Gastropod diversity at Pulau Punyit and the nearby shoreline – a reflection of Brunei's vulnerable rocky intertidal communities

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Abstract

Pulau Punyit (PPUN), a small islet on the South China Sea coastline of Brunei Darussalam, represents a significant portion of the country's natural rocky-shore ecosystem. We carried out a rapid survey of the intertidal gastropod species richness at PPUN, and compared this with species richness at other nearby natural and artificial rocky shores [Tungku Punyit (TPUN), Pantai Jerudong (PJER), Jerudong Park Medical Centre (JPMC) and Pantai Tungku (TUNK)]. A total of thirty two (32) species were collected from all of the shores. Species richness was greatest at the two natural shores studied (numbering 21 and 22 species at PPUN and TPUN, respectively), while the artificial shores were relatively depauperate. The natural shores however differed in species composition, abundance and body size of gastropods. These attributes varied with shore height, and appeared to relate to height-specific differences in abiotic stresses at the shores - at PPUN the high-shore is more exposed to the wind and sun, whereas at TPUN the mid-shore experiences greater sedimentation and mainland acidic seepage. Faunistic differences between the artificial and natural shores (Bray-Curtis similarity analysis) seemingly associate more closely with degree of habitat availability and abiotic stress than with shore proximity. We conclude that the country's rocky intertidal biodiversity, as reflected by the gastropod diversity, is mainly constituted by the natural rocky shore system. Because this is spatially constrained and vulnerable to locality-specific environmental stresses, this diversity is threatened and deserving of greater protection status.

Index Terms: gastropods, intertidal zone, marine diversity, rocky shores, species richness, tropical

1. Introduction

Intertidal ecosystems generally support significant biodiversity and provide several key ecosystem functions and services. While the shores of Brunei Darussalam comprise extensive intertidal soft benthic systems (sandy beaches, mudflats and mangroves), the country's natural hard intertidal rocky-shores are highly restricted in surface area (estimated to be less than 1 ha during spring low tide). The natural rocky intertidal ecosystem along the South China Sea coastline is largely limited to two small offshore islets, Pulau Punyit (***Figure 1A***) and Pelong Rocks, and their associated headlands at Tungku Punyit and Tanjung Batu, respectively. However, during the last decade, Tanjung Batu (near Muara) has experienced net sedimentation and has largely reverted to a sandy beach. More recently, this headland has been developed as a plan to limit erosion and establish a recreational facility. Public access to Tungku Punyit, which fringes the Empire Hotel and Country Club, is however restricted. Although artificial rocky promontories and bays have been constructed over other large tracts of the sandy beach coastline in the Brunei-Maura region (***Figure 1B***), these rocky systems are limited in habitat diversity (with the absence of platforms, intertidal pools, etc.) and apparently support depauperate intertidal biotas (DJM, personal observation).

(***A***)

(***B***)

