NATURE IN SINGAPORE 2012 **5**: 363–368
Date of Publication: 20 December 2012

THE CRAB FAUNA OF THREE SEAGRASS MEADOWS IN SINGAPORE: A PILOT STUDY

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ABSTRACT. — Three seagrass meadows in Singapore waters were surveyed for associated crab fauna using high-sided 145 cm^2 circular quadrats. Diversity of decapod crustacean genera was compared among sites and related to the seagrass species composition of the meadows. In Aug.2009, 50 quadrats were laid at Changi Beach, 60 at Chek Jawa, and 100 at Pulau Semakau. In total, 74 specimens belonging to 13 decapod genera were collected. Results suggest that small anomurans are most abundant in seagrass meadows in Singapore, and that there may be a relationship between seagrass species and the size of crabs present.

KEY WORDS. — decapod, crab, crustaceans, seagrass, Singapore

INTRODUCTION

Seagrasses are angiosperms that inhabit shallow sheltered waters of coastal areas, in both marine and estuarine environments. Often found between coral reefs and mangroves, they form widespread meadows, not unlike their terrestrial namesakes (Green & Short, 2003). Even though present in all continents except for Antarctica, Southeast Asia has some of the most diverse seagrass flora in the world, with around 20 species found in the region (Fortes, 1988). However, human-induced stress contributed largely by coastal development, seabed mining, and pollution has caused many of these areas to disappear (Orth et al., 2006; Todd et al., 2010). The fragmentation and loss of seagrass beds will likely lead to a corresponding decrease in faunal biodiversity, due to the fact that they act as a food source, habitat, and nursery for many other groups of marine organisms, including fish, mollusks, and crustaceans (Green & Short, 2003; Duffy, 2006; Vonk et al., 2008).

There are 12 seagrass species in Singapore, but large meadows are only present near some of the offshore islands and patch reefs (Yaakub & Lim, 2010). There is little documentation on the historical extent of seagrass meadows in Singapore, but records from the Herbarium, Singapore Botanic Gardens (SING) indicate that they were previously widely distributed along the Singapore coastline, with a particularly dense stretch from Tanah Merah to Changi where the majority of the local reference specimens came from (Yaakub, unpublished data). This area, like many others, has since undergone extensive land reclamation, but small tracts of seagrass still persist off the mainland at Changi Beach, Labrador Beach, and Pasir Ris.

Crustaceans constitute a major group of seagrass-inhabiting organisms and are thought to play an important role in seagrass food webs, including regulating macrobenthos through predation (Nelson, 1981). Seagrass habitat is also recognised as an important nursery ground for post-larval and early juvenile crustaceans (Perkins-Visser et al., 1996; Hemminga & Duarte, 2000; Adams et al., 2006; Verweij et al., 2008). Decapod crustaceans are a relatively well-researched group in Singapore but the diversity and abundance of decapods in seagrass meadows has not been quantified previously. This pilot study aims to document the diversity of decapod crustaceans in three seagrass meadows in Singapore and to explore possible relationships between crab size and seagrass growth forms.

MATERIAL AND METHODS

Survey sites. — Three seagrass meadows were chosen for this study based on their species compositions, with the beds at Changi Beach Park (on Singapore Island) and Chek Jawa (Pulau [= Island] Ubin, along Singapore's northern coast) characterised by small-leaved pioneering species such as *Halophila ovalis* and *Halodule uninervis*, while the meadow at

Pulau Semakau (one of many southern islands off Singapore Island) characterised by a canopy-forming climax species suite composing of *Enhalus acoroides*, *Cymodocea serrulata*, and *Thalassia hemprichii*.

Changi Beach Park (1°22′34.30″N, 104°00′20.82″E) is a public-access beach on the northeastern shore of Singapore Island (Fig. 1). It is one of the oldest coastal parks in the country. The seagrass bed off Changi Beach Park is the smallest of the three sampling sites, measuring approximately 150 m long and 40 m wide, and is predominantly comprised of *Halophila ovalis*, interspersed with mixed-stands of *Halophila spinulosa* and *Halophila uninervis*. The leaves of this species are small, typically measuring less than 5 cm long (Waycott et al., 2004).

