The Effect of Sponge Morphology on Infaunal Community Structure in *Niphates digitalis*

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ABSTRACT The effect of *Niphates digitalis* morphology on infaunal community structure was evaluated in 55 *N.digitalis* sponges between 40 and 60 feet on the fore reef of Discovery Bay, Jamaica. Numbers of individuals were associated more with the interior of the sponge than the exterior. The community structure was dominated by *Ophiothrix suensonii*. Number of individual organisms was positively correlated with maximal surface area and inversely propotional to minimum oscular measurment. Presence of predators and prey on the same sponge were negatively correlated and sponges with basal atrial openings had significantly more *O.suensonii* individuals associated with them than sponges without basal openings. Diurnal and Nocturnal observations of sponge communities showed fairly stable assemblages of *O.suensonii*, hermitcrabs, *Lysmata wudemanni*, *Stenopus hispidus*, crab and fish species.

Excellent, original study

INTRODUCTION

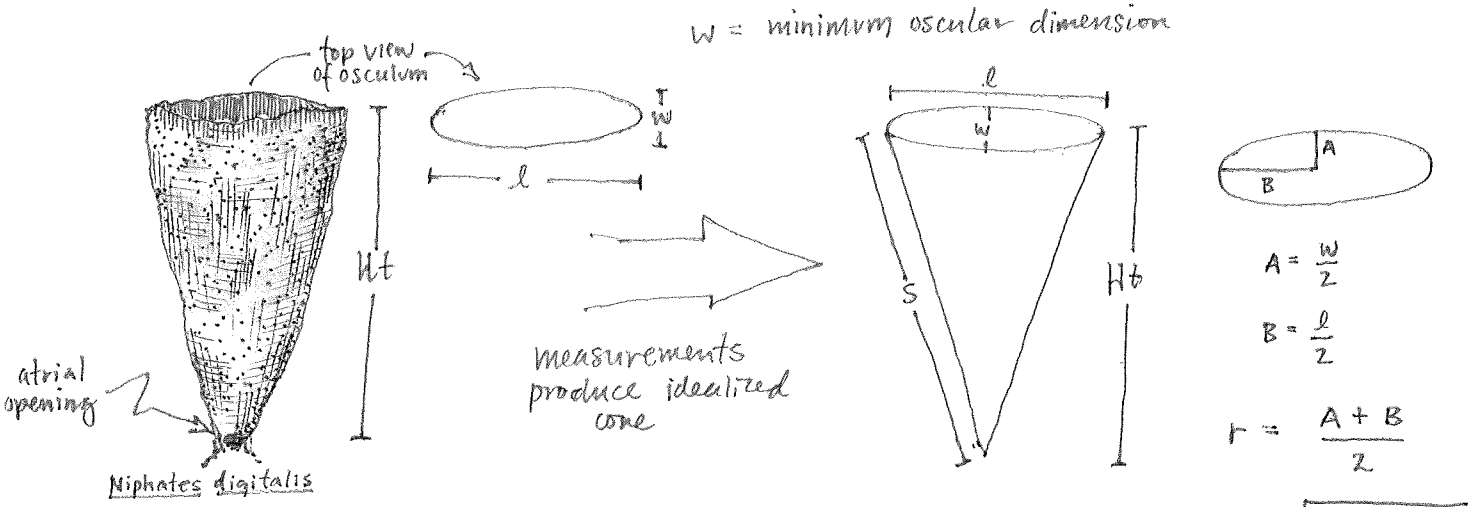
The combined pressures for substrate, food and protection from predation affect many of the organisms of the coral reef. These pressures have produced countless adaptations and behaviors. The organisms that live on and inside sponges are one example of adaptation to environmental pressures. Within the sponge community there is a whole ecosystem in itself, encompassing parasites, detritovores and predators. These infaunal organisms may be microscopic or many centimeters in length. Work by Reicher and Bachman (1978) showed that the infaunal community of Ircinia sponges is indeed diverse, with as many as 22 taxa occuring in one sponge. Sponges are able to support such communities due to their physical and chemical composition. Physical protection is found in the atria and many small ostia and canals. Sponge toxicity as a predation deterrent may also protect associated infaunal communities (Kaplan 1982) (Hendler 1984) The complexity of these sponge ecosystems will be best understood when the sponge-organism & organism-organism relationships are examined. My emphasis is on examining the effect of sponge morphology on the organisms and their subsequent interactions. Based on informal observations of the sponge Niphates digitalis and its associated community of Brittle stars, hermit crabs and shrimp, I suspect that morphology plays a large role in community structure. The relationship of sponge surface area and amount of oscular opening seem to be the most important aspects of the sponge's morphology in

