DENSITY—BODY SIZE RELATIONSHIPS AMONG *SABELLA MELANOSTIGMA* IN WALSINGHAM POND, BERMUDA.

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Abstract The relationship between density and individual size has been a highly recognized trend in ecology. Insights into this relationship expose various ecological processes, such as reproduction and resource partitioning, which provide a foundation for understanding the complexity of ecological communities. *Sabella melanostigma* are marine worms commonly found encrusted on mangrove roots and submerged rock walls throughout Walsingham Pond, Bermuda. An observational study was conducted at this location to investigate the relationship between densities of individuals and body sizes of the featherduster worms occupying the anchialine pond. A significant trend found in the data revealed that a decrease in population density corresponded with an increase in body size among *Sabella melanostigma* in Walsingham Pond.

Key Words: *Sabella melanostigma, featherduster, individual size.*

Introduction

The correlation between population density and individual body size of a certain species in a community has been one of the most widely studied patterns in ecology (Blackburn and Gaston, 1997). The nature of this relationship plays an ample role in our understanding of ecological processes because it affects evolutionary, behavioral, physiological, and ecological characteristics of a species (Ackerman and Bellwood, 2003). Body size is one of the most important attributes of an individual (White et al. 2007). Measuring body size is a simple means of condensing and summarizing a large amount of the biological information rooted within an ecological system (Woodward et al. 2005). Because size is related to lifespan the relationship between body size and density is an essential link to understanding the individual level as well as the population level traits of species and the dynamics of ecological communities (White et al. 2007). In addition, the correlation between size and abundance also tells how resources are partitioned in ecological systems (White et al. 2007). While this relationship has been studied extensively ranging from viruses to sequoia trees, there has yet to be a consensus of exactly what patterns to expect or the mechanisms that create them (Blackburn and Gaston, 1997, Blackburn et al., 1990).

This research was conducted at Walsingham Pond, Bermuda, to look at individual body size versus population density of *Sabella melanostigma.* The purple and white tentacled marine worms are abundant throughout the pond and cover a majority of the mangrove roots and submerged rock walls (Sterrer, 1992). Because the ‘average’ data collected throughout the biological world typically shows that in aquatic habitats small organisms are found at higher densities than larger ones, I hypothesized that the outcome of this observational study would show a decrease in population density with increased individual body size of *Sabella melanostigma* (Cyr et al. 2007).

Geography

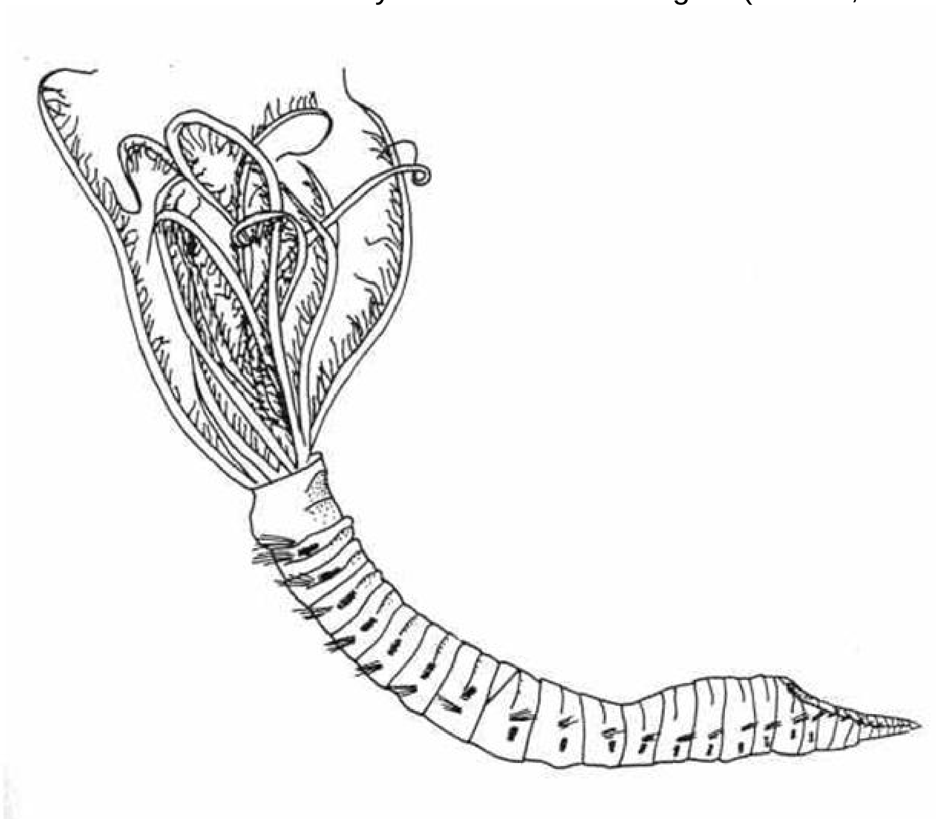
Walsingham Pond (see fig. 1) is an outstanding biological and geological treasure of Bermuda (Thomas, 2006). At 32°20’47”N and 64°42’34”W, the anchialine pond is one of the most studied sites in Bermuda (Wood and Jackson, 2005). The pond is located close to the ocean and has a very high flushing rate (Wood and Jackson, 2005). The salinity level is usually between 36-38 ppt and fluctuates tidally between 40-50 cm with an hour delay behind the local sea tides (Wood & Jackson, 2005). Walsingham is extremely productive biologically because the detritus from leaf litter washes into the pond from the land (Wood and Jackson, 2005). This provides the pond with a high level of nutrients that supports a diverse population of organisms’ characteristic of the shallow sea (Thomas, 2006). These physical characteristics make the pond an exceptionally good location for filter feeding marine animals including clams, bryozoans, tunicates, sponges and tubeworms (Thomas, 2006).

