Study II: The distribution of selected Malacostraca of Dominica, Lesser Antilles

Robert Brewer
Institute for Tropical Marine Ecology
P.O. Box 944, Roseau, Commonwealth of Dominica

Abstract This study provides a malacostracan species inventory for Dominica. Malacostracans surveyed for included Brachyura (true crabs), Diogenidae (hermit crabs), Natantia (swimming shrimps), and Palinura (lobsters). Surveys were carried out at 23 west coast sites. Species abundance was assessed by tallying individuals and recording the first time a species was found during a 20 minute survey period. Distribution patterns across microhabitat types are explained, with estimates of the area surveyed at each site included in the distribution analysis. Species distribution was found to be dependant upon both depth and specific microhabitat prevalence. Relaying distribution estimates to the local population will aid in the advancement of marine conservation efforts in Dominica by providing awareness of the overexploitation of malacostracan species.

Keywords Dominica · Crustacea · Malacostraca · Microhabitat · Symbiote

Introduction

There are approximately 42,000 members in the subphylum Crustacea (phylum Arthropoda (Brusca and Brusca 1990)) and most species are found in marine environments (Barnes 1987). Crustaceans inhabit all of the world's oceans, at all depths and in all climates (Brusca and Brusca 1990). Jointed appendages, a hard exoskeleton and the specialization of three general body segments (head, thorax, abdomen) define crustaceans, allowing adaptation to a broad range of niches in all marine habitats (Barnes 1987). Crustaceans exhibit the highest species richness and the greatest morphological range of marine invertebrates, thus being labeled "the insects of the sea" (Brusca and Brusca 1990). The largest crustaceans are found in class Malacostraca (Brusca and Brusca 1990). These larger crustaceans include section Brachyura (true crabs), family Diogenidae (hermit crabs), suborder Natantia (swimming shrimps), and suborder Palinura (spiny and slipper lobsters) as defined by Humann and Deloach (2002).

Dominica's malacostracan richness and distribution patterns had not been extensively studied previous this survey. Dominica's underwater marine topography is characterized by a narrow shelf due to the island's young geological age (Honychurch 1995). This narrow shelf minimizes the presence of expansive reef systems and lagoonal settings that Brachyura, Natania, and Palinura can heavily populate (Steiner pers comm). Despite this narrow shelf, Dominica's calmer, leeward west coast exhibits the greatest variety of marine environments off Dominica, including various patch reefs, rocky formations supporting coral growth, and seagrass beds running parallel to the coast starting 30-40m offshore (Steiner et al 2007). This study examined Dominica's west coast marine environments for the aforementioned malacostracan groups. Surveys produced a baseline inventory of malacostracan species for individual survey sites and the west coast. In addition, this study assessed the distribution patterns of species based on depth and selected faunal microhabitats.

Materials and Methods

Surveys were performed in the mid-morning at west coast locations. Habitat substrates at survey sites where divided into five categories: 1) Boulder fields < 3m deep containing unconsolidated rocks <1m in diameter; 2) True Reefs, i.e. $CaCo_3$-built structures; 3) Rocky outcrops, defined as coastal rock protrusions jutting out from the otherwise parallel contour of the coastline, usually maintaining a narrow (<5m out), shallow (<2m deep) profile; 4) Rock, which includes all other rock formations at all depths; and 5) Debris in seagrass/sand flats.