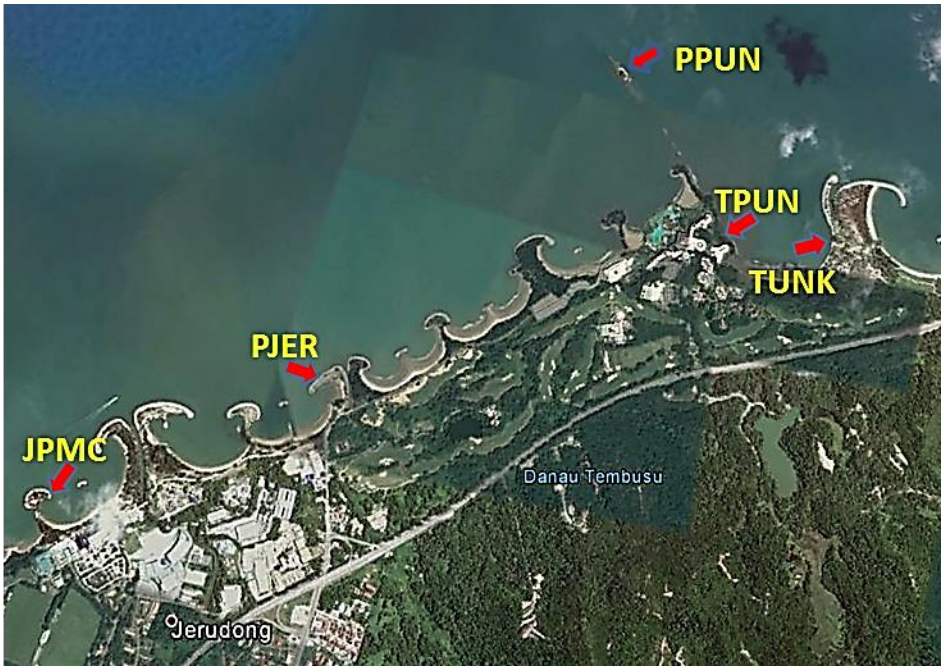

Figure 1. (***A***) Pulau Punyit viewed from a north-west aspect showing a steeply sloping rocky intertidal platform in the foreground. (***B***) Map indicating localities used in the gastropod faunistic survey. Pulau Punyit (PPUN), Tungku Punyit (TPUN), Pantai Tungku (TUNK), Pantai Jerudong (PJER) and Jerudong Park Medical Centre (JPMC)

Agbayani et al.[1] recognised the 'near-pristine' nature of Pulau Punyit (PPUN) and recommended protection status. Their report was followed by a survey of the islet's flora and fauna, which documented the occurrence and abundance of intertidal species, as well as the terrestrial species above the supralittoral zone.[2] Our knowledge of the country's gastropod fauna and its ecological significance has improved recently from studies using Brunei gastropods as a model system to understand physiological adaptation and ectothermic vulnerability to climate change.[3-6] This work has revealed inconsistencies in the gastropod species recorded at PPUN[2] and those from the nearby Tungku Punyit[7], prompting a rapid survey at PPUN. Here we report the findings of this survey. We further compare the PPUN gastropod assemblage with assemblages at Tungku Punyit (TPUN) and three nearby artificial rocky promontories at Pantai Jerudong (PJER), Jerudong Park Medical Centre (JPMC), and the far-south-west rocky headland of Pantai Tungku (TUNK)[7] (see ***Figure 1***).

2. Approach

The survey at PPUN (4.975N, 114.849E) was carried out during spring low tide (0.1m chart datum, CD; 7am to 9am) on 15 December 2016. Two biologists scanned and collected specimens of gastropods over a 2 h period (see ***Figure 1***). Observations and ad hoc collections of gastropods at other nearby localities (TPUN, 4.968N 114.855E; PJER, 4.958N 114.839E; JPMC, 4.951N 114.820E; TUNK 4.969N 114.859E; ***Figure 1***) were made over several preceding years.[3,4,6,7] Specimens were returned to the laboratory and were fixed and preserved in 70% ethanol. Reference specimens are housed in the UBD Museum (UBDM). Species were identified using several sources including Dharma (2005),[8] and species lists were compiled in MS-Excel. On the assumption that our records are representative of the taxa at each site, we undertook comparative diversity analyses. Diversity indices and a Bray-Curtis cluster analysis, to assess relationships among the assemblages, were computed using Primer, ver. 6.1.15. Species collected at PPUN, but currently not known at the other sites, or other species collected within the study area that are missing from the current existing photographic record,[7] were photographed using a Canon EOS digital camera (see ***Figures 4*** and ***5***).

3. Results and Discussion

A total of thirty two (32) rocky intertidal gastropod species were recorded during this study. Twenty one (21) species occurred at Pulau Punyit (PPUN), seven of which were not found elsewhere (see ***Table 1***). Species richness and diversity indicies of PPUN and the nearby natural shore at TPUN were comparable, though assemblages (species composition) differed between these localities for different shore levels (see ***Table 1***). PPUN showed a greater species richness in the mid to low shore, with *Cypraea arabica*, *Conus coronatus* and Columbellidae (5 spp.) recorded only there, whereas TPUN exhibited a more diverse high shore assemblage, with more Littorinidae and Neritidae species. These assemblage differences are likely influenced by multiple environmental factors, including more extensive low-shore rocky platforms and habitat availability at PPUN, and acidic water drainage and greater sedimentation loads at TPUN. Deposition of suspended sediment, originating from the Baram River (Miri) during the south west monsoon (more severe) and from the Brunei Bay during the north east monsoon season (less severe) potentially influences the assemblage structure at TPUN by smothering of the rock surfaces and constraining algal regrowth. The most susceptible species to sedimentation appeared to be *Monodonta* sp., *Batillaria* sp. and *Nerita albicilla* and *N. undata*, whereas *N. chamaeleon* and the higher-shore *N. polita* seemingly avoid or better tolerate the effects of sedimentation. The more rapidly circulating water current system and shoreline topography at PPUN are probably reasons for reduced sedimentation there. However, the high-shore habitat at PPUN is more exposed to solar radiation and wind than that at TPUN, where the littorinid assemblage is enhanced by coastal trees overhanging the upper shore.