Tanjong Chek Jawa (1°24′40.24″N, 103°59′31.83″E) is located on Pulau Ubin, an island located to the northeast of Singapore (Fig. 1). Chek Jawa is an intertidal flat that consists of several different ecosystems, including a seagrass lagoon, mangrove forest, and a sand bar (Tan & Yeo, 2003). Chek Jawa was designated as a "wetlands area" in 2007 and is managed by the National Parks Board. Boating activity is prohibited in the area and human access is confined to a boardwalk with exceptions made for regular monitoring and research. There are eight species of seagrass present at this site, two of which are dominant: *Halophila ovalis* and *Halophila uninervis* (see Tan & Yeo, 2003). The main seagrass meadow at Chek Jawa covers an area of approximately 3.5 ha (Yaakub & Lim, 2010) but, owing to tide restrictions, we limited the study site to a 200 m by 60 m area.

Pulau Semakau (1°12′27.07″N, 103°45′26.60″E) is an offshore landfill located to the south of Singapore Island (Fig. 1). The landfill was created by building a bund to join a smaller island, Pulau Sakeng, to the larger island, Pulau Semakau. The seagrass meadows occur on the western shore of Pulau Semakau, and therefore were spared from the construction. The meadow at Pulau Semakau is the largest of the three sites at 11.8 ha and is a mixed-species bed dominated by *Enhalus acoroides*, *Cymodocea serrulata*, and *Thalassia hemprichii*, all of which are relatively large species with canopy heights from 15–150 cm (Waycott et al., 2004). Owing to the sheer size of the seagrass bed at Pulau Semakau, we limited the sampling site to an area of approximately 300 m by 150 m in the middle section of the main meadow.

Sampling strategy. — Surveys at all the sites were conducted over one week during low tide (<0.5 m) in Aug.2009. Transects (40 m) were laid randomly but in parallel to the shoreline. Only areas with at least 60% cover of seagrass (visual estimation) were surveyed. Five transects were laid in Changi, the smallest site out of the three sites; six transects were laid in Chek Jawa; and 10 were laid in Pulau Semakau, which had the largest seagrass meadow. Ten