Two primary methods of data collection were used to assess malacostracan presence and abundance at selected sites. 1) Twenty minutes surveys were given to search for malacostracans with a body length > 1cm. Surveys were performed by swimming in a zigzag pattern at a slow, steady pace over areas 80-500m^2, with area covered confirmed post-survey using Google Earth© (2005) imagery. Species found between 0-5 min into the survey were given a "time of sighting" ranking 5, 5-10 min – rank 4, 10-15 min – rank 3, 15-20 min – rank 2, and species found outside the timed period were labeled "+ min" and given a rank of 1. Species site abundances were tallied and assigned an "abundance" ranking. Species occurring once at site were labeled 'rare' (rank 1), two to ten times 'occasional' (rank 2), and over ten times 'common' (rank 3). Each species at each site was assigned an index number, expressed as ("time of sighting" rank x "abundance" rank) / (area in m^2/100), providing an estimate of abundance for the area surveyed. Identifiable species found dead fully intact *in situ* were added to site inventories. Any identifiable exoskeletal parts found with no sign of a core body were noted to be present in Dominica, but were not included in site inventories.

2) A predetermined number of specific microhabitat fauna known to contain malacostracan symbiotes were surveyed and the area covered at the site recorded. The percentage of microhabitat hosts

containing symbiotes was determined. Fifty *D. antillarum* (long-spined urchins), fifteen *Condylactis gigantea* and *Bartholomea. annulata* (anemones), and fifteen *Xestospongia muta* (barrel sponge) were examined for the presence of malacostracans. If fewer than predetermined numbers were found, all microhabitats present were assessed and the area covered recorded. Malacostracans found apart from these four microhabitats were recorded for the site as a "+ survey" species.

At sites where both survey methods were used, timed surveys were carried out before microhabitat surveys, in order to avoid bias in choosing a timed survey area for each site. Depth of all surveys was recorded. Species identification was done *in situ*, and based on Humann and Deloach (2002). SCUBA gear was used for surveys below 5m.

Results

Richness and abundance

Twenty-two malacostracan species were observed during this study (Table 1) and were recorded across five substrate types, all occurring between 0-16m deep (Table 2). In the four groups surveyed, fourteen new species were found for the Dominican inventory, including three Brachyura species, four Diogenidae species, six Natantia species, and one Palinura species. (Table 1). The most common species found during 20 minute surveys were three Brachyura species *Percnon gibbesi*, *Stenorhynchus seticornis*, and *Mithrax verrucosus*, along with the Natantia species *Stenopus hispidus*. All occurred at three or more sites and produced an index average over the mean (Table 3). In eight microhabitat surveys below 5m, *S. seticornis (*Brachyura), *Calcinus tibicen* (Diogenidae), *Periclimenes pedersoni* and *S. hispidus* (Natantia) occurred at least seven times (Table 4). No large Brachyura or Diogenidae species (body length >8cm) were found during any surveys. Each Palinura species occurred only once, each on different surveys, with only *Panulirus argus* having multiple individuals found (Tables 3 and 4).

Distribution by depth and microhabitat

Most malacostracans occurred at a 0-5m depth range or a 5-16m depth range (Fig 1). Two common malacostracans illustrating opposite depth distribution patterns were *P. gibbesi* and *S. seticornis*. Both species were facultative regarding their microhabitat selection, i.e. not depending upon microhabitats from one phylum or one particular substrate for housing (Table 3, Fig 2b,c,d). *P. gibbesi*, a small (1-3 cm carapace length) flat-bodied crab, occurred mainly at 0-5m (Fig 1). *P. gibbesi* resided primarily under the echinoid *Diadema antillarum* (Fig 2a), which appeared in its highest numbers at 2-5m deep at survey sites. *P. gibbesi* also appeared common to occasional at 0-2m in near shore boulder fields (Table 3). The only *P. gibbesi* sightings below 5m occurred on cement buoy anchors in the middle of a sand flat 100m off shore (Site 10), with no rock or reef structures nearby (200m+). *S. seticornis*, a thin spider-like crab, mainly occurred below 5m and used multiple fauna on rock and reef substratum (Fig 2b,c,d) or metal, rubber, and cement debris lodged in sand to conceal themselves (Table 3). *Gnathophyllum americanum* was the only obligate malacostracan symbiote (requiring microhabitats of a particular phylum, with no alternative habitats observed) found solely above 5m, occurring with *D. antillarum* (Fig 2a).

