AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Species diversity and spatial structure of intertidal mollusks in Padada, Davao del Sur, Philippines

Jess H. Jumawan, Fervil F. D. Tripoli, Ela E. S. Boquia, Kimberly L. M. Niez, Judy A. H. Veronilla, Sairyn A. Dellomes, Rahima M. Udtie, Noraiza K. Seit, Nadzraleen A. Hasim, Mark J. O. Gatinao

Department of Biology, College of Natural Science and Mathematics, Mindanao State University, General Santos City, Mindanao, Philippines. Corresponding Author: F. Tripoli, simplifire11@yahoo.com

Abstract. Studies on mollusk diversity in Mindanao island, southern Philippines is considerably scarce. Recent studies in southern Mindanao are still not enough to suffice basic information in the inventory and community structure in the area. The study aimed to provide analysis in the diversity and spatial structure of shoreline mollusks found in Padada, Davao del Sur. Sampling was conducted along the coastline area by establishing a transect (50 m) with interval of at least 50 m. A total of 10 transects were installed perpendicularly along the shoreline. Each transect consisted of 10 plots with a dimension of 1 m x 1 m. The results identified a total of 31 species coming from class Gastropoda (17 species) and Bivalvia (14 species). Diversity indices and species importance values were determined. The spatial structure of mollusks showed variability across the sampling area as revealed by cluster dendrogram and nMDS. The data is the first attempt to provide baseline information on mollusk diversity and community structure in the study area.
Key Words: mollusks inventory, community structure, cluster dendrogram, gastropods, bivalves, Mindanao.

Introduction. Mollusks are one of the most ancient animals on earth today (IUCN 1995). They are naturally distributed in the Indo-West Pacific Ocean including Philippines (Dolorosa & Schoppe 2005). They also appear in the Oldest Cambrian Deposits more 500 million years BP. It is also one of the most successful of all animals and is second to insects in numbers of species. However, base on fossil records, it does not show the continuous presence of all families and genera through time (IUCN 1995). The utilization of mollusks is richly documented archeological record. Aside from its consumptive value, their shells were utilized for religious purposes (Léo Neto et al 2012).

Mollusks are an important ecological resource and its importance has provided protein subsistence to coastal communities. Philippines are believed to have around 22,000 species of mollusks (PBCPP 2002) of an estimated 70,000 species globally (IUCN 2004). It is considered as a mega diverse country in terms of mollusk diversity. Studies on mollusks in the country are seemingly inadequate to provide data about diversity and structure. Most of the studies relating to mollusks were based on foreign researchers such as the works of Hugh Cumming from 1836 to 1840 as cited by Batomalaque et al (2010).

Assessing the recent status of molluscan diversity in the intertidal zone is not yet given so much attention in Philippines. At present, there is limited study that has been published on the status of biodiversity of molluscan species in southern Mindanao. Limited study conducted in Sarangani Bay suggested potential sites for assessment of mollusks (Manzo et al 2014). Thus, it is the objective of the study to assess the diversity and community structure of mollusks in the study site. The data gathered in the study

can be useful for future purposes since there are no published articles done on mollusk diversity in the Padada, Davao del Sur.

Material and Method.

Study area. The study was conducted from January to March 2015, along the Davao Gulf, Mindanao that is geographically lying between 6°38'22.63"N - 6°40'25.57"N and 125°19'34.01"E - 125°20'53.06"E (Figure 1 & 2).

