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Gastropods in the Intertidal Zone of Asry Beach, Kingdom of Bahrain

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Abstract: A study of intertidal gastropods using quadrat method was conducted from August 2012 to July 2013. Specifically to identify and classify taxonomically the gastropods in Asry Beach, Kingdom of Bahrain; find out significant differences in the number of identified gastropods within the taxonomic groups; and determine heterogeneity and alpha diversity of species using Shannon diversity index (H), and species richness using Magalef's (d) diversity index. A total of 2,136 individual species were identified in the sandy and rocky intertidal zones which belong to 16 families, 5 genera and 28 species of gastropods. Statistical analysis using Analysis of Variance (ANOVA) with multiple comparisons depicted significant difference on the number of gastropods at varying taxonomic groups. Result of Shannon (H) and Magalef's (d) diversity indices revealed diversity and species richness of the three species, Calliostoma selectum, Lirobittium attenuatum, and Homalopoma luridum. Gastropods are abundant in the sandy and rocky intertidal zone.

Keywords: Gastropods, Intertidal zone, Quadrat method, Magalef's diversity index.

I. INTRODUCTION

The small parcel of the intertidal pool is a good habitat for many life forms. The sustenance of life relies on the interdependent dynamics that begins in the intertidal zone of any marine ecosystem. Life in the intertidal zone is influenced by the interplay of abiotic cycles. Diversity indices provide the total composition of community structure which can be assessed in many ways. Alpha diversity as a method determines ecosystem stability, thus allowing the ecosystem to better withstand natural or anthropogenic disturbances. The Shannon diversity index (H) describes alpha diversity in a community. Species richness can be described with Margalef's index which will provide data on community index. Marine organisms differ conspicuously according to their means of dispersion. The organisms that inhabit the shorelines are found to be zoned according to the type of immersion in sea water that they require for survival [1]. The gastropods seem to be the abundant animals in the intertidal pool since these organisms are remarkably diverse [2]. The type of substrate also determines the type of organism [3]. Studies on the pattern of distribution and diversity of gastropods were conducted in various marine ecosystems [4-8]. Characteristically, gastropods have worldwide distribution considering their wide adaptations [9].

Bahrain is strategically located in the Gulf region characterized by sprawling marine ecosystems. One of the public beaches of interest is Asry in Al Muharraq, a shipyard and docking station other than the presence of industrial plant and human habitation. In the north-eastern part is the intertidal zone characterized by sandy and rocky substrates. This area is used for recreation and a public beach resort where the study was conducted. Hence, this study was conducted to determine the gastropods in the intertidal zone in Asry Beach, Kingdom of Bahrain. Specifically, to identify and classify taxonomically the gastropods; find out significant differences in the number of gastropods within the taxonomic groups; and determine Heterogeneity and alpha diversity of species using diversity index (H), and species richness using Magalef's diversity index (d).

II. RESEARCH METHOD

This study made use of a descriptive-experimental research design. A 50 m belt transect was established parallel to the shoreline divided into 1 x 1 m^2 quadrats.

A. Diversity Indices and Statistical Analysis

The distribution of gastropods occupying the same area utilizing similar resources was determined. Alpha diversity was calculated using Shannon diversity index [H] to find out the heterogeneity of gastropods in the area. The formula is

$$H = \sum - (Pi * In\ Pi),$$
$$1\text{-}1$$

where, H, the Shannon diversity index; Pi is the fraction of the entire population made up of species 1; s, the number of species encountered; $\sum$, the sum from species 1…, and In, the natural logarithm of a number. The higher the computed H value the more heterogeneous, hence, the more diverse the community. The H value also determines how the species is distributed in relation to all other species in the community. Species richness was determined using Margalef's diversity index (d) with the formula given as

$$d = \frac{S-1}{InN},$$

where d is the species richness index; S, the number of species in a population, and N, the total number of individuals in S species. As a measure of species diversity, the higher the index, the more diverse the organisms are. Analysis of Variance (ANOVA) with multiple comparisons was used to find out significant differences in the number of gastropods at varying taxonomic groups.

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III.RESULTS AND DISCUSSION

A. Identified Gastropods and their Taxonomic Classification

Table 1. Identified Gastropods and their Classification Asry Beach, Kingdom of Bahrain August 2012 – July 2013

