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Epifaunal organisms on spines of two deep sea urchins, *Cidaris blakei* and *Stylocidaris lineata*

Abstract

Although many hard substrata in the deep sea have been examined for associated fauna, the epifaunal communities attached to spines of the deep sea urchins *Cidaris blakei* and *Stylocidaris lineata* have yet to be examined. Individuals of both species were collected over the course of ten days from various deep sea dives in the waters off the Bahamas. A total of 15 attached epifaunal organisms were associated with *Cidaris blakei* and 14 were associated with *Stylocidaris lineata.* In general, spines located towards the aboral side of urchins of both species had higher species richness of epifaunal organisms and spines of different shapes had different numbers of associated organisms.

Introduction

In many areas of the deep ocean, where hard substrata are rare, communities of organisms develop attached to other organisms such as sponge stalks, corals and even spines of sea urchins. It is generally thought that these assemblages act as islands where epifaunal species can associate for social/mating purposes (Levin 1991). Additionally, these biogenic structures may act as refuges for both juveniles and adults (Ilan et al. 1994). Epifaunal organisms have an impact on the host animal. In some cases, the relationship may be mutually beneficial. For instance, the scallop *Chlamys hastata* is commonly found with sponges encrusting the shell (Farren and Donovan 2007). It appears that the sponge provides both a tactile and chemical camouflage which deters predation by the sea star *Pycnopodia helianthoides.* The presence of the sponge also deters settlement of the other common epibiont on *Chlamys hastate,* a barnacle. The barnacle illustrates the idea that not all epifaunal organisms are beneficial as the extra weight and drag associated with the barnacle growth increases the likelihood that the scallop will be caught and consumed by *Pycnopodia* (Farren and Donovan 2007).
In the deep sea, epifaunal communities are often associated with biogenic structures such as sponges (Beaulieu 2001a,b, Schiaparelli et al. 2003) and coral (Henry 2001, Buhl-Mortensen and Mortensen 2005). Many species are associated with both organisms, but sponge stalk communities often have higher diversity (in terms of number of taxa as well

as number of individuals) than many other deep sea hard sediment communities (Beaulieu 2001b). These communities often consist of serpulid polychaetes, zoanthids, anemones, bryozoans, shrimp, copepods, sabellid polychaetes, and hydroids, but are usually dominated by foraminiferans (Ilan et al. 1994, Beaulieu 2001a, b). Deep water gorgonian and scleractinian corals also harbor epifaunal communities containing sponges, hydroids and bryozoans as well as some echinoderms and polychaetes (Henry 2001, Buhl-Mortensen and Mortensen 2005).

Although epifaunal assemblages associated with corals and sponges are important, there are others which have thus far been overlooked. For instance, a number of deep sea urchins such as *Cidaris blakei* and *Stylocidaris lineata* host a number of epifaunal organisms which grow attached to their spines. The following is a description of the species associated with these two urchin species collected near the Bahamas.

Methods

Sea urchins of both species were collected from the sea floor using the Jason Sea Link II on a series of dives throughout the Bahamas in May 2008. Individuals of *Cidaris blakei* were collected in a variety of locations including Southwest Reef (SW reef), and off Paradise Island. *Stylocidaris lineata* was collected at Southwest Reef in addition to other locations. Both species were collected and brought to the surface where they were maintained in filtered sea water in a cold room maintained between 10 and 12 degrees C.

Urchin test size (diameter and height) was measured with calipers along with length and maximum width of each spine. Additionally, the shape and position of the spine on the urchin were noted. Spines of *Cidaris blakei* can be three different shapes (paddle, small paddle or round) whereas the spines of *Stylocidaris lineata* are only round. The long spines on *Cidaris blakei* are found in three main rows which we designated 'aboral,' 'equatorial,' and 'oral.' Long spines on *Stylocidaris lineata* are found in two main rows, 'aboral' and 'equatorial.' For individual epifaunal animals, numbers on each spine were counted (barnacles, worms, zoanthid polyps). The percent cover for zoanthids was also estimated using a bin system (0-5%, 5-25%, 25-50%, 50-75%, 75-90%, 90-100%). In some cases, both number and percent cover were difficult to assess (hydrozoans, bryozoans), so the presence of these organisms was simply noted. Total number of species on each spine was also noted.

Spines were measured on 27 *Cidaris blakei* and 28 *Stylocidaris lineata* for a total of 1318 measured spines.

