Factors affecting predation on brittlestars (Echinodermata: Ophiuroidea)

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Abstract: Overlapping spatial distribution can be maintained because brittlestars feed differently. Exposure of arms during feeding places brittlestars at risk of predation by crabs, fish and asteroids. Brittlestars are able to break off their arms when attacked, and then regenerate lost arms. Thus, the proportion of arms regenerating is a measure of predation on individual brittlestars. We hypothesized that the risk of predation for an individual brittlestar would be affected by its distribution and relative size to other brittlestars. We predicted that predation would be greatest on individuals found in aggregations, would differ between species, and would increase with brittlestar armspan and disc diameter. Individuals found in aggregations did not have a greater proportion of regenerating arms than solitary individuals, and arm length did not differ between species. There was no difference in the proportion of regenerating arms between any of the species. We found a significant increase in the proportion of regenerating arms with increasing brittlestar disc diameter. If increasing disc diameter correlates with size of brittlestar, then our results indicate that larger brittlestars are at greater risk of predation. The variation in brittlestar disc diameter, as it relates to proportion of regenerating arms, suggests that disc diameter is probably not a primary indicator of predation risk in brittlestars.

Key Words: arm regeneration, coral reef, feeding behavior, predator-prey interaction

Introduction

There are nine common species of brittlestars (*Ophiuroidea*) found in the backreef of Discovery Bay, Jamaica, many of which occur under the same slab of rubble (Sides et al. 1985). This overlap in distribution is partially facilitated by differences in brittlestar feeding behavior, which reduces interspecific competition for food resources (Sides et al. 1985).

At night, brittlestars extend their arms from rubble openings to feed on particulate organic matter. This feeding behavior places brittlestars at risk of predation by crabs, fish, and asteroids. Brittlestars are able to defend against predation by voluntarily breaking off their arms when attacked. They are then able to regenerate lost arms. It follows that arm loss by an individual brittlestar can be used as an indicator of predation.

We hypothesized that the risk of predation for an individual brittlestar would be affected by its distribution and size relative to other brittlestars. We predicted that brittlestars found in aggregations (more than one individual underneath a slab of rubble) would have a greater proportion of regenerated arms than solitary brittlestars, as aggregated individuals would presumably have less rubble space per individual in which to hide from predators. Furthermore, research by Sides and Woodley (1985) has shown that predators prefer *Ophiocoma pumila* over other brittlestars and that *O. pumila* has longer arms than congenerics. Thus, we predicted that *O. pumila* would have the greatest proportion of regenerating arms. More generally, we predicted that the proportion of regenerating arms would increase with armspan across all species. Finally, we used disc diameter as an alternative measure of size and predicted that the proportion of regenerating arms would increase with increasing disc diameter of brittlestars, as well.

Methods

We snorkeled the West back reef of Discovery Bay on 25-26 February 2001 haphazardly turning over slabs of rubble of equivalent size (~1200 cm^2) and collecting all brittlestars found with a net. We placed brittlestars from each slab of rubble into plastic ziplock bags (one bag per slab) for transport back to the lab. We sorted the brittlestars

by morphotype and identified the three most abundant morphotypes to the species level (Hendler et al. 1995). We noted whether the brittlestar was found in an aggregation (greater than one brittlestar underneath a slab of rubble) or alone. We measured disc diameter at the widest point and measured armspan (arm + disc diameter + arm) of each brittlestar, using two full-length arms when possible. We then counted how many arms each brittlestar was regenerating, but excluded from our count missing arms that showed no signs of regeneration, as these may have been artifacts of our sampling (on several occasions we accidentally ripped off brittlestar arms). We are confident that actively regenerating arms were not a result of sampling because Sides (1987) found that it took at least 10 days to see the first signs of regeneration. We made informal behavioral observations in the lab in order to roughly evaluate the aggregation dynamics of the collected brittlestars. To assess the effects of brittlestar distribution and disc diameter on proportion of regenerating arms, we arcsine transformed the proportion of regenerating arms and ran an ANOVA and regression, respectively, using data from all individuals. To assess the effects of species/morphotype on armspan and on proportion of regenerating arms, we ran ANOVAs using data from the three most abundant morphotypes.

Results

We found 96 brittlestars under 42 slabs of rubble. In total, nine species were found, although the three most abundant species were *Ophiocoma pumila*, *O. wendtii*, and *O. echinata*. (Table 1). We found no difference in proportion of regenerating arms between aggregated and solitary brittlestar individuals (ANOVA, $F = 0.03$, $df = 95, 94$, $P = 0.85$). Arm span did not differ between species (ANOVA, $F = 0.18$, $df = 70, 68$, $P = 0.83$). We found no difference in the proportion of regenerating arms between any of the species, including *O. pumila* (ANOVA, $F = 0.93$, $df = 70, 68$, $P = 0.50$). We found a significant, but small, increase in the proportion of regenerating arms as brittlestar disc diameter increased ($r^2 = 0.05$, $df = 95, 94$, $P = 0.01$; Fig. 1). Size and predation data for all species/morphotypes are summarized in Table 1.

In the lab, we observed that brittlestars aggregate on top of each other, as opposed to spreading out in the available area. When no shelter was available, the brittlestars aggregated on top of each other in the corners of the indoor sea table.

