Spatial distribution and larval biology of *Spirobranchus giganteus*

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Abstract

*Spirobranchus giganteus* is an obligate associate of live coral. Its distribution was studied at two sites in Opunohu Bay, Moorea, French Polynesia in November of 2002. There was found to be a very non-random distribution of worms among corals which may result from pre-settlement adaptations. *Spirobranchus giganteus* larvae were successfully studied for 5 days and observations of development agreed with all previous studies.

Introduction

Coral reefs are complex ecosystems in which symbiotic associations are very common yet poorly understood. A striking example of symbiosis, well represented in the lagoons of Moorea, is the association between Christmas tree worm, *Spirobranchus giganteus*, and their coral hosts. *Spirobranchus giganteus* is a serpulid polychaete that is an obligate associate of live hermatypic coral (Hunte, Conlin, Marsden 1990). It is dioecious, with planktonic larval of 9 to 12 days. It is found in tropical and sub-tropical seas, and has been divided by Hove (1970) into two subspecies, *S. giganteus corniculatus* in the Pacific and *S. giganteus giganteus* in the Atlantic and Caribbean. In Moorea, *Spirobranchus giganteus* is not randomly distributed among coral species, lagoon locations, and depth. Little is known about the post-mortality rate of these worms. This non-random distribution probably is a result of larval preferences before settlement. Habitat selection for *Spirobranchus giganteus* is critical because they are sessile organisms, living within a calcareous tube surrounded by live coral. Once settlement has occurred the organism is committed to its location for life. The larval phase of *Spirobranchus giganteus* is dispersal. Gamets are released into the water column, leaving adult worms with no direct control whether or not fertilization ensues. In order to increase the probability of successful fertilization it is important for adult worms to be placed close to conspecifics. This need for aggregations probably induces the larvae to have a preference for settling gregariously.

Studies of *Spirobranchus giganteus* have occurred in Barbados and the southern region of the Great Barrier Reef. In each area different corals were observed in the field to be preferential for settlement. In Barbados *Diploria strigosa* and *Montastrea annularis* are preferred (Hunte, Conlin, Marsden 1990). On the GBR *Acropora prolifera* is preferred (Marsden
In Moorea it is observed that *Spirobranchus giganteus* prefers to settle on *Porites lobata* and *Porites rus*.

The purpose of this paper is to investigate the spatial distributions of *Spirobranchus giganteus* within regions in the lagoon, with depth and on a small scale (within a coral). Also examined will be the relationship between tube diameter and worm length in order to find a convenient tool for measurement. This paper also looks at the initial stages of the larval development of *Spirobranchus giganteus*, comparing it with previous studies.

**Materials and Methods**

**Study Site**

The distribution of *Spirobranchus giganteus* on corals was studied from November 6th to November 28th 2002 at two sites within Opunohu Bay, Moorea: Public Beach and Coconut Grove. Public Beach (S 17° 29.277', W 149° 50.952') consists of four regions, the crest, crest patch, fringing patch and fringing reefs. The crest region is the outer part of the lagoon comprising of massive corals and rubble due to wave action. The crest patch lies inside the crest. Having less wave action this area allows for the beginning of more branching corals and less rubble. In further lies the fringing patch area that has no wave action, where a diverse group of corals can be seen. The fringing reef begins where the island meets the water. Distribution and abundance sampling at Public Beach was conducted to determine *Spirobranchus giganteus* distribution within these four lagoon regions. Coconut Grove (S 17° 29.277', W 149° 50.952') is a fringing reef that varies greatly in depth. Studies at Coconut Grove were used to determine *Spirobranchus giganteus* distribution in relation to depth.

**Spatial distribution of *Spirobranchus giganteus* as a function of region**

Live and dead *Porites lobata* were randomly chosen by throwing a weighted line in any direction and measuring both the nearest live and dead lobata in each of the four regions of Public Beach. Number of worms per unit area was recorded for each randomly chosen coral. Area of coral was measured using a rope marked at 10cm, 20cm, 30cm, 40 cm, and 50cm, choosing the most appropriate measurement for each coral and counting all *Spirobranchus giganteus* within that area.
Spatial distribution of Spirobranchus giganteus as a function of depth

Four 100m² area (25m x 4m) transects were performed at five, fifteen, twenty-five and thirty-five feet depths at Coconut Grove. All P. lobata was measured and number of worms per unit area was recorded as previously described.