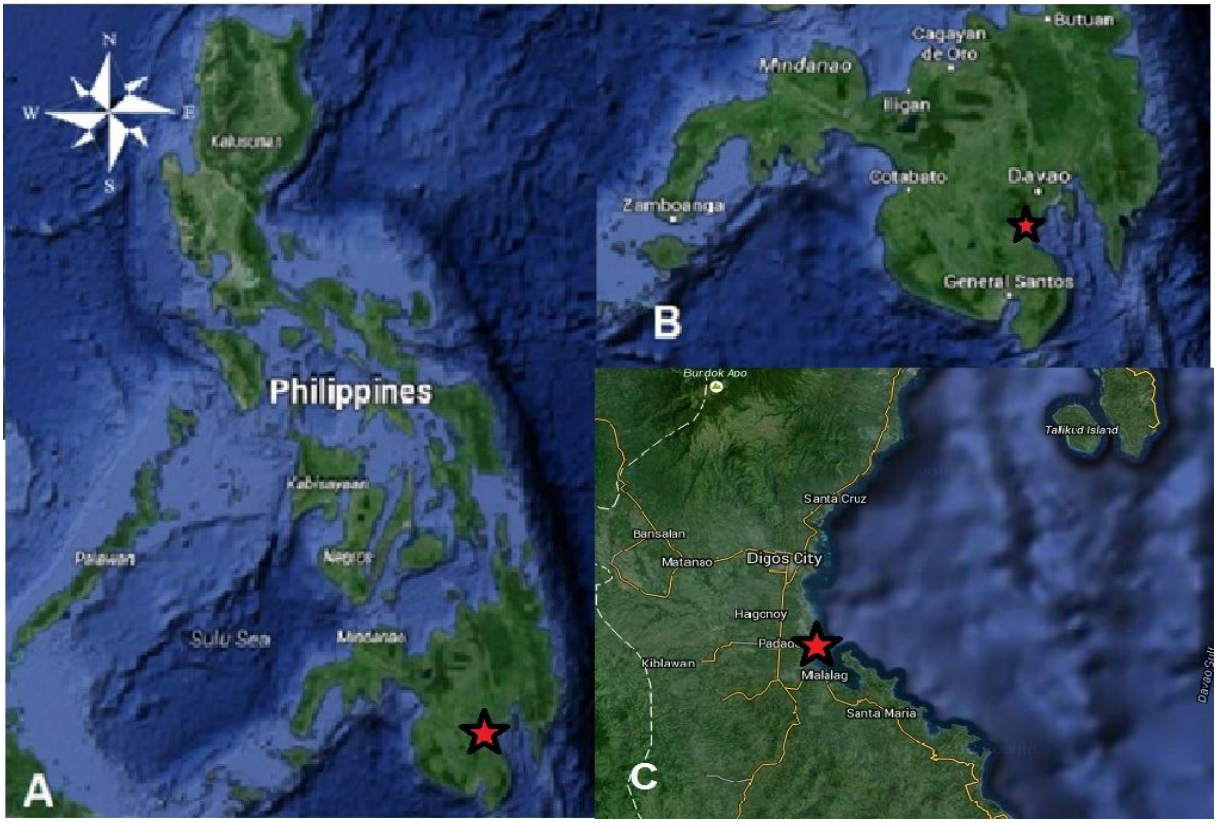

Figure 1. The study site showing the Map of the Philippines (A), Mindanao island (B), and Davao Gulf (C) specifically at Padada, Davao del Sur (Google Earth 2015).

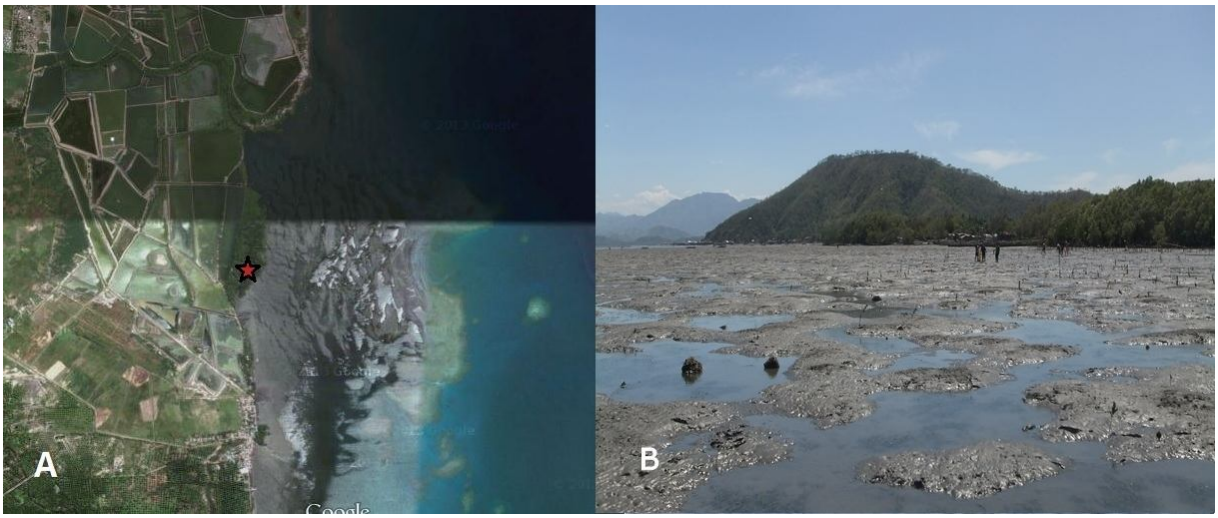

Figure 2. Location of the sampling area. The site was located at coastal area in the municipality of Padada (A) and showing the location of the actual sampling site (B) in Davao del Sur (Google Map Satelite 2015).