The Demospongia species *Xestospongia muta* was found mainly below 5m and exhibited the highest malacostracan symbiote richness of the four major microhabitat types assessed, supporting four Diogenidae species and four Natania species (Fig 2b), yet none of these eight species were obligates of *X. muta*. Most obligate symbiotes were found at sites below 5m, and included three *Periclimenes* spp, *Thor amboinensis* and *M. verrucosus.* These species depended on anemones and one corallimorph microhabitat for housing, a trend of some *Periclimenes* spp (Barnes 1987, Humann and Deloach 2002), mainly *Condylactis gigantea* and *B. annulata* (Fig 2c,d). All *Periclimenes yucatanicus* and *M. verrucosus* were found with one host species, occurring on 40.5% and 25.7% of *C. gigantea* individuals respectively (Fig 2c,d). *P. pedersoni* covered *B. annulata* at 79.5% (Fig 2c), creating the highest rate of occupancy of one host species by one malacostracan species. *P. pedersoni* also occurred twice on *C. gigantea* and once on a corallimorph species. *T. amboinensis* was found primarily on *C. gigantea* but also upon one *Stichodactyla helianthus*, residing next to *Periclimenes rathbunae*.

Discussion

Richness and abundance

All species newly found for Dominica (except for Palinura species *Justitia longimanus*), and seventeen of the twenty-one malacostracans found overall during this study had body lengths no greater than 8 cm. The lack of richness and abundance of larger Malacostracans (body longer than 8 cm) in the groups Brachyura, Diogenidae, and Palinura is most likely due to a combination of overfishing and narrow coastal shelves providing minimal habitat space. The greatest species richness for a single group was 9 species of Natantia, possibly because the specific microhabitats these symbiotes use are easily identifiable in the field and can be readily checked for mutualisms or commensalisms. With Palinura species and the larger Diogenidae and Brachyura species seeking cover during the day anywhere along the general habitat substratum (whether in a multitude of shells, under small overhangs, or buried in sand flats), places to search within survey areas for these groups were not readily obvious. This being said, the great abundance disparity found between defined large and small malacostracans is likely due to major differences in overall abundance numbers, and indicates larger malacostracans are relatively uncommon along Dominica's west coast.

Distribution by depth and microhabitat

The fact that species mainly occurred above or below 5m can likely be attributed to Dominica's narrow and steep coastal shelf creating very different habitat types above and below 5m. Habitats above 5m usually occurred within 30-40m of the shoreline at survey sites, and were subject to tidal turbulence and high sedimentation. Many of these near shore habitats, mostly rocky shelves and outcrops, are places where *D. antillarum* anchored in high numbers and thus provided abundant habitat space for *P. gibbesi*. *P. gibbesi* also occurred above 5m in a specific type of boulder field, consisting of small boulders (1/2 to 1m diameter) at least two layers deep which fit together tight enough to provide narrow escape routes which piscivores cannot breach. It appears this species demands specific protection requirements from its microhabitats that *D. antillarum* and these boulder formations are equipped to provide. Lower *D. antillarum* numbers and fewer boulder fields observed on surveys below 5m, combined with an increased predation threat from larger and more numerous piscivores may discourage *P. gibbesi* habitation below 5m.

The other faunal microhabitats assessed directly, *C. gigantea*, *B. annulata*, and *X. muta* occurred in greater numbers below 5m along consolidated rock beds and reef structures off shore (40m+), no doubt partly to avoid a turbulent shoreline and a higher rate of sedimentation. The increase in readily identifiable microhabitats at 5-16m directly caused the increase in species richness within this depth range (Table 4, Fig 1). *Xestospongia muta* was found at all microhabitat survey sites where hard substrate existed (reef and the 2 rocky substrate types) at or below 3-4m (Table 4). As mentioned, none of *X. muta*'s eight malacostracan symbiotes were observed as obligates of the phylum Demospongia, despite having the highest symbiote richness of faunal microhabitats assessed. The hermit crabs *Calcinus tibicen* and *Dardanus venosus* occurred frequently on *X. muta* but also appeared four times above 5m on bare rock with little or no fauna present (Table 3: Sites 1, 2, 5, 7). Based on survey data, *X. muta* prevalence, and their mobile capabilities at all depths due to housing on their backs, these two Diogenidae species can be postulated to be commonly and evenly distributed along the west coast.