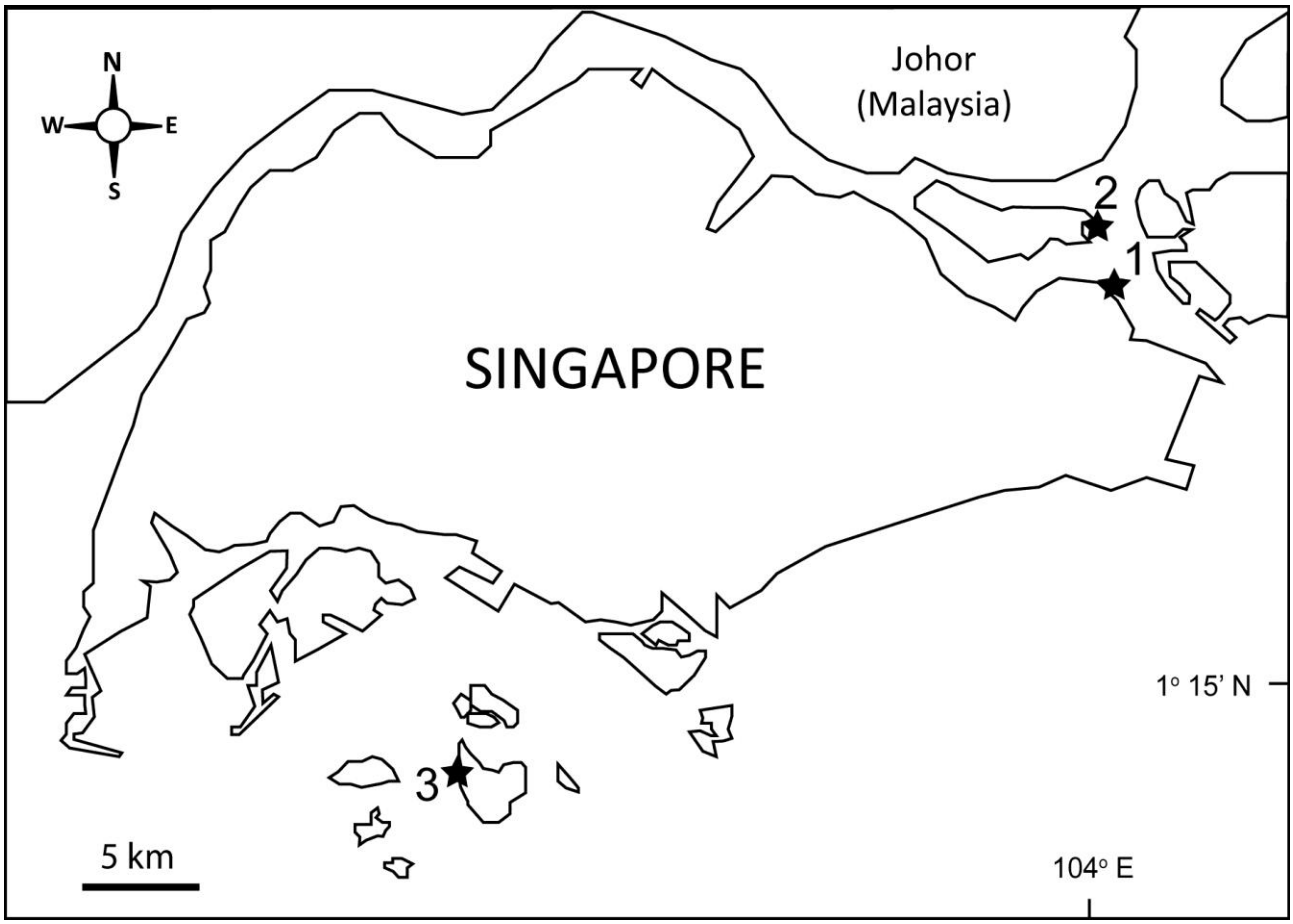

Fig. 1. The locations of the three survey sites: 1, Changi Beach Park; 2, Chek Jawa, Pulau [= Island] Ubin; and 3, Pulau Semakau.

circular plastic quadrats (43 cm in diameter and 20 cm tall) were laid alternately left and right of each transect at random distances generated from a random number table. Each quadrat was pushed approximately 1 cm into the sediment to encircle any surface-dwelling and shallow-burrowing crabs. Small dip nets with mouth sizes measuring 15 × 10 cm and a mesh size of 2 mm were then used to drag along the sediment (five times per quadrat) to capture any crabs present. All crabs caught were placed into containers with seawater and brought back for identification.

Identification. — In the laboratory, crabs were separated and preserved in 95% denatured ethanol. Specimens were first categorised based on the following morpho-species: spider crabs, porcelain crabs, elbow crabs, fiddler crabs, hermit crabs, moon crabs, and rock crabs—the last two morpho-species being highly mobile, pelagic, and larger (>3.5cm) than the rest. The specimens were then identified to lower taxonomic levels. Eleven different genera were identified from the seven morpho-species categories. Crab size (widest width of the carapace) was measured using a pair of vernier calipers (± 0.05 cm) before they were assigned to one of six size classes: 0.01–0.20 cm; 0.21–0.40 cm; 0.41–0.60 cm; 0.61–0.80 cm; 0.81–1.0 cm; and >1.00 cm.

Data analysis. — The species diversity of crabs at each site was calculated using the Simpson's Reciprocal Index (James & Shugart, 1970). When a genus was common to more than one site, and if there were sufficient numbers, a Student's t-test was used to test for differences in the mean size of the crabs of that genus between sites. A one-way analysis of variance (ANOVA) was used to compare crab density (all taxa combined) among the three sites.