Establishment of transects and quadrates. Sampling was conducted along the intertidal areas in Davao gulf situated in Padada, Davao del sur. A transect with a length of 50 m was established on site. The interval between transects was at least 50 m. A total of 10 transects were installed perpendicularly along the shoreline. Each transect consisted of 10 quadrates (1 m x 1 m) along the transect line.

Species survey. The survey of mollusks was limited only to bivalves and gastropods. Only alive mollusks were considered. Some specimens were brought to the laboratory for further identification of species under morphological examinations. Dissecting microscopes were used evaluation of diagnostic characters. Reliable identification guides were used in the study such as the collections of mollusks in the Philippines (Poppe 2008a,b,c), the guidelines for identifications of bivalves and gastropods (Carpenter & Niem 1998), the biography of mollusks in the Philippines (Vallejo Jr 2001), and the collections of Philippine mollusks (Springster & Leobrera 1986). Sources from the internet were also accessed aiding the species identification such were the websites on: www.gastropods.com, www.seashellhub.com, and www.jaxshells.com.

Data analysis. The data on mollusk abundance was used in the construction of matrix on species and transects. It was further subjected to different diversity and community structure analysis of mollusks in the sampling area. PRIMER software (Clarke & Gorley 2006) was used in the analysis of data.

Species accumulation curve and biodiversity indices. The plot on species count and number of samples was plotted to estimate the adequacy of sampling effort. There were different species richness estimators such were Michaelis Menten (MM), the UGE, and bootstrap estimator using 999 permutations to compare with the observed species (Sobs) in the sampling (Clarke & Gorley 2006). There were 6 diversity metrics included in the study namely: species richness, abundance, dominance, evenness, Simpson diversity, and Shannon diversity.

Describing the spatial structure of mollusks. The data on abundance was transformed using 4^{th} root transformation. A similarity matrix was constructed using Bray-Curtis similarity index. Relationship of sample points based on comparison on the similarities was used in the cluster analysis. The cluster dendrogram was constructed to show natural formation of sample groups. Non-metric multidimensional scaling (nMDS) was used in the ordination of data sets (Clarke & Warwick 2001).

Determination of species importance value (SIV). The important quantitative values were (a) abundance, (b) frequency and (c) density and its relative values (Curtis & McIntosh 1950). The formulas were:

(a) Abundance = Total number of individuals of a species in all quadrate / Total number of quadrates in which the species occurred;

(b) Frequency = Total number of quadrates in which the species occurred / Total number of occurrences in the study;

(c) Density = Total number of individuals of a species in all quadrates / Total number of individuals of all species in the study;

Species importance values (SIV) were calculated by summing up the relative abundance, relative frequency and relative abundance values.

(d) Relative abundance = Abundance value of a species X 100 / Abundance value of all species;

(e) Relative frequency (%) = Total number of occurrences of species X 100 / Total number of occurrences of all species;

(f) Relative density = Total number of individuals of a species X 100 / Total number of individuals of all species.

Results and Discussion. The depicted species accumulation curve considered species richness estimators such as: Michaelis Menten (MM), the UGE (Ugland et al 2003), and the bootstrap estimator based on the proportion of quadrates containing each species (Clarke & Gorley 2006). The observed species (Sobs), the UGE and bootstrap estimator consisted of 31 species in the entire sampling area. The MM has 31.5 estimated species richness. The figures revealed in the species accumulation plot indicated that the sampling effort was highly adequate.