Another *X. muta* symbiote was *S. seticornis*, documented as a faunal microhabitat generalist (Fig 2). *S. seticornis* can be thought to have two habitat requirements based on depth and microhabitat distribution patterns observed in this study: 1) low current strength and 2) cover provided by most any protrusion directly off the substratum. Narrow shelves that do not provide much relief from current above 5m may not allow *S. seticornis'* tall (up to 3cm off the ground), thin, spider-like body a hold on substrate, generally forcing it below 5m. While limited in depth range, this species occurred across most general habitat types in conjunction with multiple faunal microhabitats and varying debris lodged in the substratum, allowing it to occur on the most surveys (13) of any species. *S. hispidus* was frequently found upside down under rocky overhangs with or without *X. muta* nearby on the overhang's topside. Overhangs need depth to occur, causing *S. hispidus* with or without *X. muta* to occur primarily under 5m (Fig 1).

Mysidium spp were found at most sites around rock and reefs below 5m (Table 4), with seemingly no pattern to their associations with certain reef structures other than there being small recesses or substrate protrusions for hiding nearby. A body-sized hole in *X. muta* provided *Alpheus* spp the cover it needed, as did the same sized holes in isolated rocky substrate or under *B. annulata* (Fig 2b,c), which is listed as its primary habitat (Humann and Deloach 2002).

C. gigantea and *B. annulata* tended to have numerous individuals on the outskirts of rock and reef structures, while few anchored themselves over flat inner reef and rock formations. The navigated course while conducting surveys below 5m may or may not have sampled portions of these outer areas. Since malacostracan site richness and abundance data may have been affected by the survey method, the percentages of microhabitats covered by each symbiote (Fig 2) may be a more accurate picture of the health/abundance of obligate Brachyura and Natantia symbiote populations than site richness or abundance data. Rock and reef substrates supported the cnidarian microhabitats equally well as anchors; therefore, substrate most likely is not an important factor when assessing cnidarian microhabitat/symbiote populations below 5m off the west coast.

Hurricane Omar displaced individual cnidarians observed before the storm at particular sites (pers obs) suggesting malacostracan symbiote numbers were affected by Omar, possibly down to 8m (Steiner pers comm). Alternatively, two *Lysmata grabhami* individuals were found in one tire in the middle of a seagrass/sand patch 6m deep both pre and post-Omar, despite all cnidarians and molluscs being displaced from the tire by the storm. *P. rathbunae* being found on only one survey is likely a function of its host, *S. helianthus*, having its population concentration around 3 west coast sites in the same immediate vicinity (Sites 2,15,16) where it does not occur in high numbers as readily at 4-8m deep as it does at 0-3m. The coastal shelf is very steep in these areas, dipping sharply around 3m so that few hard, flat surfaces exist on which *S. helianthus* can accumulate at 4-8m. The lone *S. helianthus* individual found during surveys resided 6m deep, on rocky substrate apart from boulder/large coral structures with full sun exposure, and contained both *P. rathbunae* and *T. amboinensis*. Despite being listed to occur at 3ft

(*P. rathbunae)* and 10ft (*T. amboinensis*) (Humann and Deloach 2002), the fields of *S. helianthus* blanketing the narrow 0-3m deep shelf edge at these sites have not been seen hosting either Natantia species (pers obs).