Results

Most individuals collected harbored not only the attached species to be described below, but commonly either an ophiuroid or galatheid crab or both was associated with each urchin. It is difficult to describe this relationship specifically as the method of collection allowed for mixing of these highly mobile associated taxa.

When examining the data, it was necessary to account for the different shapes of the spines when comparing species richness. Surface area was used to normalize the richness data. Surface area of paddle and small paddle shaped spines was estimated as twice the triangular area or simply the width x length of the spine. The surface area of the round spines was estimated to be the surface area of a right cone: $\pi \frac{w}{2}\sqrt{\left(\frac{w}{2}\right)^2 + l^2}$ where w is the width and l is the length of the spine. Surface area of the spine was highly correlated with species richness per spine ($R^2 = 0.297$, $p<0.0001$). Therefore, all species richness data per spine has been normalized to area.

Epifaunal organisms.

A total of 15 epifaunal organisms were identified on the spines of *Cidaris blakei* and 14 of these also appeared on the spines of *Stylocidaris lineata* (Table 1). At this stage, individuals have not yet been identified to species, but will be presented here at the lowest known taxonomic level.

Commonly, organisms were not distributed evenly between the rows of spines, but were present on different percentages of spines depending on the position of that spine on the urchin. For instance, although the flat zoanthid was the most common organism on the spines of *Cidaris blakei* with an overall presence 40.9% of the time, it was present 50% of the time on aboral spines, 58% of the time on equatorial spines, and only 15% of the time on oral spines. Many other epifaunal species show a different pattern of distribution, that is, they are usually most prevalent on the aboral spines, then show decreasing prevalence on the equatorial through oral spines (Figure 1).

A similar pattern emerges when examining the epifaunal animals associated with the spines of *Stylocidaris lineata* (Figure 2). Here there are only two rows of large spines, but again, the majority of species are more commonly found on the aboral spines.

Most spines of *Cidaris blakei* and *Stylocidaris lineata* are brown or tan, but a few are red and still seem to possess growing epithelium. In total, 7.8% of all *Cidaris* and 9.3% of all *Stylocidaris* spines were red and none of these had any epifaunal organisms.

Species richness on spines of Cidaris blakei *from two locations*

Individuals of *Cidaris blakei* were collected from two distinct locations, Paradise Island and SW reef. We examined the overall species richness of epifaunal animals on the spines of urchins from both locations. In general, both populations have epifaunal assemblages that show the pattern of highest richness on aboral spines with a decrease through equatorial to oral spines (Figure 3). However, there are more species per unit area on equatorial spines on urchins from Paradise Island.

Additionally, species richness differs between spines of different shapes (Figure 4). Paddle shaped spines appear to have the smallest number of species present per area. The richness is higher on round spines and highest on small paddle shaped spines. In this instance, there is no apparent difference between the populations of *Cidaris blakei* from different locations.

Comparison of species richness between urchin species collected at Southwest Reef

Both species of urchin were collected at SW reef. At this location, the average number of species present per area on *Stylocidaris* spines was more than twice the number present per area on *Cidaris* spines (Figure 5). This is the case for both aboral and equatorial spines.

Discussion

The epifaunal assemblages of the two deep sea urchins *Cidaris blakei* and *Stylocidaris lineata* are quite similar. The animals which live on the spines of the urchins also show similar distributions related to the position of the spine on the body. Overall, for both urchin species, the aboral spines showed the highest species richness. It is possible that this positional preference has to do with the feeding habits of the epifaunal animals. As is common with many epifaunal communities, most of the organisms found on the urchins appear to be filter feeders (Beaulieu 2001b). Therefore, settling on spines further from the sediment may improve the feeding of the epifaunal organism thereby making it advantageous to settle on aboral spines. In the case of the shells of the gastropod *Cerithium atratum*, more epibionts were found on shells occupied by hermit crabs, which stay above the surface of the sediment, than on shells occupied by the snail itself which bulldozes through the sediment (Creed 2000).