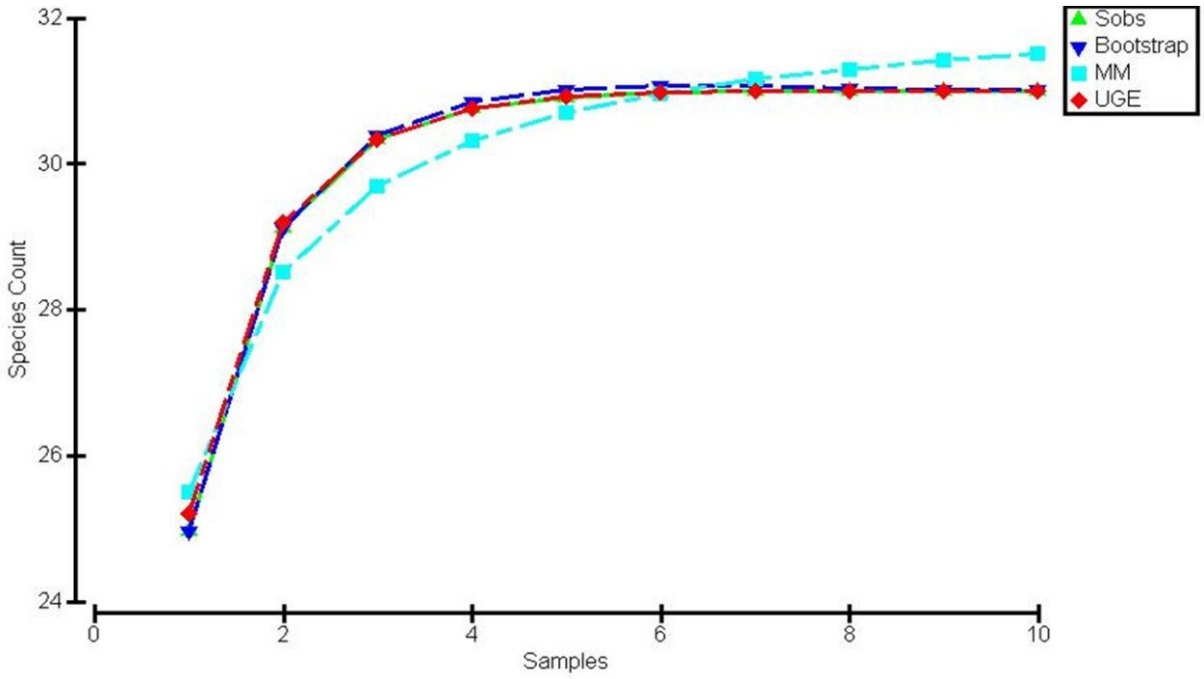

Figure 3. The species accumulation plot indicated assymptotic to UGE species richness estimator.

Table 1 is the list of species located in the sampling site. There were a total of 7,821 individuals of mollusks surveyed and attributed to 31 species, with 14 species coming from class Bivalvia and 17 from class Gastropoda. Among the bivalves the family Arcidae has the highest number of species (4). These were *Nassarius coronatus, Nassarius livescens, Nassarius pullus,* and *Nassarius venustus*. In Gastropods, the family Nassaridae has four species the highest in number namely: *Nassarius coronatus, Nassarius l., N. pullus,* and *N. venustus*.

Diversity indices were determined in the study and this includes: species richness, abundance, dominance, Simpson, Shannon diversity and evenness. The diversity indices is shown in Table 2 & Figure 4.

Table 2 shows the diversity of molluscan species in the different transects plotted in the intertidal zone. The diversity figures were considerably high. Species richness has high values in the different transects except for transect 10. The table for species abundance which was the total amount of individuals in the area indicated that it was numerous and abundant. There is an even distribution of the species in the area in relation to species richness which also suggested that increase in diversity was observed.

Shannon's and Simpson's diversity indices which utilize the values of species richness, dominance and evenness show a high value.

Table 1

Summary of mollusk species composition found in Padada, Davao del Sur

Mollusk Group	*Family*	*Species*
Bivalves	Arcidae	*Anadara Maculosa*
		Arca mutabilis
		Barbatia foliata
		Scapharca inaequivalvis
	Ostreidae	*Crassostrea glomerata*
		Lopha cristaglli
		Ostrea folium
	Telinidae	*Tellina remies*
		Tellina staurella
	Mactridae	*Lutraria rhynchaena*
		Mactra maculata
	Veneridae	*Gafrarium tumidum*
		Paphia amabilis
		Periglypta puerpera
Gastropods	Buccinidae	*Cantharus wrightae*
	Cassidae	*Phalium bandatum*
	Cerithiidae	*Clypeomorus batillariaeformis*
	Colubrariidae	*Colubraria muricata*
	Conidae	*Conus quercinus*
	Costellariidae	*Vexillum rugosum*
		Vexillum vulpeculum
	Nassaridae	*Nassarius coronatus*
		Nassarius livescens
		Nassarius pullus
		Nassarius venustus
	Naticidae	*Polinices tumidus*
		Sinumja vanicum
	Potamididae	*Terebralia palustris*
	Terebridae	*Terebra maculata*
	Trochidae	*Monodonta labio*
	Turritellidae	*Architectonica perspectiva*