Overfishing of marine resources is a concern in Dominica (Steiner pers comm), and while there is no industry targeting larger malacostracans as exists on other Caribbean islands, subsistence fishing may combine with limited habitat space to keep abundance numbers low. The constant anthropogenic threats of human and industrial waste disposal off Dominica's west coast may make uncontaminated habitat space harder for larger coastal marine organisms to find, adding to the reduction in population numbers. Conservation efforts may be needed to address specific resource depletion before larger malacostracans become even scarcer at west coast sites.

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Table 1. Species inventory of selected malacostracan groups: 2008 Fall Survey

Malacostracan Groups	Species
Section Brachyura	*Mithrax verrucosus**
	Percnon gibbesi
	*Podochela sp**
	*Portunus sp**
	Stenorhynchus seticornis
Family Diogenidae	*Calcinus tibicen**
	*Dardanus venosus**
	*Paguristes cadenati**
	*Paguristes punticeps**
Suborder Natania	*Alpheus spp. (red snapping)* *
	*Gnathophyllum americanum**
	*Lysmata grabhami**
	Mysidium spp
	Periclimenes pedersoni
	*Periclimenes rathbunae**
	*Periclimenes yucatanicus**
	Stenopus hispidus
	*Thor amboinensis**
Suborder Palinura	*Justitia longimanus**
	Panulirus argus
	Panulirus guttatus

***** denotes species newly found in Dominica

Table 2a. Survey sites for 2008 malacostracan distribution study
The five substrates at survey sites were as follows: BL (boulder field), RF (reef), RO (rocky outcrop), R (rock), DE (debris in seagrass/sand).
The microhabitats assessed containing malacostracan symbiotes were
(**D**) *Diadema antillarum*, (**X**) *Xestospongia muta*, (**C**) *Condylactis gigantea*,
(**B**) *B. annulata*., (**S**) *Stichodactyla helianthus*, (**CL**) Corallimorph spp.

20 Minute Survey Sites	Area (m^2)	Depth(m)	Substrate
1 - Scotts Head (east rock wall)	175	0-5	RO
2 - Lauro Shallows	80	2-5	R
4 - Cabrits Pier	210	8-12	DE
5 - Espagnole Bay (shallow)	180	0-2	BL
6 - Espagnole Bay (deep)	170	3-5	R
7 - Fond Cole	170	0-1	R
8a - Champagne	110	3-5	R
10 - ECD (debris/seagrass)	500	5-9	DE
12 - Anse Mulatre #2	160	1-3	BL
13 - Anse Mulatre #3	130	0-2	RO
25 - Anse à Liane #2	150	1-2	BL
26 - Anse à Liane #3	120	3-4	R

Table 2b.

Microhabitat Survey Sites	Area (m^2)	Depth(m)	Substrate	Microhabitats Surveyed
8b - Champagne	60	1-3	R	D
11 - Anse Mulatre #1	150	1-2	RO	D
14 - Rodney's Rock	100	1-4	RO	X/D
15 - Lauro Reef	180	8-9	RF	X/C/B
16 - Easy Street	250	6-9	R	X/C/B/S
20 - Barry's Dream	150	9-12	R	X/C/CL
21 - Maggie's Reef	180	9-10	RF	X/C/B
28 - Colihaut South (Quarry)	100	3-5	R	X
29 - Nose Reef	110	14-16	RF	X/C/B
30 - Rena's Hole Reef	200	9-11	RF	X/C/B
34 - Floral Gardens	300	9-11	RF/R	X/C/B
35 - Dou Dou Reef #2	200	6-9	RF/R	X/C/B

Table 3 Twenty minute surveys. Species abundance rankings for each site are given: Common ●●● Occasional ●● Rare ● + min ○
The species' general abundance estimate is shown as the species' Index Average. The Mean Index Number provides an abundance gauge, relative to other malacostracan species surveyed. Indices were not calculated for species found only in "+min".
Malacostracan species are organized by group, separated by hyphen line: (top to bottom) Brachyura, Diogenidae, Natantia, Palinura