Relationship between tube diameter and length of feeding portion of Spirobranchus giganteus

Measurements of individual worms were made to determine if there is a relationship between the height of the worm and diameter of its tube. The length of the feeding portion of worms were measured and then compared with its corresponding tube diameter. By finding a positive relationship between tube diameter and length, one can measure worms by simply measuring tube diameter, avoiding destruction of the organism and coral.

Larval Biology of Spirobranchus giganteus

Worms were collected by chipping away pieces of Portites lobata. Adult worms were extracted from their tubes by exposing both ends of the tube and using tubing, pushing the worms out their tube. Some worms would spontaneously spawn when extracted from their tube. Worms that did not spawn spontaneously were strip spawned by dissecting them and removing either sperm or ova that were clearly visible. Gametes were collected and mixed to induce fertilization. Eggs were allowed thirty minutes to sit, then fertilized eggs were washed and placed in one liter of instant ocean, and filtered into fresh instant ocean every second day. Larvae were fed Isocrysis and filtration continued every second day.

Results

Spatial distribution of Spirobranchus giganteus as a function of region

Proportion of Porites lobata (available habitat), worm density per square cm, and relative abundance of worms for each region within the lagoon are shown in Graph 1. The proportion of Porites lobata is highest in the crest region, followed by the crest patch, fringing, and fringing patch. Worm density is highest in the crest patch region followed by the fringing patch. An ANOVA analysis signifies a significant relationship between area and worm density (Table 1., P=0.04)
Relative abundance was highest at the crest patch region followed by the crest.

*Spatial distribution of Spirobranchus giganteus as a function of depth*

Proportion of *Porites lobata* (available habitat), worm density per square cm, and relative abundance of worms for various depths are shown in Graph 2. The proportion of *Porites Lobata* is highest at 5 feet and decreases with depth. Worm density is highest at 5 feet and decreases with depth. A significant regression was found between worm density and depth (Table 2., P=0.04) Relative abundance is highest at 5 feet and decreases with depth.

*Small-scale distribution (patchiness)*

Spirobranchus giganteus shows preference for gregarious settlement both within regions of the lagoon and on a small scale distribution (on a coral). This is shown with a variance to mean ratio (Graph 4). Graph 5 also demonstrates the preference for large aggregation. Within the main adult distribution large aggregations are commonly found and only sparsely distributed individuals are found in the areas were adult worms are not widely distributed.

*Relationship between tube diameter and length of feeding portion of Spirobranchus giganteus*

Tube diameter is found to have a direct relationship with feeding portion length. A significant regression was found on the relationship between tube diameter and length of the feeding portion of *Spirobranchus giganteus* (Table 3., P<0.001) (Graph 3). This may enable a measurement of length without the destruction of the worm or the coral.

*Larval Development of Spirobranchus giganteus*

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<th>Time after release</th>
<th>Observed Characteristics</th>
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<tr>
<td>15 minutes</td>
<td>No fertilization wall present. Active sperm</td>
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<tr>
<td>30 minutes</td>
<td>No fertilization wall. Sperm attacking egg</td>
</tr>
<tr>
<td>60 minutes</td>
<td>Fertilization wall fully present. Sperm blocked</td>
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<td>90 minutes</td>
<td>Fertilization wall gone.</td>
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To investigate pre-settlement preferences adult *Spirobranchus giganteus* were removed from their tubes and spawned. Males, when dissected, contained obvious amounts of spermatozoa while females have very organized egg sacs throughout each segment of their bodies. Sperm appeared white while the ova was orange in color. Eggs were fertilized and monitored successfully for five days. One hour after fertilization a fertilization wall is present. One and a half hours after fertilization the fertilizations wall begins to deteriorate with cell division beginning to take place. Within sixteen hours after fertilization a cell wall is present. Within twenty-four hours a trocophore is formed. This pattern remains constant with previous studies which state that the embryo differentiates into a planktotrophic trochophore within 24 hours and a metatrochophore within 5 to 6 days (Marsden, Conlin, Hunte). Larvae were fed with *isocrysis* beginning on the second day after fertilization. Metatrochophore were never observed. Larvae were meant to be tested for preferences of different species of coral, and between corals with or without adults present.