Many of the taxa found on the urchin spines are also found in other habitats in the deep sea. Zoanthids are common on sponges and occur between depths of 200 and 5000 meters depth (Ryland et al. 2000). There is some degree of specificity in terms of the association between particular sponges and particular zoanthids, though the relationship is rarely obligate (Swain and Wulff 2007). It is possible, though unknown at this stage, whether the flat and stalked zoanthids present on the urchins spines are specific to those species of urchin. Additionally, the presence of these cnidarians may shape and alter the community of epifaunal animals. In this case, and others, zoanthids covered entire spines even to the point of overgrowing serpulid tubes and other organisms (Beaulieu 2001a,b). Hydroids and byrozoans are also common on hard substrata in the deep sea, though hydrozan diversity is highest above 600m depth (Henry 2001). Some species of bryozoans are toxic, which may confer an advantage though chemical protection not only to the bryozoan colony but to the animal on which it is growing (Ryland 2001). At this point it is unknown whether or not the bryozoan found on *Cidaris* has any traits that may confer an advantage to the urchin.

The examination of the epifaunal communities present on Cidaris blakei and Stylocidaris lineata is in need of further study. Although a number of interesting possibilities for further examination have arisen though the course of this preliminary study, further analysis of current data is necessary and additional exploration is important.

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Table 1. List of organisms present (P) or absent (A) on *Cidaris blakei* and *Stylocidaris lineata* spines

Organism	***Cidaris***	***Stylocidaris***
Hydrozoan	P	P
Hydrozoan-tip	P	P
Flat zoanthid	P	P
Stalked zoanthid	P	P
Sabellariid worm	P	P
Serpulid worm	P	P
Nereid worm	P	P
Terebellid worm	P	P
Scalpellid barnacle	P	P
Verruca barnacle	P	P
Bryozoan	P	P
Foraminifera	P	P
Snail	P	P
Sponge	P	A
Anemone	P	P