Site Survey Depth	1 0-5m	2 2-5m	4 8-12m	5 0-2m	6 3-5m	7 0-1m	8a 3-5m	10 5-9m	12 1-3m	13 0-2m	25 1-2m	26 3-4m	**Index Average**
Percnon gibbesi		●●●		●●	●●	●●●		○	●●●		●●●	●●	7.13
Stenorhynchus seticornis			●●●	●●	●●			●●				○	4.87
Mithrax verrucosus	●●●	●●		○	●●				○			○	4.62
Calcinus tibicen	○	●		○		●							1.75
Dardanus venosus	○							○					
Paguristes punticeps	○	○											
Mysidium spp.												●●	8.33
Stenopus hispidus			●●				●●	●●					4.65
Periclimenes pedersoni				●									2.78
Periclimenes yucatanicus					●								1.76
Lysmata grabhami								●●					1.60
Thor amboinensis												○	
Panulirus argus												●●	8.33
Justitia longimanus	●												2.86

Mean Index Number 4.43

Table 4 Microhabitat surveys. Malacostracan abundance totals are shown for all 12 microhabitat surveys. A closed circle (●) indicated species found apart from microhabitats. Faunal microhabitats and their abundance numbers at each site are listed. Microhabitat key: (**D**) *Diadema antillarum*, (**X**) *Xestospongia muta*, (**C**) *Condylactis gigantea*, (**B**) *B. annulata*., (**S**) *Stichodactyla helianthus*, (**CL**) Corallimorph spp. Malacostracan species are organized by group, separated by hyphen line: (top to bottom) Brachyura, Diogenidae, Natantia, Palinura

Site	8b	11	14	15	16	20	21	28	29	30	34	35	
Survey Depth	1-3m	1-2m	1-4m	8-9m	6-9m	9-12m	9-10m	3-5m	14-16m	9-11m	9-11m	6-8m	
Microhabitat #'s **surveyed per site**	**D**50	**D**50	**X**15 **D**50	**X**15 **C**15 **B**5	**X**15 **C**8 **B**11 **S**1	**X**15 **C**3 **CL**1	**X**10 **C**9 **B**7	**X**15	**X**15 **C**2 **B**2	**X**15 **C**15 **B**9	**X**15 **C**8 **B**6	**X**15 **C**14 **B**4	**Per site average**
Percnon gibbesi	15	28	24										22.3
Stenorhynchus seticornis				3	12	2	9		7	3	2	13	6.4
Mithrax verrucosus				5	4		4			2	1	3	3.2
Calcinus tibicen				2		13		5	11	3	9	12	7.9
Dardanus venosus					1	4		5	11	2	4		4.5
Paguristes cadenati			3										3.0
Paguristes punticeps									1				1.0
Periclimenes yucatanicus				5	6	2					2	15	6.0
Periclimenes pedersoni				13	12	1	2		2	7	2	1	5.0
Thor amboinensis (1 unit = 11.3 individuals)					4		3		2	6	1	5	3.5
Periclimenes rathbunae					2								2.0
Stenopus hispidus				1		1	2	1	2	1	1	6	1.9
Alpheus spp. (red snapping)				1	●		1						1.0
Mysidium spp.				●	●	●	●	1		●	●		1.0
Gnathophyllum americanum			1										1.0
Lysmata grabhami											●		
Panulirus guttatus												●	