Figure 1: Walsingham Pond, Bermuda.

Biology

Featherduster worms (*Sabella melanostigma*) are polychaete annelids that depend on a diet of plankton and detritus (Meglitsch, 1972). These worms produce a leather-like tube to protect their soft cylindrical body that is divided into many similar segments (Meglitsch, 1972). Some structures, like muscles, nerves, and kidneys can be found repeated in each segment of its body (“Marine Life Profile,” 2009). The worm produces its protective tube by discharging leathery mucus from a structure at the base of its tentacles ("Marine Life Profile," 2009). Bits of sand and mud are also collected by the tentacles and used in the construction of the protective tube ("Marine Life Profile," 2009). The featherduster worm moves throughout the cylinder using small hairs called setae along the sides of its body ("Marine Life Profile," 2009).

Featherduster worms (see fig. 2) are also referred to as fan worms (Meglitsch, 1972). They are named for the fan-like array of tentacles that extends from their protective tube ("Marine Life Profile," 2009). These tentacles are attached to the head of the worm and are used in filter feeding and respiration ("Marine Life Profile," 2009). Small branches on the side of its tentacles capture tiny particles of food suspended in the water ("Marine Life Profile," 2009). The delicate worms are sensitive to touch, water movement, motion, and light ("Marine Life Profile," 2009). They can protect themselves from prospective predators by retreating rapidly into their protective tube ("Marine Life Profile," 2009). They will acknowledge as little as a passing shadow and instantaneously draw back; since the worms densely cover their substrate, the withdrawal of one worm often causes a chain reaction (Sterrer, 1992). A short while after a disturbance the worms will re-appear outside of the tube in small spurts until the purple and white tentacles are entirely unfolded outward again (Sterrer, 1992).



Source:http://www.padil.gov.au/pests-and-diseases/Pest/Main/135620/8721

Figure 2: An illustration of *Sabella melanostigma*.

Materials and Methods

I entered Walsingham Pond with snorkeling gear, a Flip UltraHD video camera, and a two foot long measuring stick. I proceeded to snorkel around the perimeter of the pond in a clockwise direction randomly locating populations of *Sabella melanostigma* attached to mangrove roots and the faces of submerged rock walls. Each cluster of featherduster worms was approached slowly, and the two foot measuring stick was used as a reference to make sure each video was recorded from the same distance for each lot of worms. I had determined earlier that two feet was a desirable distance because the video would still be clear and the worms would not be startled by the observer and retreat into their tubes. A minimum of ten seconds was recorded at each group of worms from two feet away for a total of twenty five videos. The videos from the Flip camera were examined in Windows Media Player and one still frame shot was taken from each of the twenty five videos. Each still was taken at a point in the video where the recorder was absolutely still to ensure good picture quality and clarity. The result was twenty five photo quadrats to be analyzed (see fig.3).

Figure 3: Example of a photo quadrat taken from video filmed with the Flip camera.

The photo quadrats were then imported into ImageJ, a java based image processing program used to calculate area and pixel value statistics (National Institutes of Health, 1997). Under the 'Analyze' tool bar I went to 'Set Measurements' and checked the 'Area' box to determine the relative size difference between each worm in the picture, the ‘Display’ box to have the measurements displayed in a table on the side of the screen, and the ‘Add to Overlay’ box to be certain the same worm was not measured twice. I traced each worm using the ‘Freehand Draw’ selection on the tool bar. After tracing each one, I scrolled to ‘Analyze’ and clicked ‘Measure’ to obtain the number of pixels in each individual for all photo quadrats.