relation to organisms within. I hypothesize that more individuals will be associated with sponges of greater surface area. Furthermore, the combination of maximal surface area and a minimum oscular opening should have the most pronounced affect on number of organisms associated with a sponge. This relationship should provide substrate and protection (smaller entrance). Based on the theory that the sponge is offering the infaunal organisms refuge, I would expect more organisms on the interior vs. exterior of the sponge. In these diverse communities where there are infaunal species feeding on other infaunal species, I would expect the negative association of predators and prey. I also plan on observing the day/night activity patterns of the sponge communities in an attempt to further understand the infaunal ecosystem.

METHODS

Fifty-five Niphates digitalis sponges between 40 and 60 feet were examined in-situ between March 1-7 1987 at three fore reef sites (LTS, EFR & M1) at Discovery Bay, Jamaica, West Indies. N. digitalis was chosen because it has one main atrial chamber in which the entire interior is visible without destruction. Associated organisms are easily seen inside and outside the sponge. The distinctive cone shaped light lavender to gray sponge has dimensions that are easy to measure and quantify.

All sponges were measured from top to bottom of atrium (Ht) and length (l) and width (w) of osculum. From the osculum dimensions, a radius (r) was derived and combined with side dimension (s) to determine sponge surface area (SA).



Assuming that the osculum is an ellipse and an ellipse is a skewed circle, a radial measurement is derived by finding the mean of the two elliptical radii (A & B)

Side measurement (s) is determined by the pythagorean theorem whereby $s^2 = r^2 + Ht^2$

DIAGRAM 1.

In addition to sponge dimensions, the existence of an opening at the base of the atrium was noted. For each sponge examined, the number of organisms, their location (inside or outside of sponge), length (a length across the central disk was used as an index of brittle star size) and species were recorded. Any other observations such as feeding behavior or abnormalities in sponge morphology (eg. ripped down the side) were also noted.

The second part of the study involved examining 14 sponges in-situ at M1 and EFR sites on the fore reef for three day periods and one night period to determine the consistency or stability of each sponge's infaunal community. Daytime and nightime observations were compared to establish daily behavior patterns. All measurements of the sponge and associated organisms were evaluated as in the previous study.

Correlation coefficients were used to evaluate sponge surface area measurements and number of organisms (four separate regressions). Students T-tests were used to establish significance in comparisons of numbers of brittle stars on sponges with open and closed atria. Evaluations of predator species (crab species, Stemopus hispidus, fish species) and prey (Brittle stars, Ophiothrix suensonii) were compared numerically.

RESULTS

The frequency distribution of the surface areas of N. digitalis is presented in fig 1. Sponge surface area ranged from 25 - 892 cm^2 ($\bar{x} = 236.5 \pm 175$)

The distribution of infaunal organisms is predominately in the interior areas (fig. 2)

There were 116 total infaunal organisms, comprised of Suenson's brittle star (Ophiothrix suensonii), hermit crab species, Red Cleaning Shrimp (Lysmata wurdemanni), Gobiidae, Banded Coral Shrimp

(*Stenopus hispidus*), crab species and fish species. Numbers of organisms found and their percentage of total infaunal population is presented in fig 3.

The non significant relationships between sponge surface area and *O. suensonii* size and between *O. suensonii* sizes inside and outside of sponges are presented in fig. 4.