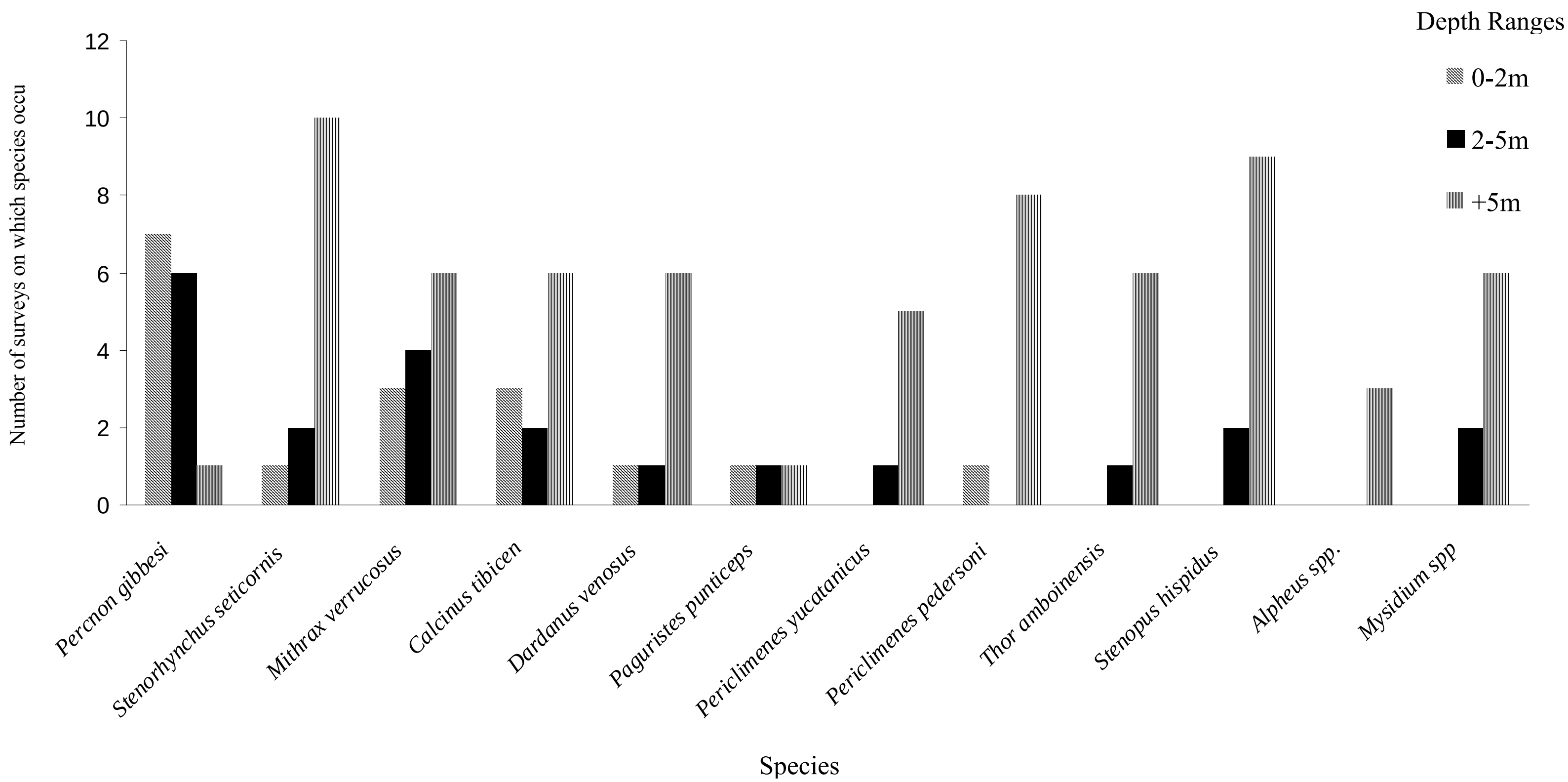

Figure 1 Depth distribution patterns for malacostracans surveyed. Illustrated is the total number of surveys on which species occurred across a depth range of 0-16m. All malacostracan species occurring on three or more surveys are listed.

