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Host Spatial Partitioning and Microhabitat Occurrence of Symbiotic Shrimp *Periclimenes brevicarpalis*

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Abstract
The spatial partitioning of the symbiotic Peacock Tail Anemone Shrimp (PTAS) *Periclimenes brevicarpalis* on its host Giant Carpet Anemone (GCA) *Stichodactyla gigantea* was analyzed by this study utilizing experimental set-up on their natural marine habitat, wherein partitioning by both sexes had been found out. The study was conducted in eastern seaboard of Catanduanes Island, Philippines. A total of 49 GCA were noted on the sites during the survey preliminaries where 46 have been recovered before the actual observation and experiment. Fifteen of the 46 GCA (33%) are established as host of the *P. brevicarpalis* shrimp. All the shrimp presence have occurred in mating pairs where females already attained great size against the male. A total of 30 shrimps were present during the conduct of the study. Results of the study reveals that spatial partitioning of the *P. brevicarpalis* species is ascertained based on sex where males prefer adjacent areas from the anemone body (0-2 cm away) while females prefer outer tentacles. Spatial partitioning is implied to be the medium for food intake and protection for the females as well as competition avoidance and at least partial territoriality for males. Moreover, in microhabitat occurrence, shallow depth (0.0-0.25m) is preferred by *S. gigantea* and eventually by *P. brevicarpalis* while microhabitats with exposed areas (5%-70%) serve as the area of symbiotic establishment.

Key words: spatial partitioning, symbiotic, microhabitat distribution, *P. brevicarpalis, S. gigantea*

INTRODUCTION

In marine symbiotic studies, some of the most popular are the benthic invertebrates living on the intertidal and subtidal region of the sea. Invertebrates in the Decapodan order (shrimps and its allies) and those in the class Anthozoa (sea anemone group) are known to be partner groups for some of their species where the anthozoan is exclusively being the host (Franzen, 1989; Jonsson et al., 2001; Khan et al., 2004; Thiel & Baeza, 2000). In some cases, a host may harbor two or more species benefiting on its resources (De Grave, 1998; Hoeksema & Fransen, 2011; Gou et al., 1996). Benefits include food stock, protection and, morphological complexity and spatial area for reproduction assurance (Baeza & Thiel, 2003, 2007; Calado et al., 2007; Valdivia & Stotz, 2006).

The shrimps in the Genus *Periclimenes* are well known when it comes to association with the varieties of the anemones (Hayes & Trimm, 2008). Studies on the behavioral interactions and distributional ranges between these shrimps are reflected in literatures which were conducted in some of the maritime regions such as the Western Pacific (Khan et al., 2003; 2004) and the Western Atlantic (Gwaltney & Brooks, 1994; Nizinski, 1989; Mercado & Capriles, 1982). Studies on *Periclimenes* shrimps as commensals have long been known (Ross, 1983). Further studies on *Periclimenes* have documented some tendencies of the shrimp to consume mucus and tentacles making the symbiotic network of the shrimp more complex; hence becoming a topic of ecological interest (Hayes & Trimm, 2008; Omori et al, 1994). Meanwhile, this study utilized the Giant Carpet Anemone (GCA) *S. gigantea* as the shrimp host, a colorful anemone with about 40-50cm diameter and with long body column that is usually buried or inserted into a crevice or other substrates (WildFActSheet, 2016).

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Khan et al. (2004) studied the spatial distribution of three symbiotic shrimps into five zones of their host anemone. Earlier partitioning studies of symbiotic shrimps were conducted by Stanton (1977) where three microhabitat zones were applied to the host sea anemone and Nizinski (1989) where observation on the uneven distributions of shrimps on the anemone surface was noted.

The symbiotic relationships of the *Periclimenes* shrimps on other host organisms, species benefits and distributional ranges on geographical areas have been the general investigation on the above mentioned literatures. This study focused on the spatial distribution of *P. brevicarpalis* shrimp by sex onto anemone body as well as distribution on depth and adjacent microhabitat.

METHODS

Preliminary survey was conducted on the eastern tidal regions of Catanduanes Island to locate the Giant Carpet Anemone (GCA) *S. gigantea* on their natural habitat. Earlier surveys were conducted on October 7-8, 2017 and December 27-29, 2017. For monitoring and continued population sample aggregation, additional surveys were conducted on January 6, 2018 and February 3, 2018. Each GCA had been noted and marked according to natural rock, crevice or any distinct markers on the area such as coral line or beach point angle since plastic rope or nylons may entangle the organism. A total of 49 GCA were noted on the area during the survey preliminaries where 46 have been recovered before the actual observation and experiment. Fifteen of the 46 GCA (33%) are established as host of PTAS *P. brevicarpalis*. All the shrimp presence have occurred in mating pairs where females already attained great size against the male. A total of 30 shrimps were present during the conduct of the study. Actual observation and experiment was conducted on March 17-19 and April 1-3, 2018 where tides are on their lowest (spring low tide). Natural observation and experiment were conducted at daytime from 11:00 AM to 3:00 PM.