The significant correlations between sponge surface area and both total number of individuals and number of *O. suensonii* individuals are presented in fig 5. Further relationships of surface area inversely correlated with minimum oscular measurement vs. total and *O. suensonii* individuals was also significant ($p < 0.01$ and $0.01 < p < 0.05$) (fig 6)

The evaluation of the presence of *O. suensonii* individuals on sponges with atrial openings vs. sponges without such openings was significant, with more individuals associated with sponges with openings

	atrium base	
	opened	closed
$\bar{x}$ number *Ophiothrix suensonii* associated with *N. digitalis*	1.64 ± 1.76 n=47	0.125 ± 0.35 n=8
	$p < 0.02$	

Prey species were never found inside sponges where predators occured in all cases.

	with predator	no predator
$\bar{x}$ number *Ophiothrix suensonii* associated with *N. digitalis*	0 n=4	1.25 ± 1.56 n=51

(No statistical relationship due to zero value)

what were the predators here? My gobies, can they eat brittle stars?

Results of sponge communities studied for 3, day periods.

9/14 sponge communities remained the same throughout the duration of the sampling period 64.3%

the 5 other sponge communities varied in numbers of O. suensonii from day to day. In some cases there were variations as much as 2 – 7 O. suensonii individuals from one measurement to the next.

Shrimp (Lysmata wurdemanni) in two sponges < 10 cm apart were found to live in both atria sometimes singly or as a pair.

The Nocturnal evaluation was rather inconclusive, in that no specific trend was noticed. Many of the sponges had similar numbers of O. suensonii as in the daytime while others had none. Brittle stars were found on the outside and inside of sponges. Shrimp were found in sponges as during the day and in one case, an orange sea lilly that had remained at the bottom of the atrium of one sponge for more than two weeks was seen high on the rim of the osculum with its arms unfurled.

DISCUSSION

My initial hypothesis of the sponge as a protective environment is supported by the fact that the majority of the associated organisms are found on the sponge interior (fig. 2) This observation is not necessarily a direct correlation to predation pressure, it may be that organisms are feeding in the internal cavity and not on the exterior.

The community structure of Niphates digitalis is dominated by Ophiothrix suensonii. O. suensonii is commonly associated with sponges and is often found inside the atrium (Kaplan, 1982). Many of the interactions within the sponge environment and many of the relationships I have presented involve this brittle star.

Based on work by Hendler (1984), predation on brittle stars was attributed to fish (grunts, squirrelfish) hermit crabs and blue spotted crabs (Sides 1975) In some of the sponges sampled, there were certain fish and crab species. Although they were never identified as direct predators on the O. suensonii population, the negative correlation of prey presence where predators occur does indicate some relationship. The O. suensonii may be able to recognize the presence of predator species and leave sponges where crabs and fish occur. It may also be that in the sponges where predators were encountered, all the brittle stars had been consumed, thus negating any possibility of brittle star's ability to detect their predators.

Co-occurence of of O. suensonii and hermit crabs was common, with 31.4% of sponges with O. suensonii also having hermit crabs. In sampling and observations no predation on brittle stars by hermit crabs was ever seen. Most of the hermit crabs co-occurring with O. suensonii were less than 2 cm in length (shell length). Hermit crabs of this size probably pose little predation pressure on the much larger brittle stars. The hermit crabs may in fact be feeding on smaller brittle stars < 0.1 cm that may live in the exhalant canals and were not evaluated in this study.

The presence of shrimp species, sea lilies and hermit crabs show the use of the sponge as a habitat for other organisms in addition to the Opiothrix suensonii. Presence of cleaning shrimp and gobies may indicate the sponges as sites of cleaning stations.