Although quantitative data are unavailable, clear numerically-dominant genera at both PPUN and TPUN were *Planaxis* and *Nerita*, with species abundances varying obviously between these localities. Whereas *N. undata* is abundant at PPUN (see also Booth et al. 1997), it is currently rare at TPUN, with the population presumably recovering from sedimentation effects. High abundance of *Trochus cariniferus* in the low to subtidal zone at TPUN probably relates to preferred habitat there, including habitat created by a closely-associated grazing sea urchin. Snail body sizes varied conspicuously between the localities, such that most species at PPUN were larger (see ***Figure 2***). This suggests greater organismal fitness, apparently due to more optimal environmental water and food availability at PPUN; *N. albicilla* and *N. undata* at PPUN reached double the shell length of individuals occurring at TPUN, and the shell length of *N. chameleon* at TPUN was on average 75% that of snails at PPUN (see ***Figure 2***). An exception was observed in the high-shore where only minute individuals of *Echinolittorina malaccana* were collected at PPUN, reflecting

greater solar and wind exposure stress in this shore zone.

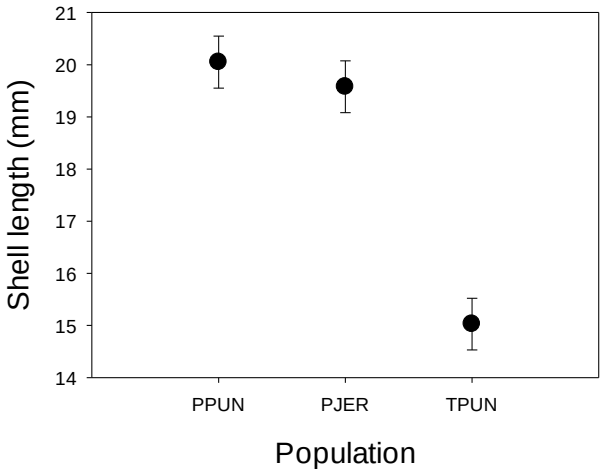

Figure 2. Mean (±95% CI) shell length of 30 randomly collected *Nerita chamaeleon* snails from each of PPUN, PJER and TPUN (see ***Figure 1*** for locality abbreviations).

When comparing natural and artificial rocky shores, the data confirm an impoverished diversity associated with the artificial shores (see ***Table 2***). Nonetheless, some species found on the artificial shores were not found, or were vastly less abundant, on the natural shores. Among the artificial sites, the diversity at PJER was greater than at the other shores; the outcrop at PJER gave rise to additional habitat, a sheltered (from wave action) habitat in a small bay. Acmeid limpets (*Notoacmea* sp.) were abundant in this sheltered bay, though absent from exposed and natural shorelines. Additionally, the muricids, *Rheshia bitubercularis*, and especially *Semiricinula tissoti* were common on the artificial piers but absent from PPUN, suggesting that they are out-competed at PPUN by their larger relative, *Mancinella echinulata*.

Relationships among the assemblages suggested a stronger influence by available habitat at a locality rather than by the locality's proximity to a more diverse natural rocky shore (see ***Figure 3***). The assemblage occurring at the artificial Pantai Tungku (TUNK), which was closest to the natural rocky ridge (PPUN and TPUN), was < 40% similar to the natural shores, whereas that at the more distant PJER showed 55% similarity (see ***Figure 3***). TUNK is clearly exposed to greater wave action, wind, sun and falls steeply to the sandy bottom with little extension of the lower shore zone. Furthermore, the PJER assemblage more closely associates with the natural rocky shore than with the other artificial shore at JPMC, which is around 60% similar to TUNK.