Table 2

Summary of diversity indices of mollousks in the 10 transects

Transect	*Species richness*	*Abundance*	*Dominance*	*Simpson*	*Shannon*	*Evenness*
Transect 1	27	124.2	0.07334	0.9267	2.863	0.6488
Transect 2	28	106.7	0.1426	0.8574	2.511	0.4399
Transect 3	30	86.8	0.07337	0.9266	2.882	0.5948
Transect 4	28	68.7	0.08924	0.9108	2.765	0.5669
Transect 5	24	44	0.1085	0.8915	2.53	0.5229
Transect 6	25	120.2	0.1597	0.8403	2.351	0.42
Transect 7	27	91.1	0.1611	0.8389	2.364	0.394
Transect 8	25	60.5	0.1548	0.8452	2.514	0.4942
Transect 9	21	53.4	0.09498	0.905	2.625	0.6571
Transect 10	17	26.5	0.1427	0.8573	2.321	0.5992

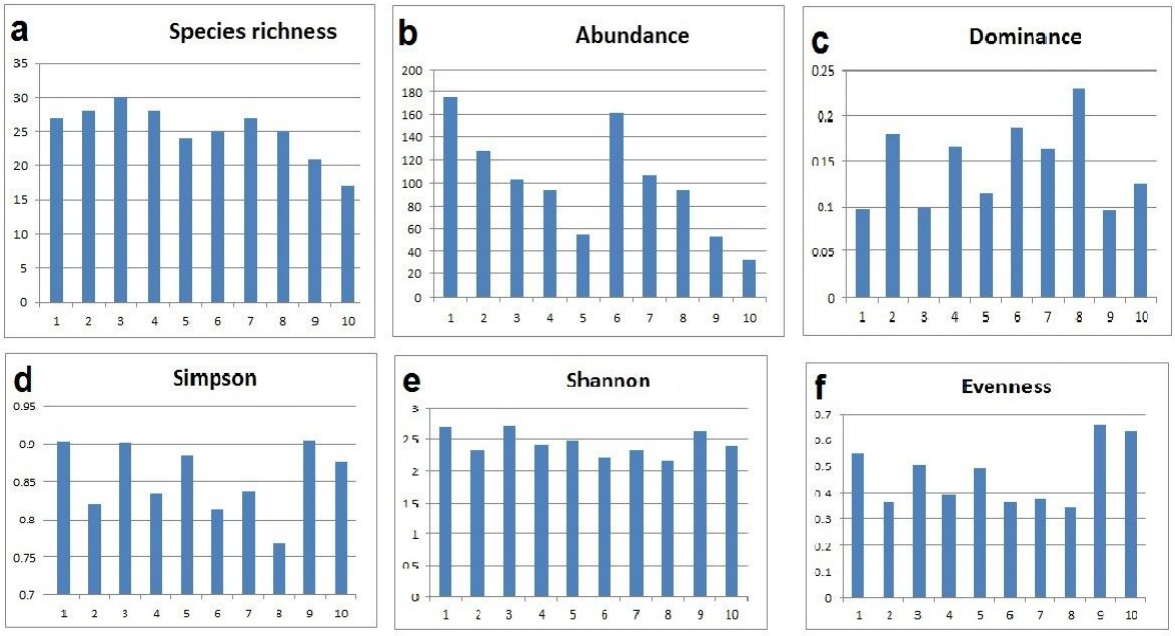

Figure 4. The graph of mollusk species diversity in the sampling area which include species richness (a), abundance (b), dominance (c), Simpson diversity (d), Shannon diversity (e) and evenness (f).

The relative values of the abundance, frequency, density, and species importance values are shown in Table 3. It was found that *Vexillum rugosum* with 20.02 relative abundance values were the most abundant species in the area. The species *Gafrarium tumidum* and *Vexillum vulpeculum* also displayed higher values indicating that these species are also abundant in the area. There were five species having the same values for relative frequency namely, *Crassostrea glomerata, G. tumidum, Tellina staurella, Clypeomorus batillariaeformis, N. pullus,* having 3.9 % which were the most frequent among the surveyed species. The relative density values of species indicated that *V. rugosum* was the densest in the intertidal zone of Piape, Padada. The species *V. rugosum, G. tumidum, V. vulpeculum, C. glomerata* and *T. staurella* showed high species importance values of 2025.52, 903.22, 776.44, 740.04 and 716.56 respectively. This indicated that these species were influential in terms of abundance, frequency, and dominance.