Evidence that there is no difference in sizes of brittle stars with increasing surface area indicates that the O. suensonii may not be selecting a sponge based on its size. Furthermore, surface area may not have anything to do with food availability or protection. (fig 4) The similarity in sizes of O. suensonii on the inside and outside indicates that there may not be any size selection by predators on brittle stars on the sponge's outer surface. There may be equal utilization of the two surfaces by all size classes of brittle stars. The advantages of location on a sponge are not well understood. Work by Hendler (1984) showed that brittle stars remained on outer surface to clean the ostia of the sponge (feeding), while other relationships

may be occurring in the N. digitalis — O. suensonii relationship. The lack of fish predators at Discovery Bay may have relaxed the predation pressure on the brittle stars to the point that all size classes can rest on the exterior without harm.

The relationships between surface areas and organism numbers shows that the number of individuals in a sponge community are very much related to the size of the sponges (fig 5) Further support for the idea of the sponge as a protective environment is found in fig 6. There may be preference by organisms or better survival of individuals on sponges with maximal surface area and a minimal ocular opening (see diagram 1, page 3). Although the four relationships in figures 5 and 6 are significant, some of the correlation is due to randomness and other factors not associated with surface area or numbers of individuals.

The evidence that openings in the base of the atrium have a significant effect on the number of O. suensonii inhabitants, supports the theory that the sponge is a refuge habitat. An opening in the atrium base allows brittle stars easy access to the interior without having to climb up over the exposed sides and top. This "back door" allows O. suensonii to move easily from the substrate to the sponge interior. It also provides an escape hatch for brittle stars and shrimp from a predator entering from the top of the sponge.

The diurnal / nocturnal study of 14 sponge communities showed a fairly stable community structure with more than 64% of the sponges remaining unchanged for the duration of the study. The variation in community structure was due mostly to migration of Ophiothrix suensonii between sponges and substrate. O. suensonii were often seen in the algae and rubble substate below sponges. Shrimp were found singly and in pairs. The night study showed little change from daytime measurements. The apparent similarity between the day and night communities may show that the infaunal organisms do not have specific diurnal and nocturnal behavior patterns. A larger sample size of sponges to make repeated measurements at night facilitate more conclusive evidence for day and night behaviors.

This study shows quite strongly that the morphology of the sponge has a great effect on the inherent community structure. These diverse microecosystems are sensitive to predation pressure and subtle changes in the sponge size or extent of openings. Species composition is also variable in these sponges, with the presence of a predator affecting the presence of prey. Sponge infaunal communities are for the most part stable ecosystems with limited migration of individuals.

FIGURE 1. Frequency Distribution of *Niphates digitalis* sampled

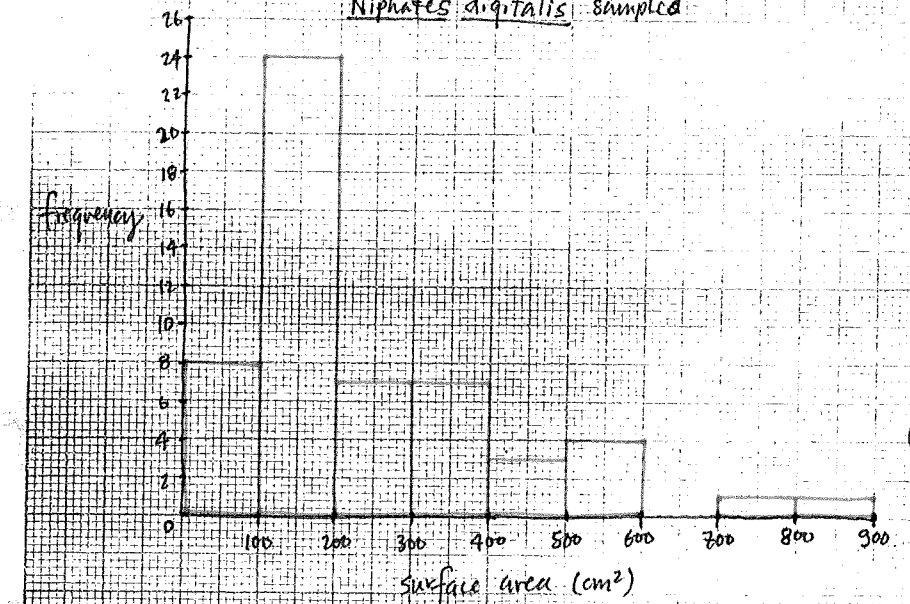


FIGURE 2.