**Discussion**

Horizontal settlement of *Spirobranchus giganteus* within the lagoon regions is greatest in the crest patch region of the lagoon were a relative high percent coverage of *P. lobata* is found. Although the highest percent coverage of *P. lobata* is found in the crest region, yet settlement may be unfavorable because of high water flow. This may be why the number of worms per unit is lower in the crest than in the crest patch.
Vertical settlement of Spirobranchus giganteus is greatest at shallow depths. This may be due to a higher percent cover of P. lobata and the swimming behavior of Spirobranchus giganteus during larval phase. In the laboratory larvae were observed swimming to the surface during the trocophore phase. According to previous studies the entire planktonic larval phase last 9 to 12 days with larvae becoming demersal immediately prior to metamorphosis and settlement (Marsden, Conlin, Hunte 1990).

Previous studies have been done on Spirobranchus giganteus in Barbados and the southern region of the Great Barrier Reef. In Barbados Diploma strigosa, Porites astereoides, and Millepora complanta were most heavily colonized (Hunte, Conlin, Marsden). In the southern region of the Great Barrier Reef adults of Spirobranchus giganteus occur most commonly on A. prolifera (Marsden). In Moorea, Spirobranchus giganteus most commonly occurs on Porites lobata, with a smaller proportion appearing on Porites rus. Almost no worms are found on other species of coral. This indicates the Spirobranchus giganteus has adapted to settle on what seems to be the most abundant and accessible coral available in their respective area. These comparisons promote their ability for local adaptation.

This study strongly indicates that Spirobranchus giganteus settles gregariously, preferring to live in aggregations rather than randomly spread out amongst the area of the coral. This clumped form of settlement would prove necessary for a sessile organism that spawns exteriorly. Once gametes have been released into the water column, adult worms have no direct control over the success rate of fertilization. Living in aggregations helps Spirobranchus giganteus increase the probability of successful fertilization by increasing the chance of sperm and ova coming in contact. Sperm density decreases rapidly by dilution, making worms that are distant from eachother having a far less chance at successful reproduction. Very few newly settled worms were observed in the field. Knowing the number of gametes these worms produce is very high, it appears that successful settlement rate is very low. With the difficulty of these worms to succesfully fertilize their eggs, survive larval phase and acheive settlement, larval behavior forming preferences for certain areas and corals with conspecifics in order to continue successful reproduction appears crucial.
References


White, J. Spatial distribution of epifaunal invertebrates on corals in Moorea, French Polynesia. (Personal Communication)


Graph 1.

- **Proportion of P. lobata**
  - Crest
  - CrestPatch
  - Fringe
  - FringePatch

- **Worm Density (# / sq cm)**
  - Crest
  - CrestPatch
  - Fringe
  - FringePatch

- **Relative Abundance of Worms**
  - Crest
  - CrestPatch
  - Fringe
  - FringePatch
Table 1: The relationship between area and density (ANOVA)

Dep Var: DENMSQ  N: 176  Multiple R: 0.215984  Squared multiple R: 0.046649

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Graph 2
Table 3: The relationship between feeding portion of worm and tube diameter in (REGRESSION)

Dep Var: LENGTH   N: 20   Multiple R: 0.804782   Squared multiple R: 0.647674
Adjusted squared multiple R: 0.628100   Standard error of estimate: 2.193526

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Analysis of Variance

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Table 2: The relationship between depth and density (REGRESSION)

Dep Var: DENSITY   N: 137   Multiple R: 0.174080   Squared multiple R: 0.030304
Adjusted squared multiple R: 0.023121   Standard error of estimate: 8.868775

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Analysis of Variance

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Spatial Distribution of Worms

Graph 5

Graph 4

LOCATION
Graph 3

![Graph 3](image-url)

- X-axis: Diameter
- Y-axis: Length

The graph shows a linear relationship between diameter and length.