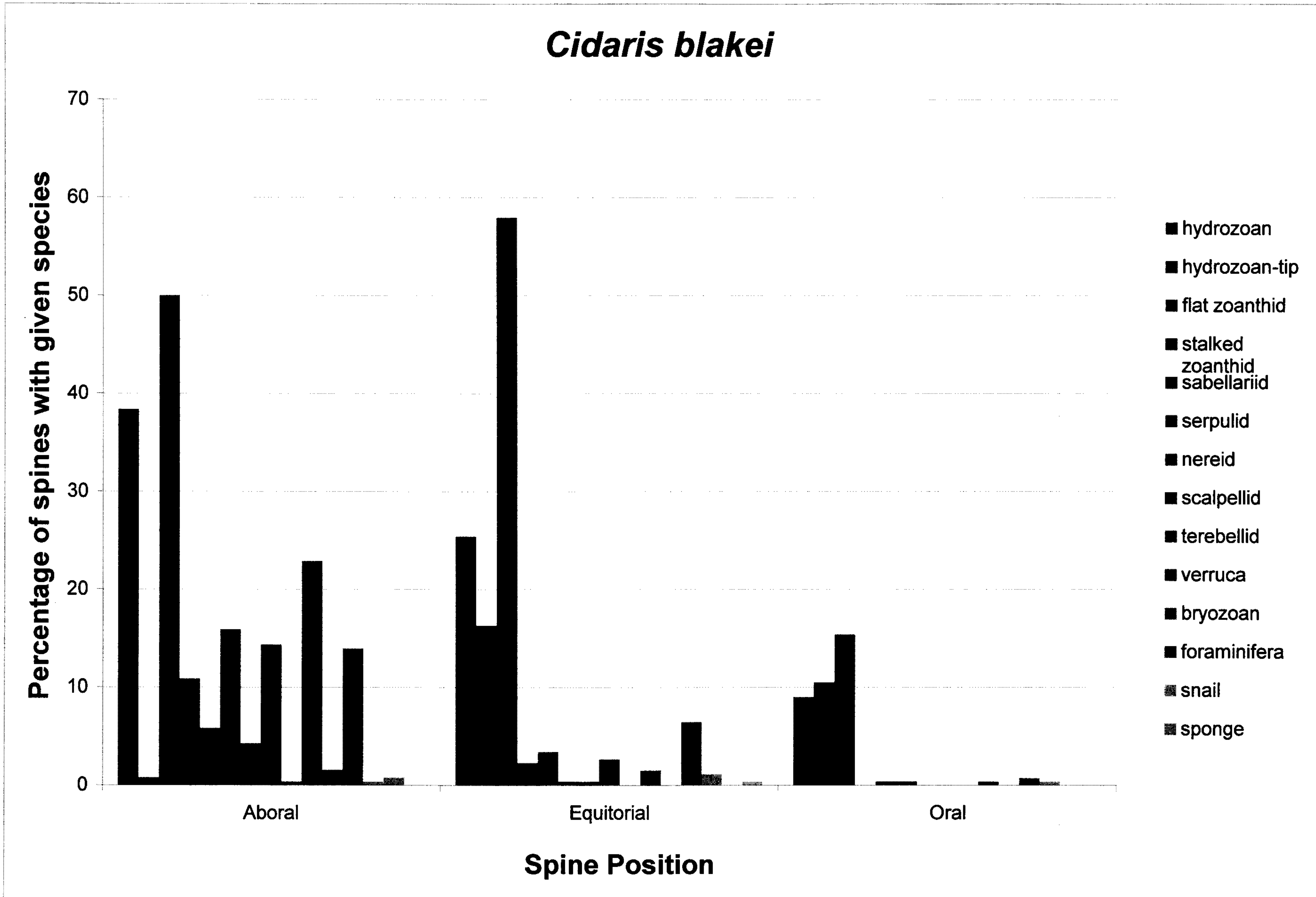

Figure 1. Epifaunal animals on the spines of *Cidaris blakei*. This illustrates the percentage of spines by position on which a particular species resides. Note that the majority of species are more commonly found on aboral spines, with decreasing prevalence through equatorial to oral spines,