Percentage of total organisms found inside or outside of the sponge

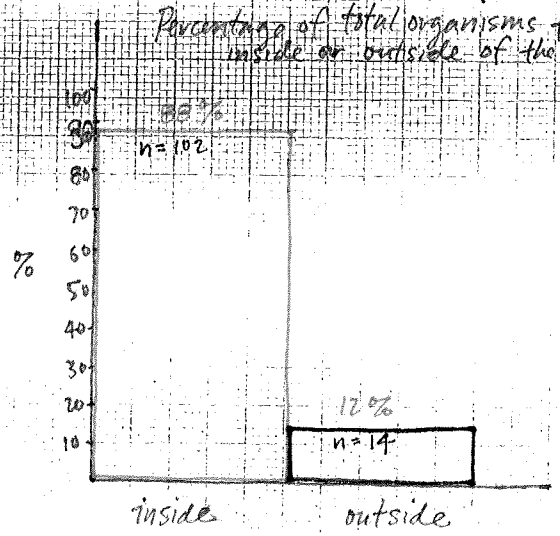


FIGURE 3.

Percentage of total infaunal community by species for all sponges examined

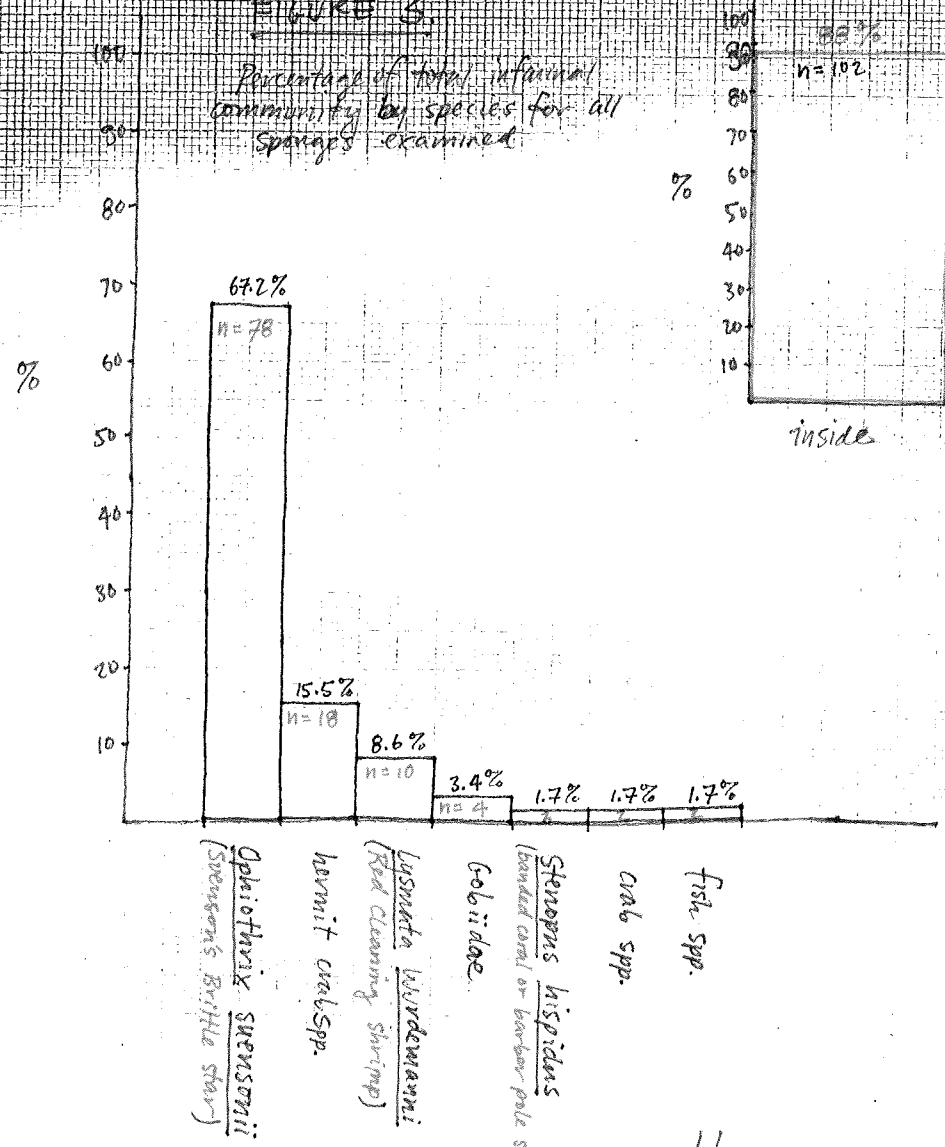


FIGURE 4

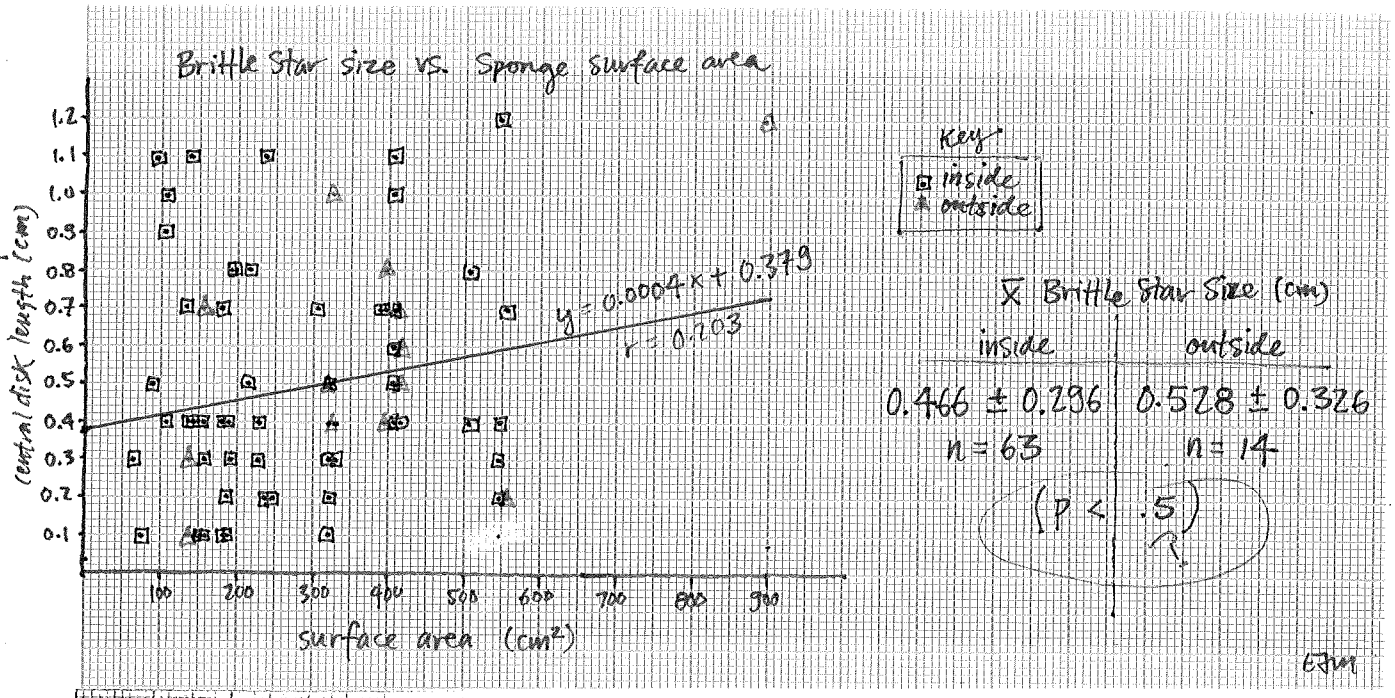


FIGURE 5 Number of individuals on or in a sponge in relation to sponge surface area (cm²)