Discussion

The lack of difference in the proportion of regenerating arms between individuals found alone and in aggregations did not sup-

Table 1. Total number of individuals found within each species/morphotype, the relative proportion of individuals found within each species/morphotype, the mean disc diameter (± 1 SE) of each species/morphotype, and the mean proportion of regenerating arms (± 1 SE) of each species/morphotype. All values reflect a two day (8 man-hours) sampling effort.

Species/ Morphotype	N	% of Total	Mean Disc Diameter (mm)	Mean Prop. Of Regenerating Arms
O. pumila	12	12.5	12.3 ± 0.63	0.1 ± 0.03
O. wendtii	31	32.3	16.45 ± 0.59	0.2 ± 0.05
O. echinata	28	29.2	17.1 ± 0.67	0.2 ± 0.04
A	6	6.3	10.0 ± 0.77	0.1 ± 0.04
B	6	6.3	20.0 ± 1.51	0.1 ± 0.04
C	2	2.1	10.5 ± 1.5	0.1 ± 0.1
D	4	4.2	10.25 ± 0.48	0.1 ± 0.06
E	4	4.2	12.0 ± 2.12	0.2 ± 0.15
F	3	3.1	12.3 ± 0.88	0.1 ± 0.01

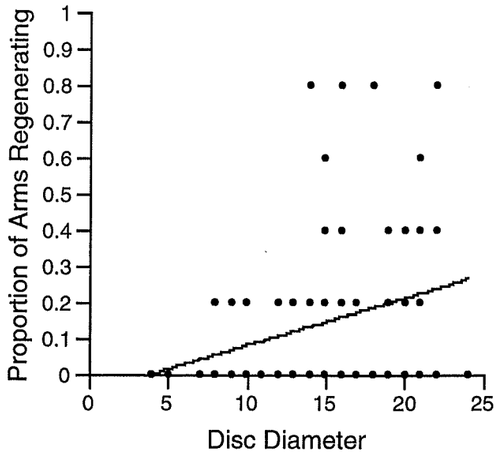

Fig. 1. Proportion of arms regenerating per brittlestar as a function of central disc diameter (n = 96).

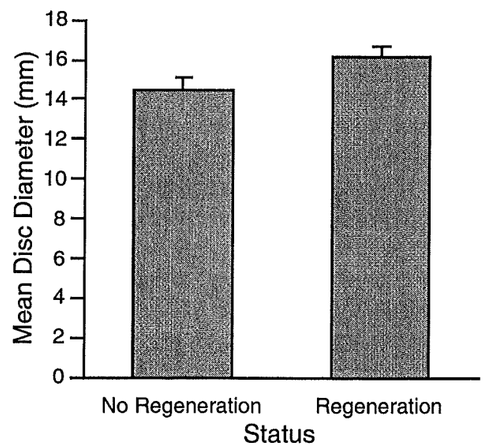

Fig. 2. Mean disc diameter (± 1 SE) of brittlestars with (n = 49) and without (n = 51) regenrating arms.

port our prediction that aggregated brittlestars would be more susceptible to predation. Our field and lab observations suggested that brittlestar arms were not exposed during the day regardless of brittlestar distribution. These observations support Paine et al. (1999), who suggested that space is not a limiting resource for brittlestars. If this is true, aggregated brittlestars may not be impacted by space pressure which could increase exposure to predation.

Our results also did not support our prediction that *O. pumila* would have the greatest proportion of regenerating arms. We based this prediction on Side and Woodley's (1985) result that *O. pumila* had the longest relative armspan, but our results indicated that there were no significant differences in armspan across the species analyzed. There was great variation in armspan within *O. pumila*, as well as the other two species analyzed, due in part to current arm regeneration. This variation, partially resulting from regeneration of arms, was also documented by Sides (1987), who found that at any given time, 46 – 100% of brittlestars exhibited signs of limb regeneration, and 40% had significant arm damage. Thus, armspan is constantly fluctuating, as arms are at various stages of regeneration, and is not a good indicator of brittlestar size.

Alternatively, disc diameter may be a better indicator of brittlestar size than armspan, because it is a constant measure that does not fluctuate temporally. The positive correlation we found between brittlestar disc diameter and proportion of regenerating arms supported our original prediction. If increasing disc diameter correlates with size of a brittlestar, then our results indicate that larger brittlestars are at greater risk of predation. This increased risk may be attributed to the niche partitioning which has been shown to occur during feeding. Since small brittlestars are limited in how far they can reach from beneath a slab of rubble by their proportionally shorter armspans, the large brittlestars have the capability to extend their arms a substantial distance to reach unoccupied or preferred space for feeding. This extra extension may put large brittlestars at greater risk of predation and may also afford the small brittlestars a certain amount of protection from predators, which are likely to encounter and prey upon the large brittlestars first. Increasing disc diameter may also correlate with the age of a brittlestar. It is likely that an older

brittlestar will have had more encounters with predators then a younger brittlestar, which could also lead to a greater proportion of regenerating arms.

The high variation in arm regeneration that was not explained by size (Fig. 1) suggests that disc diameter is probably not a primary indicator of predation risk in brittlestars. While we found it difficult to replicate a natural environment for brittlestars in the lab, we suggest further field work to assess microhabitat, such as size, angle, and location of rubble, which may be influencing predation upon brittlestars.

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