Taxonomic Group			
Family	Genus	Species	(Total)
Batillariidae	Batillaria	attramentaria	Sowerby, 1855(3)
Borsoniidae	Ophiodermelta	cacellata	Carpenter, 1864 (1)
Buccidae	Lirabuccinum Volutarpa	odirum ampullarca	Reeve, 1846(10) Middendroft,1848 (5)
Calliostomatidae	Calliostoma Calliostoma	selectum variegatum	Dillwyn, 1817 (1,522) Carpenter, 1864 (56)
Cerethiopsidae	Cerithiospis	sp. 1	(26)
Cerethiidae	Lirobittium Stylidium Bittium	attenuatum eschrichtii vanconverense	Carpenter, 1864 (174) Middendroft,1848 (11) Dall & Bartsch, 1910 (5)
Collumbilidae	Astyris	aurantiaca	Dall, 1871(1)
Epitoniidae	Opalia	borealis	Kepe, 1881(15)
Margeliidae	Oepota Oenopota	olivedensis tabulata	Carpenter,1864(2) Carpenter, 1864 (11)
Muricidae	Ocinebra Octinebrina Nucella Scabrotrophon	inornata atropupurea olamellanosa maltzani	Recluz, 1851(2) Carpenter, 1864(3) Gmelin, 1791(3) Kobett & Kuster, 1878(1)
Olivellidae	Callianax Callianax Callianax	obiplicata baetica pycna	Sowerby, 1825(6) Carpenter, 1864(6) S.S. Bery,1835 (4)
Pyramidellidae	Turbonilla Turbonilla Evalea	sp. 1 sp. 2 tenuisculpta	(50) (6) Carpenter, 1864(32)
Trochidae	Lirularia Lirularia	olirulata succinata	Carpenter, 1864(56) Carpenter, 1864(5)
Turbinidae	Homalopoma Homalopoma	luridum baculum	Dall, 1885(75) Carpenter, 1864(30)
Velutinidae	Velutina Marsenia	velutina thrombica	O.F. Muller, 1776(3) Dall, 1871(8)
Volutidae	Arctomelon	tearns	Dall, 1871(4)
Total: 16	25	28	2,136

Table 1 presents the identified gastropods in the intertidal zone of Asry Beach, Kingdom of Bahrain, August 2012-July 2013. A total of 2,136 species which belong to 16 families, 25 genera, and 28 species were identified in the sandy and rocky intertidal pool. Although the study area is a beach, results revealed the presence of gastropods in the intertidal zone. Of the 16 families, Family Muricidae comprised the most number of genera with four sepcies, followed by Family Cerethiidae and Family Olivelidae and Pyramidelidae with three species each.

Result implies that the area can still support these life forms in spite of the man-made disturbances. Gastropods are usually associated with sandy and rocky beaches [10]. The abundance and distribution of gastropods are influenced by the physical environment [11].

All members of the species respond similarly to changes in Environmental conditions irrespective of the population [12].

The different species of gastropods are usually found in the costal and marine ecosystem [13] specifically in the intertidal pool [3]. The level of sea water affects the activity of the marine organisms [14]. Hence, more organisms were found in the area. This can be attributed to the adaptation of this group of animals to their habitat [3-4]. The diversity of gastropods is also influenced by the number of types of sub-habitats and their interaction with the environment [15].

Results of statistical analysis using ANOVA with multiple comparisons on the number of gastropods at varying taxonomic groups are presented in Table 2.

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Table 2. Results of Statistical Analysis using ANOVA with Multiple Comparison on the Number of Gastropods at Varying Taxonomic Groups

ANOVA	SS	df	MS	F	Sig.
Between Groups	115836.304	4	28959.076	22.946	.000* Significant
Within Groups	42909.826	34	162.038		
Total	158745.590	38			

*The mean difference is significant at the .05 level

As shown in table, there is a significant difference on the number of gastropods at varying taxonomic groups at .05 level.

Table 2a. Results of Multiple Comparisons at varying Taxonomic Groups

(I) Species	(J) Species	Mean Difference (I-J)	Sig.
C. selectum	C. variegatum	118.8333	.000* Significant
	L.attenuatum	119.6905	
	L.olirulata	117.500	
L. attenuatum	C. selectum	-119.6905	.000* Significant
	L. olirulata		
C. selectum		-117.500	.000* Significant

Hence, a significant difference is observed in the number of the two species of Calliostoma, C. selectum (1,522) and C. variegatum (56) between L. attenuatum (174) and C. variegatum (56); L. attenuatum (174) and one species of , L. olitulata (56); L. attenuatum (174) and C. selectum (1,522); and L. olirulata (56) and C. selectum (1,522). These species comprised the most number in terms of individual count (Table 2a). The organisms share the same environment that is measured as the number of species within the given area [16]. Marine environment provides a wide range of physical condition that organisms have become highly adapted [17] which are characterized by extraordinary diversification of habitats [2].