RESULTS

A total of 73 crabs from 13 genera (in decreasing order of abundance: *Dardanus*, *Petrolithes*, *Clibanarius*, *Chlorodiella*, *Hyastenus*, *Uca*, *Calcinus*, *Pilodius*, *Ashtoret*, *Parthenope*, *Nanosesarma*, *Ozius*, and *Thalamita*) were collected from the three sites (Fig. 2). One specimen of the hermit crab morpho-species could not be positively identified and was therefore discounted from subsequent analyses that involved the genera of the crabs. Seven out of 13 of the decapod genera found were Brachyura (true crabs).

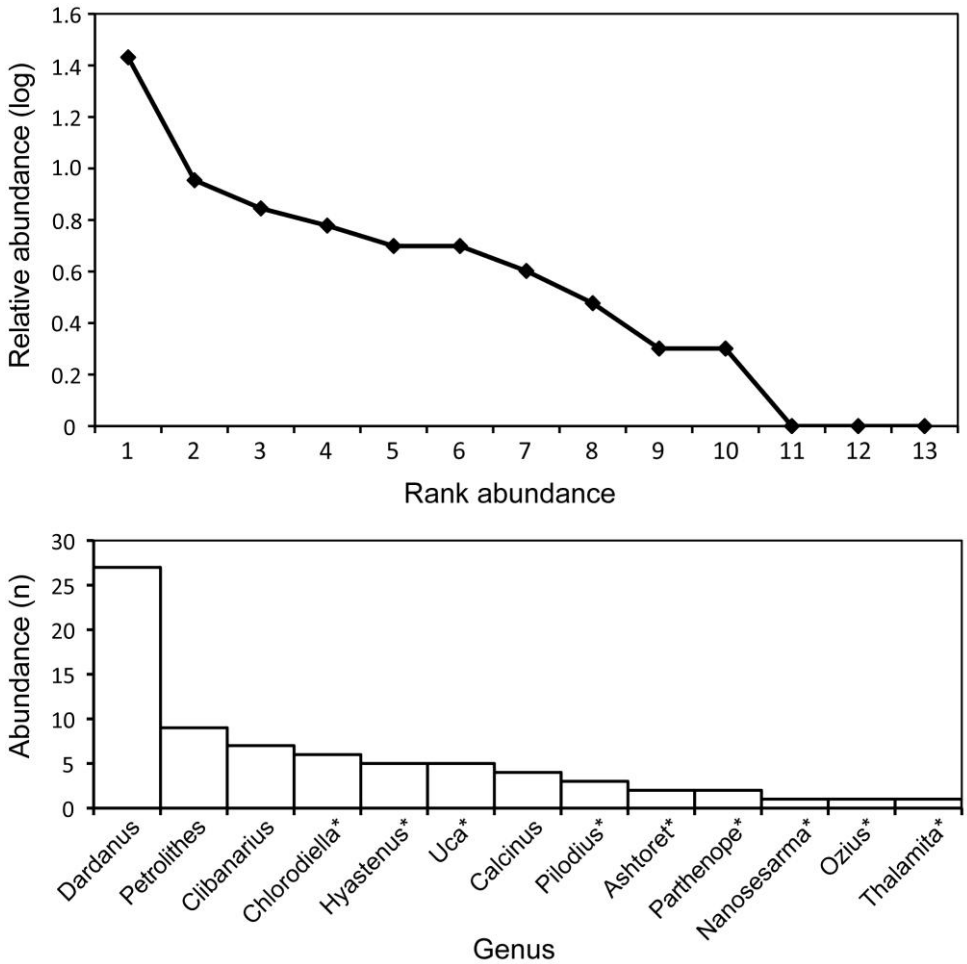

Fig. 2. Rank-abundance curve for all individuals from 13 decapod genera collected across the three survey sites, with genera considered true Brachyurans marked with an *.