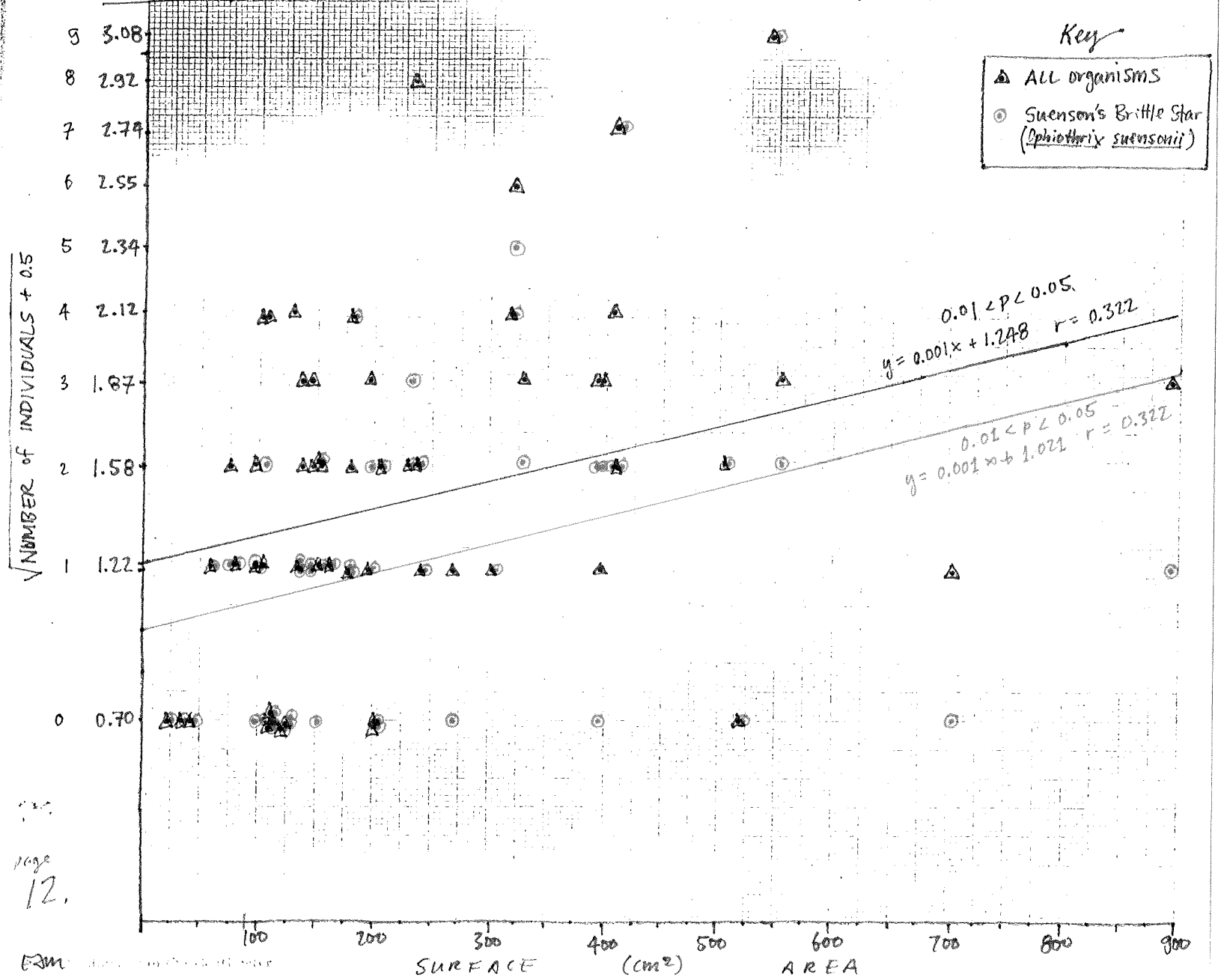
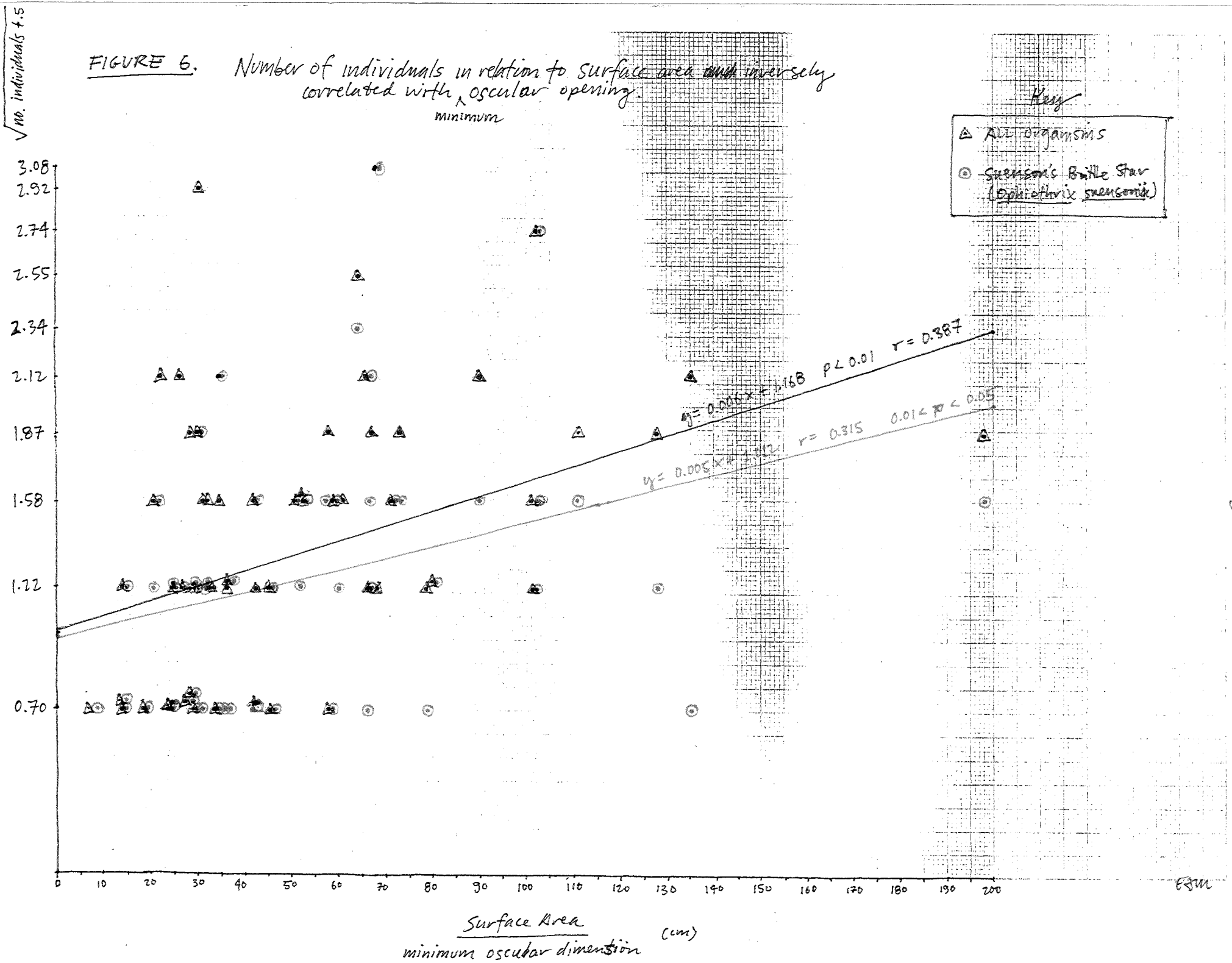


FIGURE 6. Number of individuals in relation to surface area ~~and~~ inversely correlated with minimum oscular opening.



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