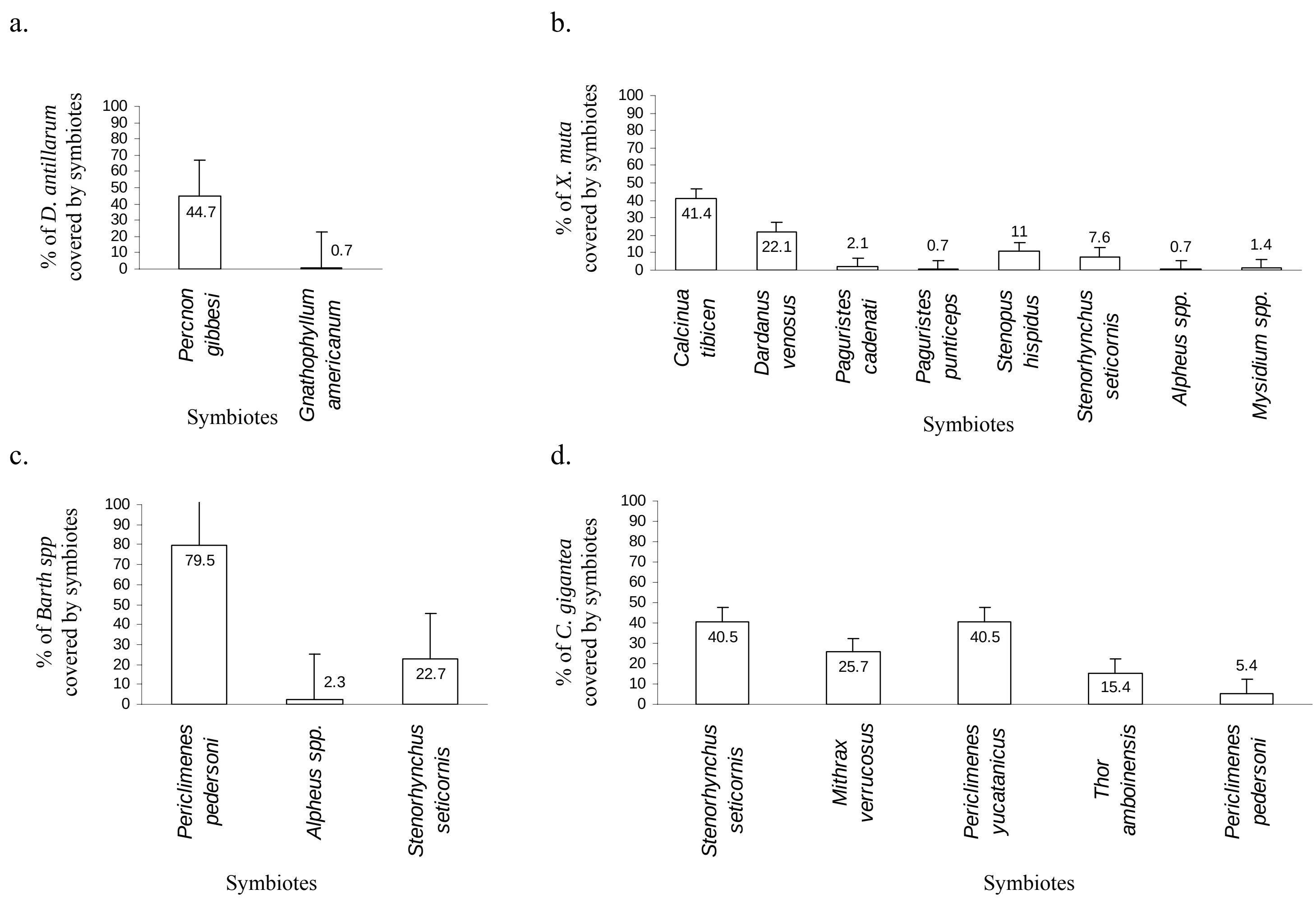

Figure 2 The four major faunal microhabitats, a. *Diadema antillarum,* b. *Xestospongia muta,* c. *Condylactis gigantea,* and d. *B. annulata* assessed for malacostracan symbiotes, depicting the percentage of each microhabitat containing each symbiote species (one microhabitat individual to one symbiote) ± S.E.