Even though Chek Jawa had the highest number of genera and greatest abundance of crabs (eight genera, 40 individuals), its overall diversity was comparable to that of Changi Beach (11 individuals, six genera; Fig. 3). Pulau Semakau was the least diverse of the three sites with 22 individuals from four genera. Only one genus, *Hyastenus*, was found at all three sites, while *Dardanus*, *Clibanarius*, and *Chlorodiella* were found at two of the three sites.

The majority of individuals collected were small (<0.4 cm) (Fig. 4). Most of these small crabs also belonged to *Dardanus* sp. (a genus of hermit crab). The *Dardanus* sp. at Pulau Semkau were significantly larger than those found at Chek Jawa (Student's t-test, p = 0.017).

There were significant differences in the mean densities of crabs between the three sites (ANOVA, F= 2.46, p = 0.032), with the highest density of crabs found at Chek Jawa, followed by Changi Beach, and Pulau Semakau (Fig. 5).

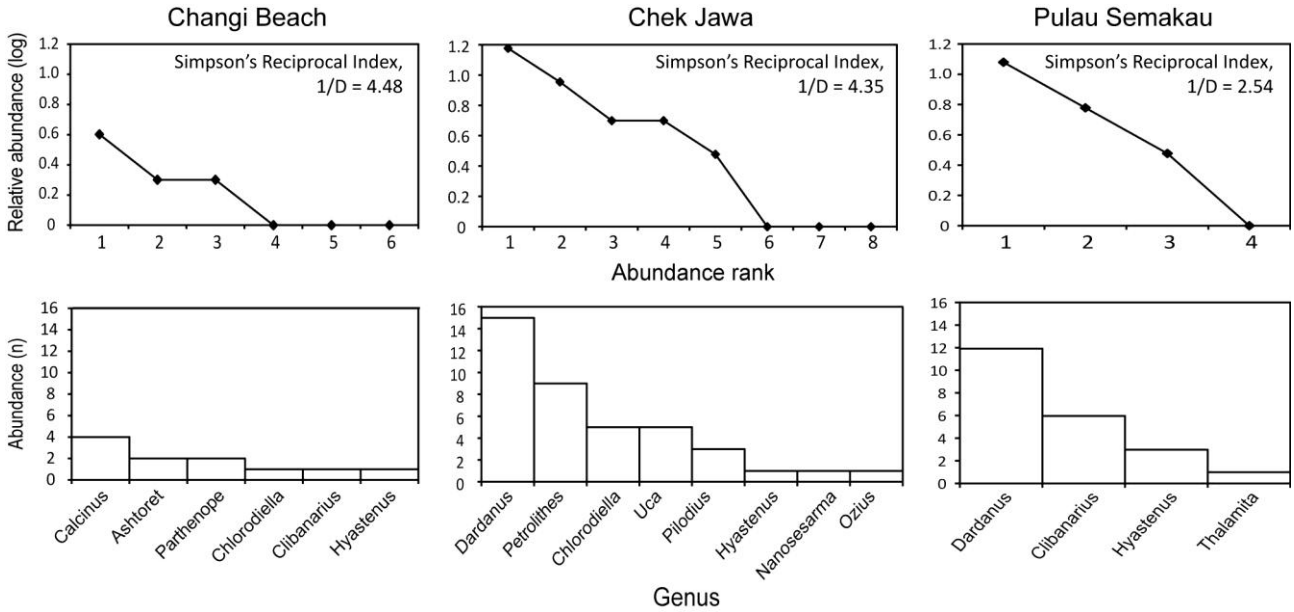

Fig. 3. Individual rank abundance curves for each individual site and its corresponding Simpson's Reciprocal Index score.