Results and Discussion

The results support my original hypothesis (see fig.4). The relationship between body size and density has been studied extensively over the years, and the pattern among featherduster worms in Walsingham Pond, Bermuda, concurs with the pattern that prevails among a wide range of taxa: smaller individuals are often found in greater numbers than larger ones. Logically, a species with a smaller body, such as the featherduster worm, has the capacity to be more abundant than one of larger size because smaller organisms have lower resource requirements (Blackburn and Gaston, 1997). The limit on population density is determined by the number of individuals that can be packed into a given area (Blackburn and Gaston, 1997). In reality, the maximum limit is never reached because resource requirements cannot be balanced under extreme packing (Blackburn and Gaston, 1997). But since resource requirements increase with individual body size, the maximum density a population can attain should decrease with increased individual body size (Blackburn and Gaston, 1997). Ultimately, small size has benefits and drawbacks (Cain et al. 2008). Smaller individuals are likely more susceptible to predation due to the fact that there are large enough predators in Walsingham Pond to consume the featherduster worm (Cain et al. 2008). Also, they are more susceptible to competition with neighboring individuals for food and environmental distresses (Cain et al. 2008).

An advantage of the small size of an individual that can have important evolutionary consequences is dispersal and the production of planktonic larval offspring (Cain et al. 2008). Since the featherduster worm is a sessile marine invertebrate it tends to disperse during reproduction (Cain et al. 2008). The free swimming larvae of the worms can be carried long distances by currents in Walsingham Pond. There are similarly good reasons that a small population density relates to increased body size. Larger individuals have been active longer than smaller individuals so they should be able to survive better at lower population densities (Blackburn and Gaston, 1997). Also, populations of larger individuals will have a smaller range of size fluctuations and may be able to produce more offspring or garner more resources for their own sustenance (Blackburn and Gaston, 1997).

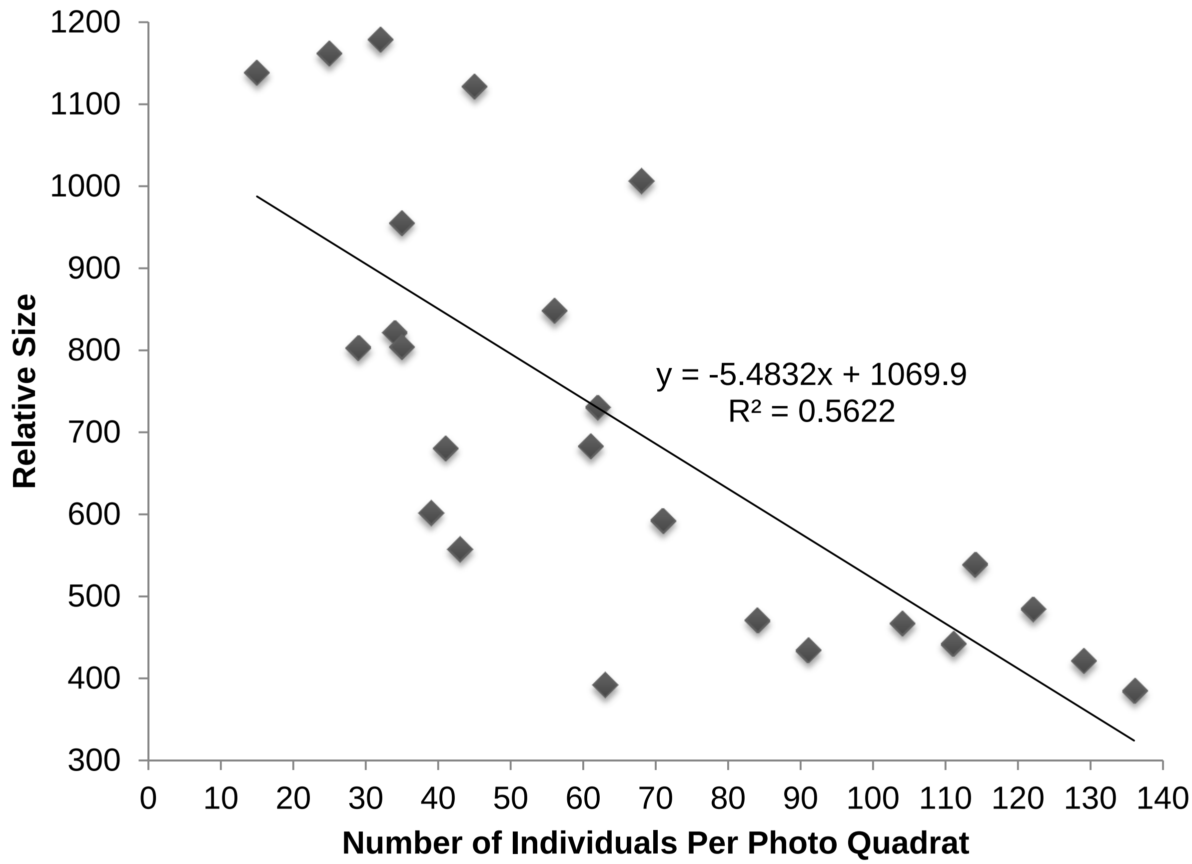


Figure 4: Size vs. Density of *Sabella melanostigma* in Walsingham Pond, Bermuda. Relative size represents the number of pixels measured per individual in each photo quadrat.

The relative size of the featherduster worm decreased significantly as the density of individuals increased (Fig.4: $r = 0.7498$, $t = 5.435$, $P < 0.001$).

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