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Predation in a Natural Community of Marine Mollusks: Using Morphology to Determine Predator-Prey Ecology

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ABSTRACT Predatory gastropod mollusks in the family Naticidae feed on bivalve mollusks and leave distinctive markings in the form of countersunk circular boreholes on the shells. These boreholes possess both an inner borehole diameter (IBD) and an outer borehole diameter (OBD) which are proportional to the size of the predator. It has been proposed that the ratio of IBD to OBD can be used to identify predator species. Variation in the ratio of the IBD to OBD was examined in two prey species (dwarf surf clam, incongruous ark clam) collected from Otter Island beach in South Carolina to determine if clams were eaten by a single species or multiple species of predator. Measurements of borehole diameter (inner and outer) were recorded in random samples of *Anadara brasiliana* (incongruous ark, n = 100) and *Mulinia lateralis* (dwarf surf clam, n = 100) shells. Comparison of the frequency distributions of the ratios revealed a unimodal, normal distribution in the combined sample indicating the potential for a single species effect. A similar pattern was revealed in the *M. lateralis* sample. In contrast, a unimodal skewed distribution was identified in the *A. brasiliana* sample indicating the potential for a multi-species effect.

INTRODUCTION

Naticidae gastropods are infaunal drilling marine predators that leave traces of predation in the form of countersunk boreholes on the shells of bivalves and, in some cases, other gastropods (Kelley, P.H, 1991; Kowalewski, M. 2002; Grey, M., Boulding, E., & Brookfield, M., 2005; Dietl, G.P. & Kelley, P.H., 2006). Boreholes offer direct proof of biotic interactions between predators and prey and have been extensively used in paleontological research of predator-prey dynamics (Kowalewski, 2002).

Previous studies of naticid predation have examined site- and size-selectivity (Kitchell et al. 1981; Dietl & Alexander, 1995; Chiba, T. & Sato, S., 2011), valve-selectivity (Hasegawa, H. & Sato, 2009), naticid cannibalism (Kelley, 1991), borehole morphology (Kitchell et al. 1981; Kowalewski, 2002; Grey et al. 2005) and co-evolution (Kelley, 1992). Thus, research on naticid boreholes has provided valuable insights into the evolutionary patterns of prey selection and the adaptive evolutionary responses among both predator and prey (Kitchell et al. 1981).
Several studies of naticid predation have relied on beach collections of predated and non-predated shells to determine the evolutionary and ecological patterns. One concern with this approach is that the identity of the predator is not known. However, previous research has shown that naticid predators can be identified by their borehole characteristics (Kitchell et al. 1981; Grey et al. 2005; Dietl & Kelley, 2006). Grey et al. (2005) used a combination of live feeding trials and beach collections to examine the geometric differences in naticid boreholes and identified a species-specific component to borehole geometry. In this study, the boreholes belonged to the only known predator in the area (Atlantic moon snail, _Neverita duplicata_). Thus, predator-prey dynamics in this system were regulated by a single predator species.

In the current study, we used this type of morphological approach to attempt to identify the predator-prey dynamics occurring in a natural community of marine mollusks. In this community, multiple species of bivalve mollusks exist and are preyed upon by unidentified naticid predators. We used beach collections of naturally predated bivalves (incongruous ark, _Anadara brasiliana_; dwarf surf clam, _Mulinia lateralis_) from Otter Island, South Carolina to determine if predation was due to a single species or multiple species of naticid predator.

**METHODS**

_Anadara brasiliana_ sample collection

_Anadara brasiliana_ (n = 134) samples were collected at two different times. First, in December 2013 a random sample of 78 shells was collected from three sites (distanced 30.5 m apart) on Otter Island, South Carolina using a shovel to scrape the surface of the sand. An additional 56 shells were randomly collected in December 2014 from the same location using the same sampling method. After sorting and individually coding each shell, a random number generator was used to obtain a sub-sample of 100 shells from the original sample (Urbiniak and Plous, 2008). Once the sample size was complete (n = 100) each specimen was placed on a platform affixed with a metric ruler, and digital images were captured using a VT300 portable microscope. The images were then uploaded to an image processing program, ImageJ, where two measurements of outer borehole diameter (OBD) and inner borehole diameter (IBD) were recorded (Figure 1).