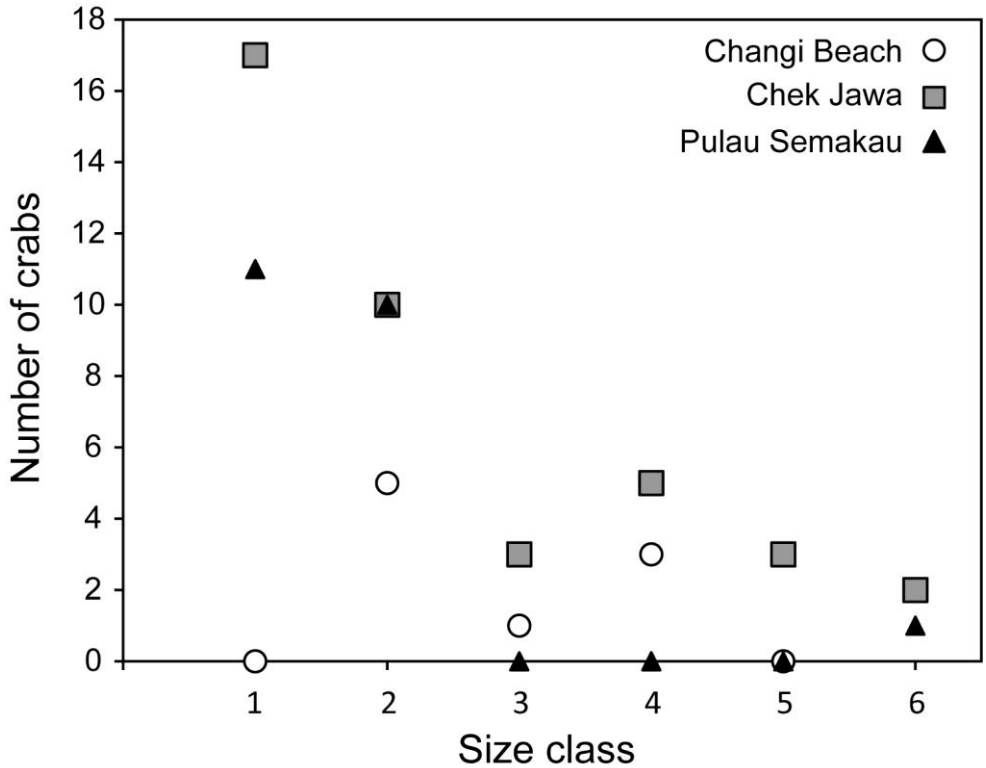

Fig. 4. A size class and abundance distribution of carapace length for the three survey sites, with Size Class 1 containing smallest crabs and Size Class 6 containing the largest.

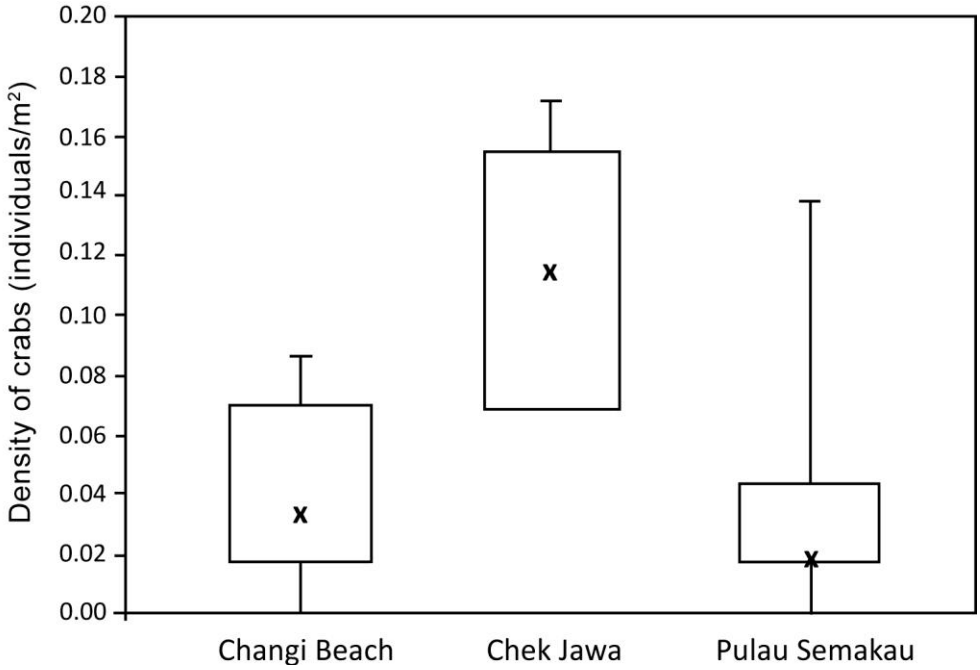

Fig. 5. The mean densities of crabs sampled at the three survey sites.