The mollusk spatial structure was analyzed and shown in cluster analysis and non-metric MDS (Figure 5 & 6). The similarity matrix using Bray-Curtis index was used to construct a cluster dendogram. It showed that in the entire sampling area where formed 3 major groups. There was one transect (T10) consisted of unique species compared to the three sampling areas. This observation was highly similar when a non-metric MDS was used. The data was plotted in a two dimensional plane and sampling points with close proximities indicated higher similarities. Three major groups were also observed with T10 isolated from the rest of the samples. Among the groupings, group 1 and group 2 were more similar in structure. However, group 1 also shares closer similarities to the mentioned two groups. Transect 10 was typically isolated in terms of proximity. This suggested that the transect has less proximity and similarity as compared to the rest of the mollusk structure in other transects. The community structure as depicted in the results showed variability. It is also interesting to understand the factors affecting the variability of mollusk spatial structure in the sampling site. However, this undertaking was not included in the study but suggest that it shall be conducted in future studies. The nMDS figure showed a stress value of 0.06 suggested that the values depicted in the data ordination were very reliable.

Table 3

Relative values of the abundance, frequency, density, important values of mollusk species in Piape, Padada, Davao del Sur

Species	*Value*
Relative abundance	
Vexillum rugosum	20.01521168
Gafrarium tumidum	8.903398459
Vexillum vulpeculum	7.648089016
Crassestrea glomerata	7.287768712
Tellina staurella	7.055304001
Relative frequency	
Crassestrea glomerata	3.984063745
Gafrarium tumidum	3.984063745
Tellina staurella	3.984063745
Clypeomorus batillariaeformis	3.984063745
Nassarius pullus	3.984063745
Relative density	
Vexillum rugosum	22.0176448
Gafrarium tumidum	9.794143971
Vexillum vulpeculum	8.413246388
Crassestrea glomerata	8.016877637
Tellina staurella	7.761155862
Importance value	
Vexillum rugosum	*2025.520443*
Gafrarium tumidum	*903.2273081*
Vexillum vulpeculum	*776.4410543*
Crassestrea glomerata	*740.0487037*
Tellina staurella	*716.5697678*