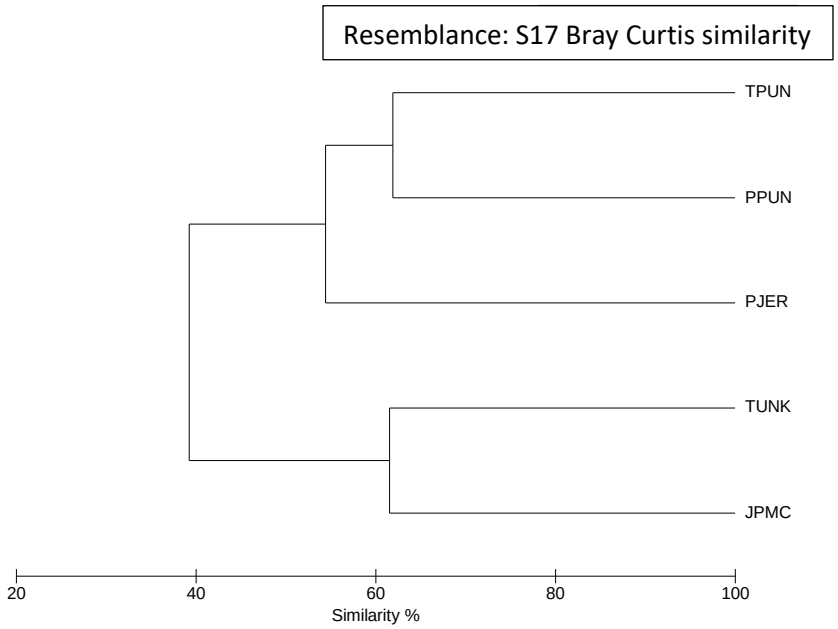

Figure 3. Bray Curtis similarity analysis showing faunistic associations across localities (see ***Figure 1*** for locality abbreviations).

4. Conclusion

Here we present the first dedicated (though preliminary) survey of the rocky-shore gastropods along the South China Sea coastline of Brunei Darussalam (excluding Brunei Bay), as a proxy for the country's intertidal hard-substratum, open-shore biodiversity. Essentially, this fauna - which typically dominates taxonomically and functionally in rocky intertidal systems - is depauperate and variable among natural and artificial shores. It appears fully constituted in the natural systems - in other words artificial shores only slightly enhance the diversity through the creation of more and novel habitat. Given the overall spatial constraint of the natural rocky shores in the region, there is a need for in-depth surveying and monitoring of key benthic taxa (algae, polychaetes, crustaceans, molluscs and echinoderms), as well as the implementation of a management and conservation plan.

Figure 4. Snail species collected at PPUN and not found at the other localities (A-G), as well as new photographic records of rocky shore littorinids from TPUN (H-J). A,Columbellidae sp. 1 (12); B, *Euplica scripta* (14); C, *Pictocolumbella ocellata* (15); D, Columbellidae sp. 2 (17); E, *Mancinella echinulate* (28); F,*Conus coronatus* (28); G, *Cypraea arabica* (39); H, *Echinolittorina melanacme* (7); I, *Littoraria sp*.(12); J, *Littoraria carinifera* (13). Number in parenthesis indicates shell length (mm).

Table 1. List of gastropod species recorded at Pulau Punyit and nearby natural (nat) and artificial (art) rocky shores (1=present, 0= absent)

		PPUN nat	TPUN nat	PJER art	JPMC art	TUNK art	Total
Species	**Family**						
Cellana testudinaria	Nacellidae	1	1	1	1	1	**5**
Notoacmea sp.	Acmaeidae	0	0	1	0	0	**1**
Patelloida saccharina	Acmaeidae	0	1	1	0	0	**2**
Monodonta canalifera	Trochidae	1	1	0	1	0	**3**
Trochus cariniferus	Trochidae	1	1	1	1	0	**4**
Angaria delphinus	Angariidae	0	1	0	0	0	**1**
Turbo intercostalis	Turbinidae	1	1	1	0	0	**3**
Nerita chamaeleon	Neritidae	1	1	1	0	0	**3**
Nerita albicilla	Neritidae	1	1	0	0	0	**2**
Nerita undata	Neritidae	1	1	0	0	0	**2**
Nerita polita	Neritidae	1	1	0	0	0	**2**
Nerita insculpta	Neritidae	0	1	0	0	0	**1**
Batillaria sp.	Batillariidae	1	1	0	0	0	**2**
Planaxis sulcatus	Planaxidae	1	1	1	0	0	**3**
Cypraea arabica	Cypraeidae	1	0	0	0	0	**1**
Echinolittorina malaccana	Littorinidae	1	1	1	1	1	**5**
Echinolittorina vidua	Littorinidae	1	1	1	1	1	**5**
Echinolittorina melanacme	Littorinidae	0	1	1	1	0	**3**
Littoraria undulata	Littorinidae	0	1	0	1	0	**2**
Littoraria carinifera	Littorinidae	0	1	0	0	0	**1**
Litoraria unid.	Littorinidae	0	1	0	0	0	**1**
Pictocolumbella ocellata	Columbellidae	1	0	0	0	0	**1**
Euplica scripta	Columbellidae	1	0	0	0	0	**1**
Columbellidae sp 1	Columbellidae	1	0	0	0	0	**1**
Columbellidae sp. 2	Columbellidae	1	0	0	0	0	**1**
Conus coronatus	Conidae	1	0	0	0	0	**1**
Semiricinula tissoti	Muricidae	0	1	0	1	1	**3**
Reishia bitubercularis	Muricidae	0	1	0	0	1	**2**
Morula sp.	Muricidae	1	1	1	0	0	**3**
Mancinella echinulata	Muricidae	1	0	0	0	0	**1**
Siphonaria atra	Siphonaridae	0	0	1	0	0	**1**
Siphonaria javanica	Siphonaridae	1	0	1	0	0	**2**
Total		**21**	**22**	**13**	**8**	**5**	