![Figure 1. Measurements of inner borehole diameter (left) and outer borehole diameter (right) taken in ImageJ.](image)

_Mulinia lateralis_ sample collection

During December 2013, 542 shells of the Mactridae family were collected from Otter Island, SC. After categorizing the sample by genera and species, the most abundant species was identified as _M. lateralis_ (n = 469). Each specimen was coded and placed into equally sized vials. The vials were then mixed and placed into a large container, from which a blindfolded anonymous subject was utilized to randomly select a set of ten vials. This sampling method was conducted ten times, mixing the vials in the container in between sets, until a final sample size of 100 shells was obtained. Due to the relatively small size of _M. lateralis_, cross-sectional measurements of IBD and OBD were obtained using a dissecting microscope.

**IBD:OBD ratio**

The individual measurements (one horizontal, one vertical) of IBD and OBD for each shell were averaged, and the subsequent values were used to calculate an IBD:OBD ratio. A Pearson correlation analysis was used to determine the relationship between IBD and OBD for each prey species. To determine whether _A. brasiliana_ samples differed in this relationship, we first obtained separate values for each sample (2013, n = 77; 2014, n = 23) Frequency distributions of the IBD:OBD ratios were plotted and examined to determine the modality and normality of the distributions of both _M. lateralis_ and _A. brasiliana_ samples.
RESULTS

The relationship between IBD and OBD for each species is shown in Figure 2. Pearson correlation analyses for *M. lateralis* and *A. brasiliana* revealed strong positive correlations between IBD and OBD for each species. The IBD/OBD relationship did not differ between the two samples collected for *A. brasiliana* (2013, $r_p = 0.93$; 2014, $r_p = 0.93$).

![Graph showing correlation between IBD and OBD for *M. lateralis* and *A. brasiliana*.](image1)

The frequency distributions of the IBD:OBD ratios for each species and the combined sample are shown in Figure 3. Analysis of normality using a Shapiro-Wilk test revealed that the distribution of ratios in the combined sample was normal ($p = 0.1$). For the individual species, the distribution of ratios for *M. lateralis* was normal ($p = 0.8$). In contrast, the distribution for *A. brasiliana* was non-normal ($p = 0.001$) and skewed. Graphical analysis of modality (unimodal vs. bimodal) revealed that all three of the distributions were unimodal.

![Bar graph showing frequency distribution of IBD:OBD ratio in combined sample (top), *M. lateralis* (middle) and *A. brasiliana* (bottom).](image2)

**Figure 2.** Relationship between inner borehole diameter (IBD) and outer borehole diameter (OBD) in *Mulinia lateralis* (top) and *Anadara brasiliana* (bottom).

**Figure 3.** Frequency distribution of IBD:OBD ratio in combined sample (top), *Mulinia lateralis* (middle) and *Anadara brasiliana* (bottom).
**DISCUSSION**

Results of the correlation analyses indicate strong positive relationships between IBD and OBD for each species. Analyses of the frequency distribution of the IBD:OBD ratios for the combined sample, which included both prey species, identified a unimodal, normal distribution. This pattern most likely indicates a single predator species feeding in the bivalve community. Consistent with this overall pattern, the IBD:OBD ratios obtained for *M. lateralis* were also unimodal and normal. Contrary to this pattern, the distribution of IBD:OBD ratios for *A. brasiliana* was unimodal but skewed. A similar pattern was seen in a previous study which attempted to differentiate naticid species based on variability in IBD:OBD ratios (Dietl & Kelley, 2006). A frequency distribution of IBD:OBD ratios of two naticid gastropods (*Euspira fortunei*, *Neverita duplicata*) revealed similar ranges. However, a skewed distribution of *N. duplicata* was observed which mirrors that of the distribution in the *A. brasiliana* sample. This pattern, although skewed, may indicate *N. duplicata* as the dominant naticid predator species in the community. Alternatively, the skewed distribution identified in *A. brasiliana* could be due to a second predator present in the community.

To determine whether multiple predators do exist in the community, an examination of borehole geometry could be used. Kitchell et al. (1981) established methods for measuring borehole angles of numerous naticid species. Applying this methodology to measure the angles of the boreholes within the *A. brasiliana* sample and referencing the angles of known naticid species (Kitchell et al. 1981) would assist in identifying the type of predators present.

Overall, the results obtained are consistent with the interpretation that predator-prey dynamics are regulated by a single naticid species. This type of pattern is consistent with the results obtained in another single-species dominated system from North Carolina (Grey et al. 2005). The dominant species in the North Carolina system was identified as *N. duplicata* (Atlantic moon snail). Consistent with this finding, live *N. duplicata* have been observed in the area of Otter Island, SC, and *N. duplicata* shells have regularly been found on the local beaches. Collectively, these findings suggest that *N. duplicata* may potentially be the species dominating in the community studied on Otter Island.

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**REFERENCES**