B. Results of Diversity Indices

The heterogeneity of the sampled population of gastropods as a measure of alpha diversity was determined using Shannon diversity index (H) (Table 3). Results showed that C. selectum of Family Calliostomatidae incurred the highest H value, 2.883, followed by L. Attenuatum of family Certiidae, H= 2.12, and H. luridum, H= 1.00 of Family Turbinidae. Similarly, the same species had the highest individual count (Table 1). Statistically, there is a significant difference in number of these species within the taxonomic group (Table 2). Results imply that the identified species are more diverse compared to other species. These species are frequently occurring in the sampled quadrats. Species have specific adaptations [12] regardless of geographic distribution [2]. The coastal components are the most biologically diverse of all the marine ecosystems [10]. The use of mathematical indices evaluates the status of a particular ecosystem [18].

Table 3. Result of Shannon Diversity Index (H) for Heterogeneity and Alpha Diversity

Taxonomic Group			
Family	Genus	Species	H
Batillariidae	Batillaria	attramentaria	0.053
Borsoniidae	Ophiodermelta	cacellata	0.08
Buccidae	Lirabuccinum	odirum	0.08
	Volutarpa	ampullarca	0
Calliostomatidae	Calliostoma	selectum	2.883
	Calliostoma	variegatum	0.854
Cerethiopsidae	Cerithiospis	sp. 1	0.308
Cerethiidae	Lirobittium	attenuatum	2.12
	Stylidium	eschrichtii	0.23
	Bittium	vanconverense	0.177
Collumbilidae	Astyris	aurantiaca	0
Epitoniidae	Opalia	borealis	0.186
Margeliidae	Oepota	olivedensis	0.046
	Oenopota	tabulata	0
Muricidae	Ocinebra	inornata	0.046
	Octinebrina	atropupurea	0.046
	Nucella		0.046
	Scabrotrophon	olamellanosa maltzani	0
Olivellidae	Callianax	obiplicata	0.124
	Callianax	baetica	0.046
	Callianax	pycna	0
Pyramidellidae	Turbonilla	sp. 1	0
	Turbonilla	sp. 2	0.778
	Evalea	tenuisculpta	0.149
Trochidae	Lirularia	olirulata	0.319
	Lirularia	succinata	0.186
Turbinidae	Homalopoma	luridum	1.00
		baculum	0.08
	Homalopoma		
Velutinidae	Velutina	velutina	0.399
	Marsenia	thrombica	0.046
Volutidae	Arctomelon	tearns	0.23

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Table 4. Result of Margalef's Diversity Index (d) for Species Richness

Taxonomic Group			
Family	Genus	Species	d
Batillariidae	Batillaria	attramentaria	0
Borsoniidae	Ophiodermella	cacellata	0
Buccidae	Lirabuccinum	odirum	3.2
	Volutarpa	ampullarca	1.6
Calliostomatidae	Calliostoma	selectum	56.51
	Calliostoma	variegatum	13.19
Cerethiopsidae	Cerithiospis	sp. 1	0
Cerethiidae	Lirobittium	attenuatum	51.8
	Stylidium	eschrichtii	4.79
	Bittium	vanconverense	1.38
Collumbilidae	Astyris	aurantiaca	0
Epitoniidae	Opalia	borealis	0
Margeliidae	Oepota	olivedensis	0.69
	Oenopota	tabulata	3.57
Muricidae	Ocinebra	inornata	2.07
	Octinebrina	atropupurea	3.29
	Nucella		3.29
	Scabrotrophon	olamellanosa maltzani	0
Olivellidae	Callianax	obiplicata	4.394
	Callianax	baetica	5.46
	Callianax	pycna	2.77
Pyramidellidae	Turbonilla	sp. 1	20.8
	Turbonilla	sp. 2	3.58
	Evalea	tenuisculpta	13.97
Trochidae	Lirularia	olirulata	12.727
	Lirularia	succinata	1.61
Turbinidae	Homalopoma	luridum	31.94
	Homalopoma	baculum	5.42
Velutinidae	Velutina	velutina	1.09
	Marsenia	thrombica	4.63
Volutidae	Arctomelon	tearns	0

Results in Table 5 showed that C. selectum of Family Calliostomatidae had the highest (d) index, 56.51, followed by L. attenuatum (Family Cerithiidae), d= 51.8, and H. luridum (Family Turbinidae), d= 31. These three species are also the most diverse as shown in the result of Shannon diversity index (H) (Table 3). Species population has its own dynamics based on abundance [19]. Marine gastropods have high diversity [20] since this group contains a vast number of named species [2]. Hence, it can be implied that Asry Beach is a stable community of the identified gastropods in the intertidal zone. As a stable ecosystem, it means that the resources of the community can support its population, thus maintaining its carrying capacity.

V. CONCLUSION

Species of gastropods are abundant in the sandy and rocky intertidal zone of Asry Beach, Kingdom of Bahrain. Some species of the identified gastropods significantly vary in number within the taxonomic groups. The indices of diversity measure the heterogeneity, alpha diversity and species richness of the area. The intertidal zone serves as a stable habitat for marine gastropods.

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