Table 2. Univariate species diversity indices.

Sample	S	N	d	J'	Brillouin	Fisher	H'(loge)	1-Lambda'
PPUN	20	20	6.342	1	2.117	****	2.996	1
TPUN	22	22	6.794	1	2.203	****	3.091	1
PJER	12	12	4.427	1	1.666	****	2.485	1
JPMC	8	8	3.366	1	1.326	****	2.079	1
TUNK	5	5	2.485	1	0.9575	****	1.609	1

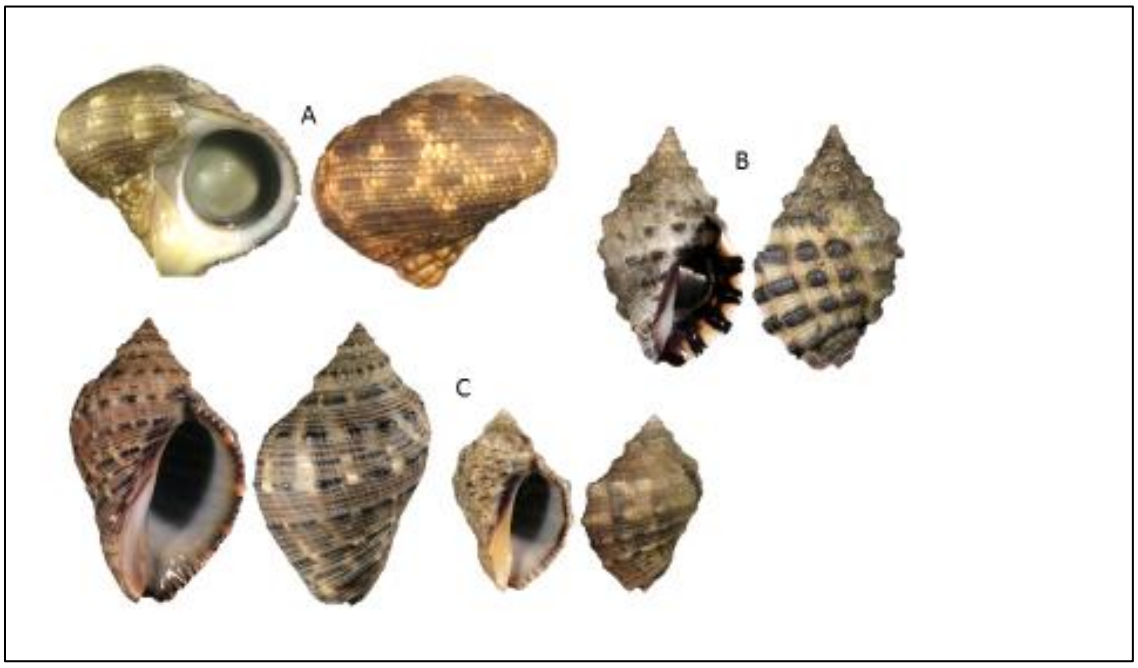

Figure 5. Recent snail species collected within the study area not included in the study and not previously given in photographic record for Brunei. A, *Lunella cinerea* (Born, 1778) (TPUN, 21); B. *Morula* sp. (Pantai Tungku, 16); C, *Purpura panama* (Röding, 1798) (Pantai Tungku, 34). Number in parenthesis indicates shell length (mm).

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