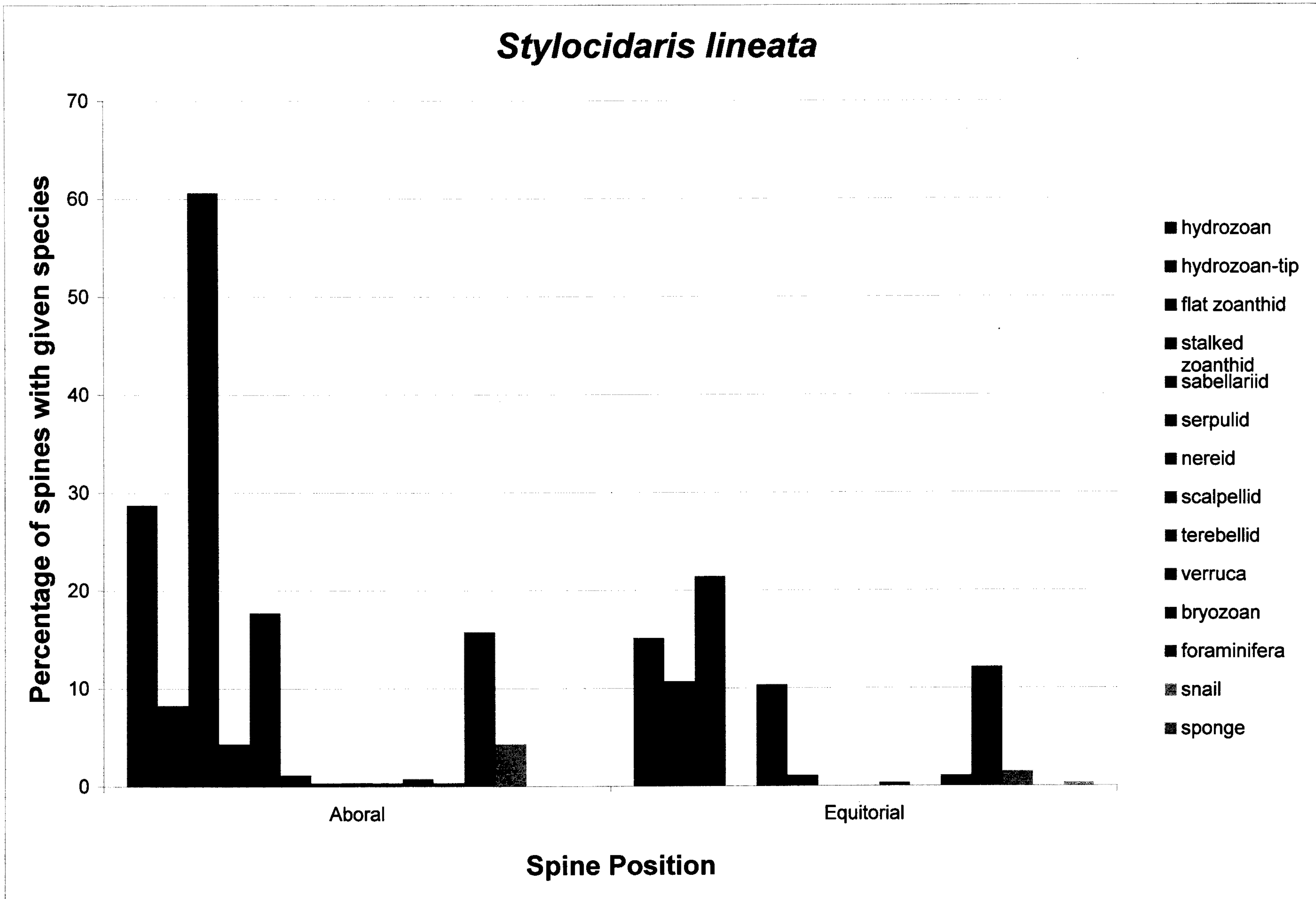

Figure 2. Epifaunal animals on the spines of *Stylocidaris lineata*. This illustrates the percentage of spines by position on which a particular species resides. Note that the majority of species are more commonly found on aboral spines and occur less frequently on equatorial spines,

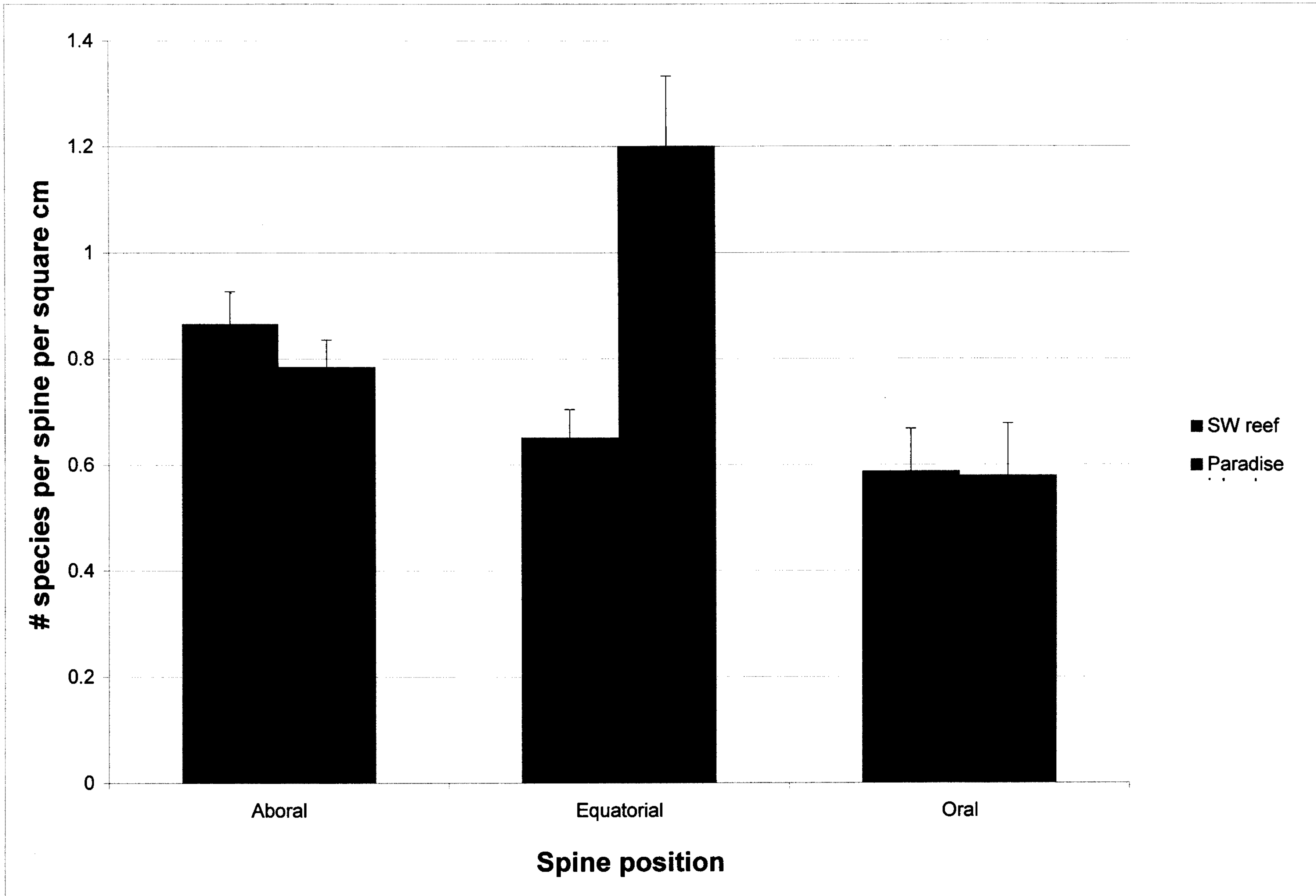

Figure 3. Overall species richness of epifaunal assemblages per spine per unit area for two populations of *Cidaris blakei* based on spine position on the urchin. Error bars represent standard error of the mean.

