ROCKIN' AROUND THE CHRISTMAS TREE WORM: THE EFFECT OF SURGE ON *SPIROBRANCHUS GIGANTEUS* MORPHOLOGY

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Abstract: Spirobranchus giganteus is a serpulid polychaete that builds calcareous tubes on the surface of live coral heads. These worms are unique among suspension feeders; their spiraled radiole crown requires external current to separate incurrent from excurrent flow. Otherwise, water is moved by cilia along the tentacles and is filtered multiple times, making the system is inefficient. However, this compact spiraled form allows for a large filtering surface area, and *S. giganteus* may trade efficiency for compactness in order to deal with drag from surge. We hypothesized that *S. giganteus* crown morphology would be affected by surge. Since surge decreases with increasing depth, we predicted that the radiole crown would become more elongated with depth. We found that *S. giganteus* crowns were more elongated with depth, supporting the idea that their morphology is affected by drag. The compact spiraled crown of *S. giganteus* may allow this worm to exploit areas with high flow not tolerated by other suspension feeding tube worms. Further studies should assess the effects of predation pressure on crown morphology.

Key words: calcareous tube worms, depth, radiole crown, suspension feeding efficiency

INTRODUCTION

The Christmas tree worm, *Spirobranchus giganteus*, is a tropical serpulid polychaete that lives in calcareous tubes built on the surface of live coral heads (Hunte et al. 1990). These worms suspension feed by extending two spiraled crowns or radioles into the water current. The stacked spiral arrangement of the crowns gives the worm a large but compact filter, but this design is at the cost of some efficiency. Cilia along the radioles and then pinnules generate current, but incurrent flow is not separated from excurrent flow, so water passes through several whorls, and thus, is filtered multiple times. Therefore the worm depends on external flow perpendicular to the crowns to separate incurrent from excurrent flow (Strathmann et al. 1984).

This compact crown morphology may be the result of multiple selection pressures. Strathmann et al. (1984) speculated two possible explanations for *S. giganteus'* unique suspension feeding shape. The tentacles may be compact and close to the tube entrance to decrease the risk of predation, or the compact shape may prevent tentacles from being bent over by drag, thereby decreasing filtering efficiency. Our study examines this second idea that the compact crown shape of *S. giganteus* is an adaptation to cope with drag. We hypothesized that surge would affect *S. giganteus* crown morphology due to a tradeoff between drag and filtering efficiency. Since surge decreases as depth increases, we used depth as a proxy measure for the amount of surge. We predicted that *S. giganteus* crowns would become more elongated with depth, as the danger of radioles being bent would be reduced and elongated crowns may filter more efficiently.

METHODS

We measured 85 Christmas tree worms at Discovery Bay, Jamaica from 3 - 8 March 2004. We swam transects at three sites on the fore-reef (M1, Dancing Lady and Dairy Bull), sampling across a depth range of 3 - 16 m. For each worm in our transects we measured its height from base to tip and its width at the base of one of its

two spiraled radiole crowns. We counted the number of visible spirals, noted the coral species on which the worm lived and recorded water depth.

Radioles at the top of the crown are shorter and perhaps younger than those at the bottom of the crown. Therefore, it seems likely that worms grow by extending their crown axis as radioles increase in length. We assumed that the number of spirals was indicative of worm age. Therefore, we calculated an index of elongation for each worm, standardized for age, by dividing its height by the number of spirals.

RESULTS

Elongation increased with increasing depth ($r^2 = 0.21$, df = 82, $P \leq 0.0001$; Fig. 1). A three-way ANOVA showed that variance in elongation was explained by depth ($F_{1,73} = 13.47$, $P = 0.0005$) and dive site ($F_{2,73} = 3.36$, $P = 0.04$), but not by coral species ($F_{7,73} = 0.2$, $P = 0.98$). There was an increase in *S. giganteus* crown height with increased depth ($r^2 = 0.11$, df = 83, P = 0.002; Fig.2). The number of spirals increased with crown height ($r^2 = 0.63$, df = 83, $P \leq 0.0001$; Fig. 3). Crown height and width were highly correlated ($r = 0.85$, df = 1, $p \leq 0.0001$), so we did