Study Site

Catanduanes Island is located in eastern sea board of the Philippines located at 13. 5 to 14. 1 degrees North Latitude and extends from 124. 0 to 124. 5 degrees East Longitude (DENR-Catanduanes, 2009). It has an area of 1,511.5 km^2 (DOST, 2010). A population of 260,964 people was registered in the 2015 Catanduanes census (PIA, 2017). The island is bordered by the Philippine Sea/Pacific Ocean to the east and north, Lagonoy Gulf and Cabugao Bay to the south and southwest and Maqueda Channel to the west. Most parts of Catanduanes marine waters are some of the major fishing grounds in the country (PSA, 2016). Gigmoto municipality is located at eastern seaboard of Catanduanes Island.

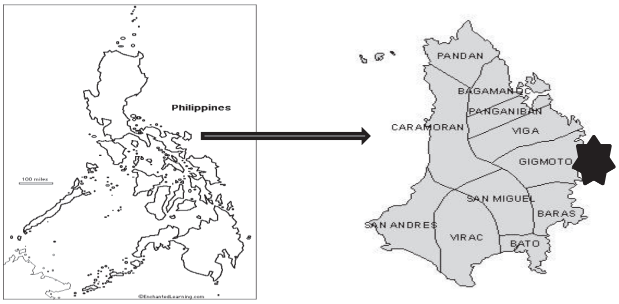
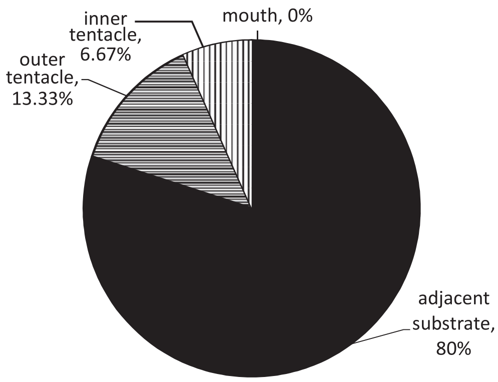


Fig. 1. Map of the Philippines with Catanduanes sampling site highlighted *Photo Credit: pinterest.com and nap.psa.gov.ph*

On the spatial distribution in the anemone's body, partitioning was assigned to the anemone. In order to find out distinct spatial distribution on their host anemone, the shrimps were temporarily separated and reintroduced thereafter. The shrimps were contained in 1, 000 mL sized beaker for 10 minutes and isolated 2-meter away from their host anemone under water. This was done in each male and female individual. Other symbiotic crustaceans and anemone fishes were temporarily removed from the anemone body during the reintroduction. The shrimps were released on the oral disc or mouth region of an anemone, one at a time at 5-min intervals and observed on 20 minute time period while the position of each shrimp on the anemone was recorded every 5 minutes (Khan et al., 2004). The experiment was replicated three times. On distribution of host-symbiont on the nearby microhabitat, field observation surveys of the symbiotic partners were conducted using percent cover of the marine vegetation and substrate area. The locations of the anemones were treated as the center of a square figure radiating to one meter from all its sides (4 squared meters [$2xm^2$]). Grids were utilized in order to facilitate data collection by percentage. Survey of the algal cover and other marine vegetation and area are usually conducted in small area scale ($\pm$ $1m^2$) (UPMNH Module, 2014). Moreover, data on depth of the water column was taken per establishment of the two partner organisms.

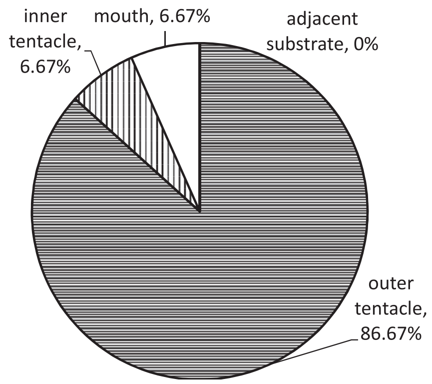
RESULTS AND DISCUSSIONS

The male and female individuals of *P. brevicarpalis* selectively chose their respective area (both P values < 0.05); adjacent substrates (off-anemone) for the males and outer tentacle for the females. Most females tend to stay on the inner area of the anemone and seldom onto the margin nearing to the adjacent substrates. Females tend to be more motile however, against the less motile males. This spatial distribution of the females is implied on the foraging food especially at sexual maturity or nearing to sexual maturity where nutrients are at high necessity. Female-preferred spatial area is usually rich in trapped planktonic organisms while the shrimp may easily clip and consume the host tentacles (Calado et., 2007; Fautin et al., 1995; Khan et al., 2003). None of the male individuals stayed more than 2 cm away from their host though many of them were already touching the substrate and were off the anemone body. The off-anemone location of the male *Periclimenes* shrimps is in line with the location away from their hosts in literature (Khan et al., 2004; Nizinski, 1989; Stanton, 1977). It is not clear whether males are more territorial than females that is why they seem to guard the anemone margins or they have only wider nutrient requirement aside from food bits, mucus and tentacles which are traditionally found on the anemone surface. Figures two and three show the partitioning of the male and female *P. brevicarpalis* on the *S. gigantea.*