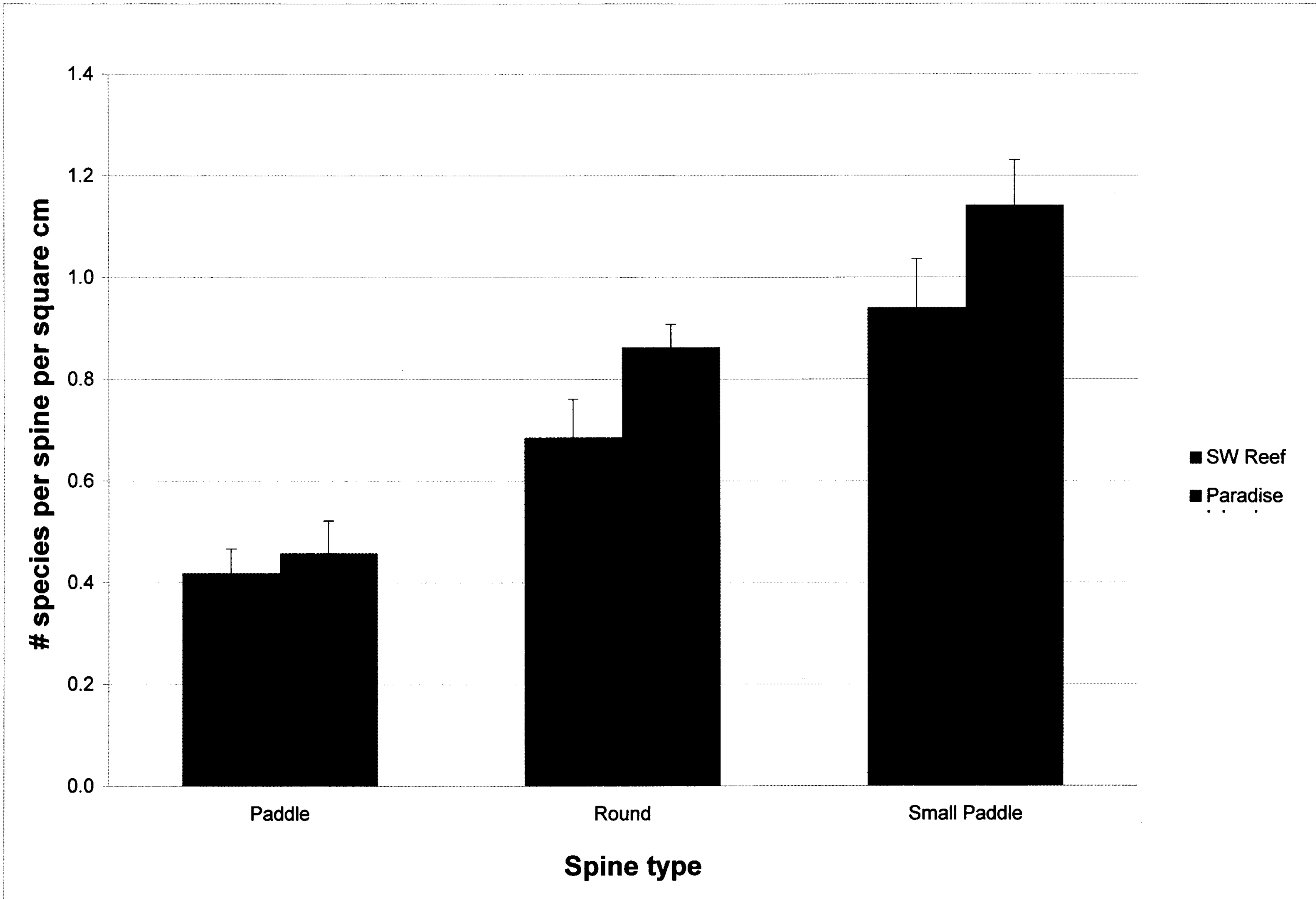

Figure 4. Overall species richness of epifaunal assemblages per spine per unit area for two populations of *Cidaris blakei* based on shape of the spine. Error bars represent standard error of the mean.