DISCUSSION

There have been previous surveys of coastal areas around Singapore that incorporate some seagrass work, including the 'Chek Jawa Transect' (2004), 'Pulau Semakau Transect' (2005), the ongoing 'Mega Marine Survey', and 'Project Semakau'. These have all documented the diversity of flora and fauna in local coastal and marine habitats, but the current study is the first to focus solely on crab diversity and abundance in seagrass beds. Our results indicate that small anomurans (commonly grouped as hermit crabs) belonging to the genera *Dardanus* and *Petrolithes* dominate the specimens collected. These genera are generally known to be scavengers, detritivores or algal feeders (Ruppert et al., 2004). Seagrass beds trap sediment and detritus, and epiphytic algae grows on seagrass leaves (Hogarth, 2007), providing abundant food for these taxa.

Chek Jawa had the highest abundance and diversity of the three sites surveyed, whereas Pulau Semakau had the lowest. Differences in macrofauna abundance and diversity in seagrass beds have previously been attributed to seagrass shoot density (Atrill et al., 2000; Boström et al., 2006a). The meadow at Pulau Semakau is dominated by *Enhalus acoroides*, a large seagrass that grows to lengths of 150 cm. Larger seagrass species tend to adopt a clonal growth strategy that forms less compact meadows with lower shoot densities (Marbà & Duarte, 1998). In contrast, Chek Jawa is predominantly composed of *Halophila ovalis*, a small seagrass that grows in denser stands. This denser, and possibly more complex, habitat at Chek Jawa may provide additional niches and hence support a greater diversity. Alternatively, the seagrass meadow at Chek Jawa may be benefitting from being closely associated with a variety of nearby and extensive intertidal and shallow subtidal ecosystems. The *Dardanus* species crabs at Pulau Semakau were significantly larger than those found at Chek Jawa and this may also be attributed to the observed differences in shoot density. This potential relationship between seagrass size and crab size warrants further study.

It is possible that the combination of sampling method and water level at Pulau Semakau contributed to low number of specimens collected there. The meadow at Pulau Semakau grows in a shallow trough that is inundated even at a low spring tide, hindering sampling. In contrast, the meadows at Changi Beach and Chek Jawa are fully exposed at low tides, making them easier to position quadrats and catch crabs. Furthermore, to create a comprehensive checklist of decapod species for seagrass beds in Singapore, a variety of methods based on possible modes of locomotion and behaviours (e.g., swimming and crawling, burrowing, and burying) should be employed. Finally, to account for the possible diurnal and seasonal differences in crab abundance and activity (Bauer, 1985), future studies can include a wider range of sampling periods.

The crab diversity recorded here is not as high as that for local mangrove forests (Tan & Ng, 1994), but mangrove crabs in Singapore have been studied in much greater detail. The results presented in this pilot investigation revealed 13 decapod genera from just three seagrass meadows. This suggests that they constitute an important component of seagrass beds in Singapore, as they do in other parts of the world (see Boström et al., 2006b), and a more intensive and widespread effort should be made to document their diversity in full.

ACKNOWLEDGEMENTS

We are grateful to the staff and students at the Marine Biology Laboratory, National University of Singapore, for their support in the field and in the laboratory. The research presented in this work was conducted as part of the Singapore-Delft Water Alliance's Marine & Coastal Research Programme (Theme 2): "Dredging and infrastructure development near critical marine ecosystems" (R-264-001-001-272).

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