X^2= 24.73; P Value = 0.0000185

Fig. 2. Partitioning of male *P. brevicarpalis* onto anemone body area.



X^2= 30.60; P Value = < 0.00001

Fig. 3. Partitioning of female *P. brevicarpalis* onto anemone body area.

When it comes to the depth of the water column, preference of the shallowest region is favored, the shallowest region at 0.0-0.25m during the spring low tide harbored the highest frequency of *S. gigantea* and *P. brevicarpalis* (X^2= 41.33; P < 0.00001). It is to be noted however, that the depth used in the study is true only during spring low tides. During spring high tides the shallowest zone in this study (0.0-0.25m) reaches up to 1. 75m. As previously described, *S. gigatea* requires sunlight for the symbiotic algae inside their body; hence shallow points are an advantage. The partial protection by coastal vegetations and substrates and the occasional shallowing tides are also believed to be other factors on their distribution in the shallower parts of the sea. The distribution of the *S. gigantea* is also true to their symbiotic shrimps although there are some symbiotic shrimps that occasionally leave their host at night (Khan et al., 2004; Stanton, 1977).

In the case of microhabitat areas as substrates or nearby cover, there were no significance difference on the spatial ecology of the shrimp (P = 0.308022). This means that any of the microhabitat are established areas for the *P. brevicarpalis* shrimp. Figure three shows the occurrence of PTA *P. brevicarpalis* on microhabitat.

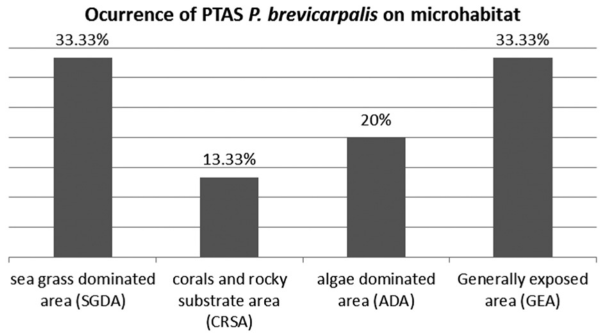


Fig. 4. X^2= 3.60; P = 0.308022. SGDA = 60-75% sea grass, 15-25% algae, 10-15% exposed area. CRSA = 85-90% corals, 5% algae and sea grass combined, 5-10% exposed area. ADA = 70-80% algae, 15-20% sea grass, 5-10% exposed area. GEA = 60-70% exposed area, 15-30% sea grass, 10-15% algae. Exposed area means no sea grass, algae or coral cover.

Contrary to popular belief that symbiotic shrimps must need thick marine vegetation, this study found that *P. brevicarpalis* must need at least 5-10% open spaces in the area near its host (4x4m); in fact the generally exposed area (GEA) had recorded a 33% occurrence in the study. This could be a direct attribution to the symbiotic single-celled algae, zooxanthellae that live in the tissue of the anemone host which undergo photosynthesis to produce food from sunlight (WildFactSheet 2016).

CONCLUSIONS

Spatial partitioning of the *P. brevicarpalis* species is concluded based on sex. Males prefer partitioning on adjacent areas (0-2 cm away) while females prefer partitioning on outer tentacles. Spatial partitioning is implied to be the medium for food intake, protection and protection for the females while competition avoidance and at least partial territoriality for males. On depth distribution, shallow depth (0.0-0.25m) is preferred by *S. gigantea* and eventually *P. brevicarpalis*. This depth may reach 1.7-2.0m however in spring high tide. Moreover, partly exposed area of the intertidal habitat reinforced by coral, sea grass and algae serve as the area of symbiotic establishment.

RECOMMENDATIONS

Spatial partitioning based on sex and location must be established in the aquarium trade and in several scientific experimentation; this is to limit mortality or disturbance to symbiotic shrimps during acclimation or introduction. Also, tidal conservation is to be encouraged as symbiotic shrimps and sea anemone host represent models in the understanding of the organismic behaviors of tidal organisms. Further, more studies on the interspecies spatial partitioning and microhabitat distribution on the shrimp-anemone symbiosis are recommended.

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