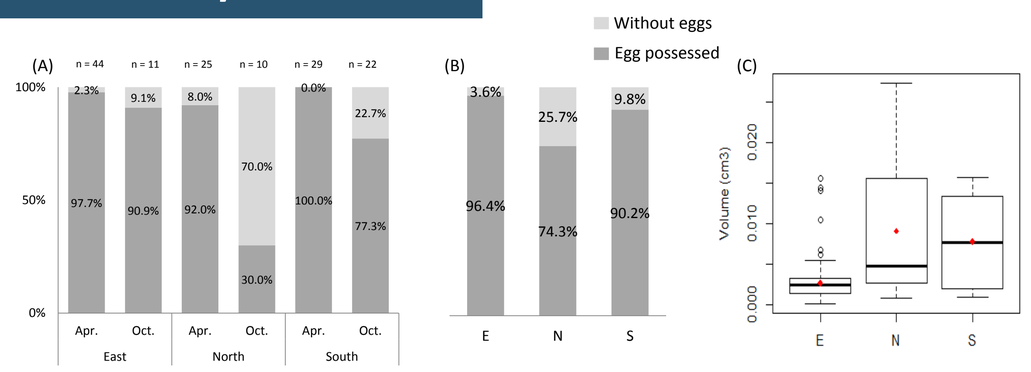


Fig.3 Percentage of egg possessed individuals and egg volume of *Galkinia equus*. (A) in each sampling month and zone, and (B) combined for each zone. (C) Egg volume at eastern (E), northern (N) and southern (S) outer reefs.

The percentage of egg possessed individuals is lower in October than April at the northern and southern zones, while about the same at the eastern zone, where the impacts of internal waves are most severe (**Fig.3A**). However, there is no significant difference for egg volume among zones (**Fig.3C**). The first two PCA axes can explain 92.075% of the total variation. In short, PIC and Chl a are the two main oceanographic features in shaping the barnacle biological features in Dongsha Atoll.

On average, northern zone has the highest density, followed by eastern and southern zones. The results of point pattern analysis showed no consistency among the barnacle orientations (**Fig.5**) corresponding to the direction of internal waves based on CircStats.

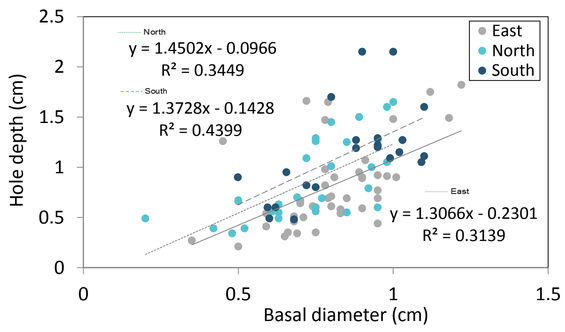


Fig.4 Relationship of basal diameter and hole depth in Galkinia equus at eastern, northern and outer reefs.
The size of basal diameter reached a plateau of 0.8 to 1.2 cm with increasing basal depth, and the maximum limit was 1.62 cm observed at S2.

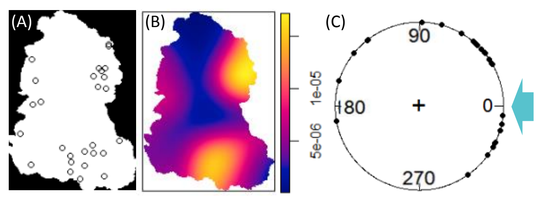


Fig.5 Barnacle distribution on a coral host at south zone (ID: S2-2).
(A) Coral host outline and counts of barnacle individuals (circles) in R, (B) Kernel Density image, (C) barnacle distribution compared to the center of host coral; the arrow indicates the direction of internal waves.

Conclusions & future work

- Although our results showed no significant difference for egg volume among zones, there are trends showed the barnacles in eastern outer reef have higher reproductive ability. In addition, the variation for all biological parameters among zones seems to imply something.
- The HPTLC analysis are on going, and the Linear Mixed-Effects Models (LME) will be further performed to reveal the relationship between biological variables of coral barnacle and environmental variables of internal wave.

References

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Wang, Y. H., et al. (2007). "Physical and ecological processes of internal waves on an isolated reef ecosystem in the South China Sea." Geophysical Research Letters 34(18).
Troscianko, J. (2014). "A simple tool for calculating egg shape, volume and surface area from digital images." Ibis 156(4): 874-878.