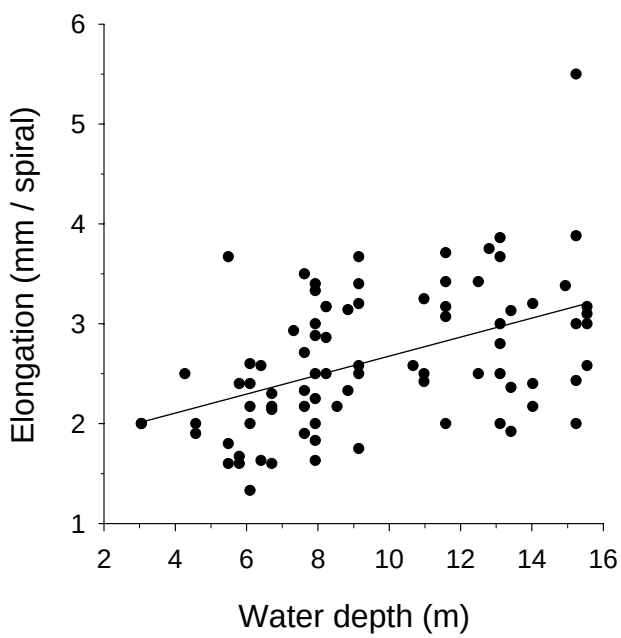

Figure 1. Relationship between elongation of the radiole crown (height / number of spirals) and depth for *S. giganteus* (n = 84). Regression equation: Elongation = 1.73 + 0.09 x Depth.

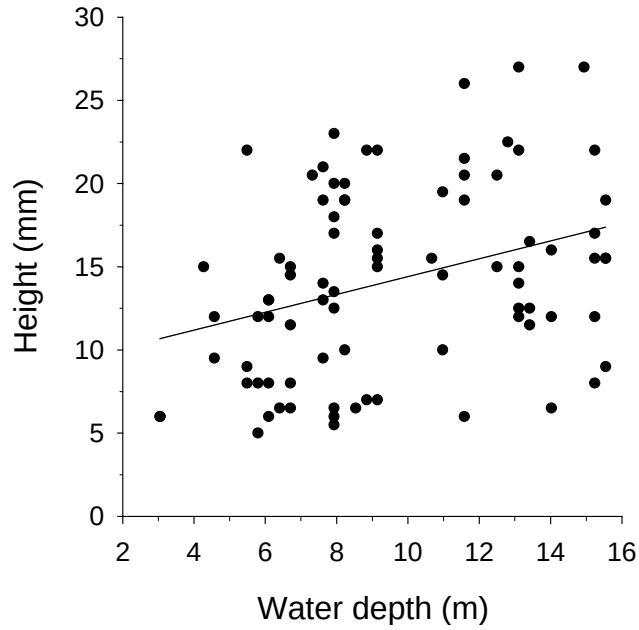

Figure 2. Relationship between height of the radiole crown (from base to tip) and depth for *S. giganteus* (n = 85). Regression equation: Height = 9.05 + 0.54 x Depth.