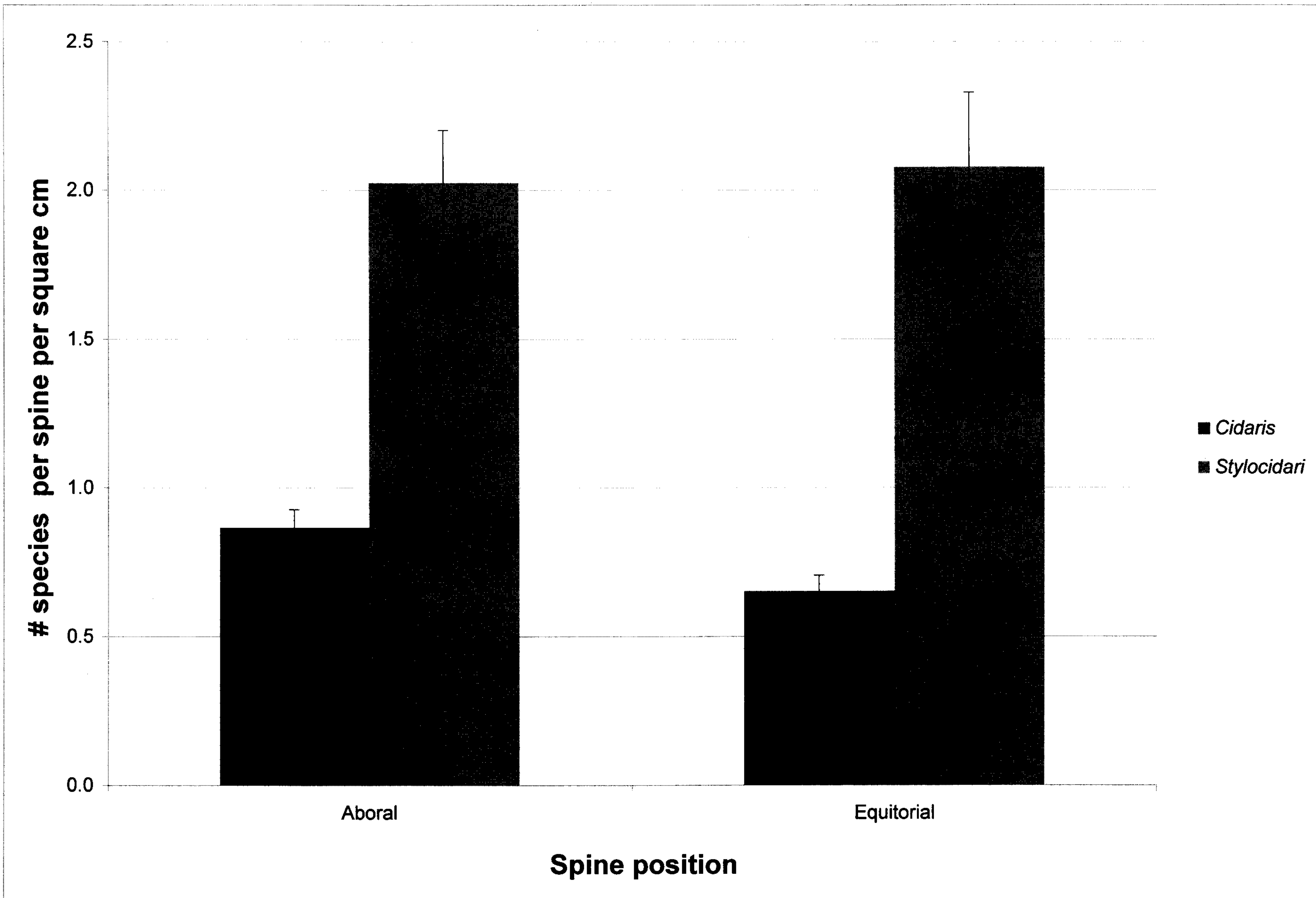

Figure 5. Species richness of epifaunal assemblages on spines of both *Cidaris blakei* and *Stylocidaris lineata* collected at SW reef. Error bars represent standard error of the mean.