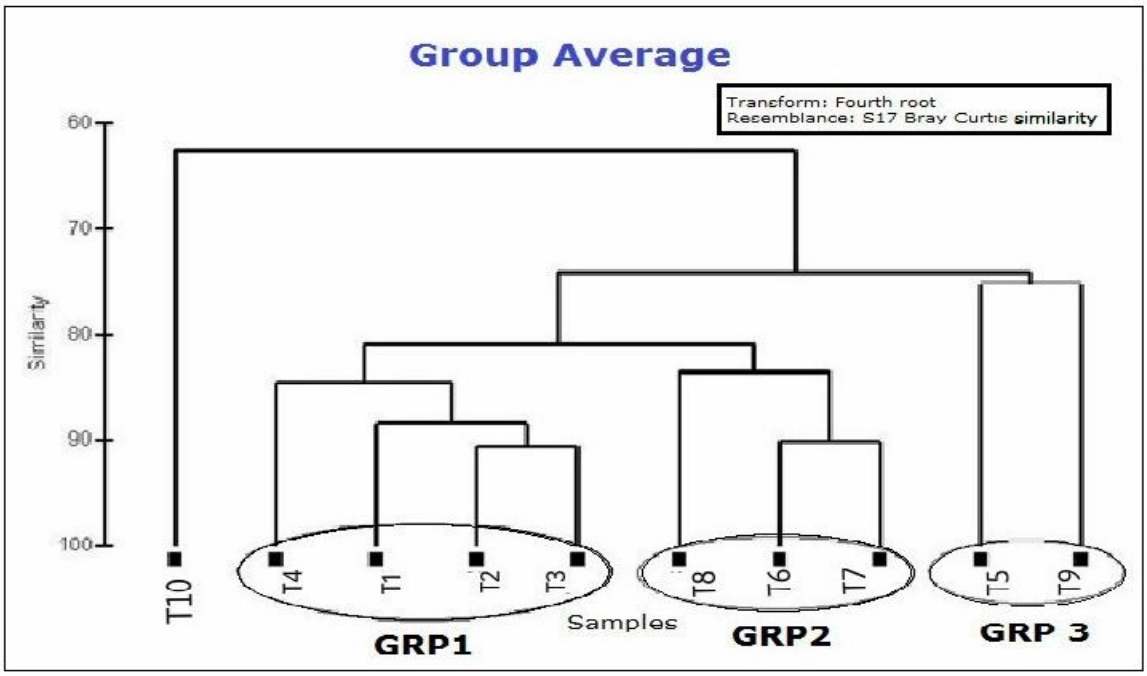

Figure 5. The cluster dendrogram. The mollusk community structure showed 3 major groupings.

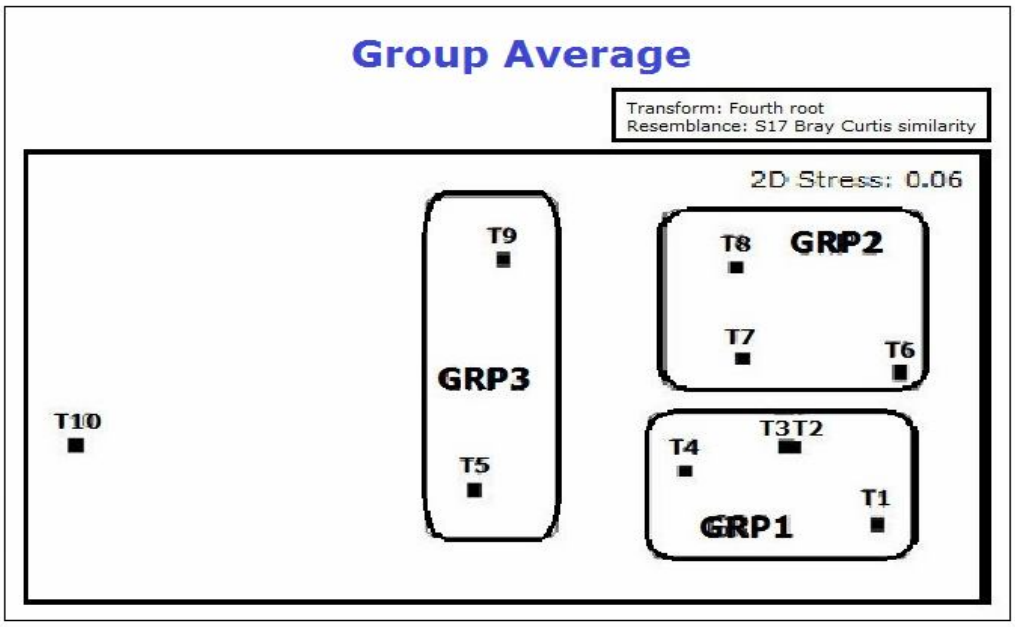

Figure 6. The cluster Non-metric multidimensional scaling (nMDS). The mollusk community structure showing 3 major groupings.

Conclusions. This study showed that there were a total of 31 mollusks species (14 Bivalvia and 17 Gastropds). The diversity metrics indicated high diversity values. The species *V. rugosum, G. tumidum, V. vulpeculum, C. glomerata* and *T. staurella* showed high species importance values. Based in the results gathered, it can be concluded that mollusk diversity and spatial structure showed variability along the shoreline of Padada, Davao del Sur. The study provides basic information in the status of mollusks community structure in Padada, Davao del Sur.

Acknowledgements. The authors would like to express their deepest gratitude and thanks to the Mindanao State University administration for the support in the endeavor of research.

References

Batomalaque G. A., Arce B. G. P., Hernandez M. B. M., Fontanilla I. K. C., 2010 Survey and spatial distribution of shoreline malacofauna in Grande Island, Subic Bay. Philipp J Sci 139(2):149-159.

Carpenter K. E., Niem V. H. (eds), 1998 The living marine resources of Western central Pacific. Volume 1: Seaweeds, corals, bivalves and gastropods. FAO Species Identification Guide for Fishery Purposes, Rome, Italy.

Clarke K. R., Gorley R. N., 2006 PRIMER v6.1: User Manual/Tutorial. PRIMER-E, Plymouth, United Kingdom.