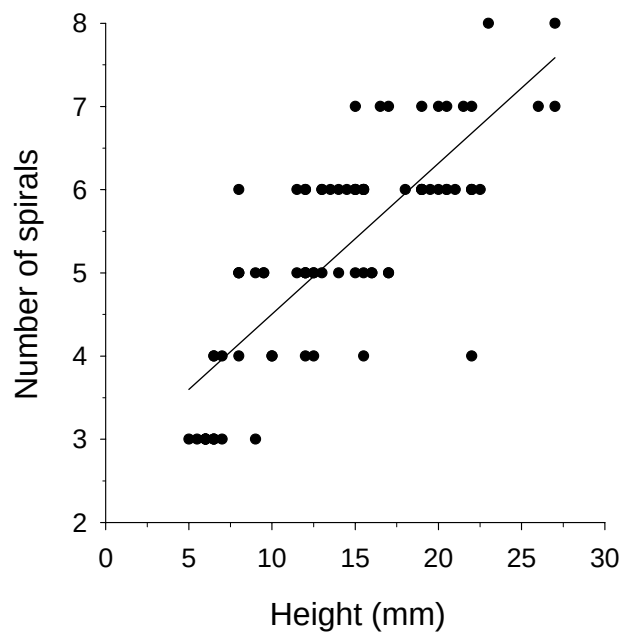

Figure 3. Relationship between the number of spirals in a radiole crown to the height of the radiole crown in *S. giganteus* (n = 84). Regression equation: Number of spirals = 2.69 + 0.18 x Height.

not use width for analyses. There was no relationship between number of spirals and depth ($r^2 = 0.01$, df = 82, P = 0.37), coral species ($F_{7,76} = 1.84$, P = 0.09) or dive site ($F_{2,81} = 0.67$, P = 0.51).

DISCUSSION

The radiole crowns of *S. giganteus* became more elongated with depth, suggesting that crown morphology may be influenced by drag. Although the number of spirals was unrelated to depth, radiole crown height increased with depth, indicating that changes in crown morphology are likely unrelated to age. The increase in number of spirals with crown height supports the assumption that number of spirals is a function of age, since larger worms have more spirals. There was some variance attributable to dive site. However, we could not examine the same range of depths at each site, and the strong effect of depth may have created variance between dive sites that was actually due to depth.

Unlike other suspension feeders, *S. giganteus* is reliant on external current to feed efficiently. A compact spiral crown may allow them to exploit shallow areas where surge is common, while minimizing the potential for their tentacles to be bent over by drag. As surge decreases with depth, the need for compactness decreases, and the worms may take on a more elongated morphology that allows them to expose more surface area to the water column to suspension feed more efficiently.

Differences in radiole crown shape with depth may indicate that *S. giganteus* exhibits morphological plasticity, where elongation of the radiole crown depends on the flow conditions where the worm settles. Alternatively, differential mortality may select for a more compact form in shallow water, and elongation in deep water. In shallow water, worms with elongated crowns may be unable to maintain an upright position to feed in heavy drag, while at deeper depths there is too little surge for worms with more compact crowns to separate incurrent from excurrent flow. In these cases, worms would not be able to feed efficiently and would therefore be less likely to survive.

Other kinds of fanworms are able to suspension feed efficiently just by generating their own current. However, without a compact morphology these fanworms may not be able to withstand as much surge as *S. giganteus*, and may be restricted to more protected microhabitats. Suitable settlement space for tube building worms may be limited on reefs since larvae must settle on patches of dead coral to avoid being eaten by coral polyps (J. Gilbert, pers. comm.). Thus, to avoid competition, *S. giganteus* may be exploiting a unique niche by settling in areas where the current is too strong for other suspension feeding worms. In general, we casually noticed that other suspension feeding worms in the family Sabellidae were not in the same microhabitats as *S. giganteus*. They seemed to be more prevalent in more protected parts of coral mounds, where surge and drag would be reduced. Further studies could look for differences between *S. giganteus* and other fanworm microhabitats to address the possibility of niche differentiation.

Drag appears to be an important determinant of *S. giganteus* morphology. However, this does not exclude the possibility that predation pressure may also influence the compactness of the worms' radiole crowns. We observed that worms quickly retract into their tubes when approached and that worms have a plethora of color patterns even within a coral mound. Since color patterns are unrelated to substrate type or depth (Dickenson and Douzinas 1998), color variation may be a predator confusion tactic. If worms face predation pressure, as this variation in color suggests, then a compact radiole crown may allow for quicker retraction into their tubes

when worms are attacked. Consequently, our finding that worms have more elongated radiole crowns with depth may reflect reduced predation risk with depth. Further studies should examine whether predation pressure on *S. giganteus* influences crown morphology, or if there are other patterns that suggest that predation or other abiotic factors influence the morphology of these organisms.

LITERATURE CITED

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