Clarke K., Warwick R., 2001 Change in marine communities: an approach to statistical analysis and interpretation, 2nd ed., PRIMER-E: Plymouth, UK.

Curtis J. T., McIntosh R. P., 1950 The interrelations of certain analytic and synthetic phytosociological characters. Ecology 31:434-455.

Dolorosa R. G., Schoppe S., 2005 Focal benthic mollusks (Mollusca: Bivalvia and Gatropoda) of selected sites in Tubbataha Reef National Marine Park, Palawan, Philippines. Science Diliman 17:1-10.

(IUCN) International Union for the Conservation of Nature, 2004 IUCN Red List of threatened species. Accessed on August 2014 at: www.redlist.org

(IUCN) International Union of the Conservation of Nature, 1995 The conservation biology of molluscs. Beshara Press, Chentelham, United Kingdom.

Léo Neto N. A., Voeks R. A., Dias T. L. P., Alves R. R. N., 2012 Mollusks of Candomblé: symbolic and ritualistic importance. J Ethnobiol Ethnomed 8:10. doi:10.1186/1746-4269-8-10.
Manzo K., Estandarte M., Dalipe R., Ulangutan J., Lecera J., Acob A., Diamalod J., Salmo W., Jumawan J., 2014 Survey and diversity of intertidal mollusks in Alabel and Maasim, Sarangani Province, Philippines. AACL Bioflux 7(6):449-457.
(PBCPP) Philippine Biodiversity Conservation Priority setting Program, 2002 Philippine biodiversity conservation priorities: a second iteration of the national biodiversity strategy and action plan: final report. Ong P. S., Afuang L. E., Rosell-Ambal R. G. (eds), Quezon City: Protected Areas and Wildlife Bureau-Department of Environment and Natural Resources, Conservation International - Philippines, Biodiversity Conservation Program-University of the Philippines Center for Integrative and Developmental Studies.
Poppe G. T., 2008a Philippine marine mollusks. Volume 1: Gastropoda- Part I. Conchbooks. Hackenheim, Germany, 759 pp.
Poppe G. T., 2008b Philippine marine mollusks. Volume 1: Gastropoda- Part II. Conchbooks. Hackenheim, Germany, 848 pp.
Poppe G. T., 2008c Philippine marine mollusks. Volume 1: Gastropoda- Part III. Conchbooks. Hackenheim, Germany, 702 pp.
Springster F. J., Leobrera F. M., 1986 Shells of the Philippines. Carfel Seashell Museum, Manila, Philippines, 377 pp.
Ugland K. I., Gray J. S., Ellingsen K. E., 2003 The species-accumulation curve and estimation of species richness. J Anim Ecol 72(5):888-897.
Vallejo Jr. B., 2001 The biogeography of Philippine marine mollusks. Loyola Schools Review 1:58-77.
*** http://www.google.com/maps/satellite
*** http://www.www.gastropods.com
*** http://www.seashellhub.com
*** http://www.jaxshells.com

Received: 12 March 2015. Accepted: 20 May 2015. Published online: 29 May 2015.
Authors:
Jess H. Jumawan, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: jehoju78@yahoo.com
Fervil Fritz Tripoli, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: simplifire11@yahoo.com
Ela Ellen Sumaganday Boquia, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: elaellen_elegant@yahoo.com
Kimberly Laze Montemor Niez, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: kimberlylazeniez@yahoo.com
Judy Ann Hubay Veronilla, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: judy02veronilla@yahoo.com
Sairyn Acojedo Dellomes, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: sairyndellomes@rocketmail.com
Rahima Mangagcom Udtie, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: rahima_udtie@yahoo.com
Noraiza Kunanding Seit, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: bhainor_16@yahoo.com
Nadzraleen Asnawi Hasim, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: ballpenkoo@yahoo.com
Mark Joseph Obestano Gatinao, Mindanao State University, College of Natural Science and Mathematics, Biology Department, Philippines, Mindanao, General Santos City, 9500, e-mail: josephgatinao@yahoo.com

How to cite this article:
Jumawan J. H., Tripoli F. F., Boquia E. E. S., Niez K. L. M., Veronilla J. A. H., Dellomes S. A., Udtie R. M., Seit N. K., Hasim N. A., Gatinao M. J. O., 2015 Species diversity and spatial structure of intertidal mollusks in Padada, Davao del Sur, Philippines. AACL Bioflux 8(3):301-309.