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Species Composition, Abundance and Distribution of Seawater Bugs (Order Hemiptera: Class Insecta) in Badian, Cebu, Philippines

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Abstract The presence of seawater bugs in the coastal area is an indicator of good water quality and stable mangrove habitat. As energy source of other organisms, their role in the food chain (Chen *et al.*, 2005) makes them important in the marine ecosystem. This study was conducted in order to know the species occurrence, abundance and distribution and their relationships with the physicochemical parameters such as light, humidity, temperature, pH, salinity, dissolved oxygen, nitrite, nitrate and phosphate that would affect their population to fluctuate or change. In the sampling sites, a quadrat sampling method was used for collections and gathering of data. Results indicated that 824 adult bugs composed of 4 Families, 8 Genera and 13 Species were found. The species were *Halobates calyptus*, *Halobates hayanus*, *Halobates proavus*, *Pseudohalobates inobonto* and *Stenobates sangihi* of the Family Gerridae; *Haloveloides femoralis*, *Halovelia esakii*, *Halovelia malaya*, *Halovelia bergrothii*, *Xenobates* sp. 1 and *Xenobates* sp. 2 of the Family Veliidae; *Hermatobates marcheii* of the Family Hermatobatidae and *Corallocoris marksae* of the Family Omaniidae. The most abundant was *H. femoralis* and the species were not associated each other and showed clumped pattern of distribution. Pearson's r- correlation coefficient showed that the effect of light, temperature, dissolved oxygen and phosphate level had a strong relationship with the abundance and distribution of bugs. This means that the higher the relative humidity, temperature, dissolved oxygen and phosphate concentration the higher was the number of bugs. The lower the pH, salinity, nitrate and nitrite the higher the number of seawater bugs. However, the mangrove forest in Badian is still stable.

Keywords: *seawater bugs, composition, abundance, distribution, physicochemical parameters*

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1. Introduction

Seawater bugs are found in mangrove areas, in rocky shorelines, in the intertidal zones, dispersed along coasts and chains of islands and even in open seas or oceans (Andersen, 1989) [1] where some occupy on the surface of the water (Tait, 1986) [34] like the genera *Halobates*, *Pseudohalobates*, *Haloveloides* and *Xenobates* group while some lived underwater inside air-pocket holes on crevices of stones and corals during high tide and came out during low tide like the genera *Halovelia*, *Hermatobates* and *Corallocoris* group (Andersen, 1989; Andersen, 1999; Chen *et al.*, 2005) [1,2,13]. They undergo incomplete metamorphosis, with piercing-sucking type of mouthparts (McGavin, 2000) [26] and feed on various planktonic organisms and some floating insects (Chen *et al.*, 2005) [13] like the *Nereis* larvae in mangroves areas in Olango Island, Cebu, Philippines. The adult are always wingless (Andersen, 1999) [2] with life stages ranged from 50 to 70 days like the *Halobates* species depending on temperature (Andersen and Cheng, 2004; Chen *et al.*, 2005) [3,13]. They are easily attracted by lights during the nights (Cheng (1972) [10] and some can withstand the heat of the sun like the coastal or oceanic *Halobates* species ((Cheng *et al.*, 1978; Damkaer, 1980; Andersen and Cheng, 2004) [3,11,15] and abundantly occurred during summer (Cheng *et al.*, 1990) [12]. They are considered as bioindicators of pollution (William and Felmate, 1992) [36] like heavy metals such as lead, aluminum, iron, etc. (Nummelin *et al.*, 1998) [27].

Today, hundreds of species are now classified and identified distributed mostly in tropical regions of the world (Andersen, 1999; Chen *et al.*, 2005)) [2,13] and believed invaded in marine habitat 20 to 45 mya from the estuaries or swamps as their ancestral habitat evolving from their relatives in the freshwater environment ((Andersen, 1989; Andersen and Cheng, 2004) [1,13]. In the Philippines for instance, seawater bugs were already studied by Gapud (1986) like the *Corallocoris marksae* and genera *Stenobates*, *Pseudohalobates* and *Halobates* by Zettel (1998), Zette (2001), Zettel (2003), Zettel (2004) [39,40,41,42]. This enormous diversity is a result of the allopatry of several endemic species occupying 7,000 islands of the country and relatively few species of insects might have reached the Philippine archipelago, survived and became part of the splitting or separation of the islands resulting in a high number of allopatric species (Zettel, 2001) [39].

According to the ASEAN Center for Biodiversity, the Philippines ranked as number 26 among the biodiversity hotspots in the world and ranked as the number 15 and number 17 in terms of biodiversity and endemism in the Southeast Asian region (www.conservation.org) [22]. But the biodiversity status are on the verged of collapse due to climate change, environmental degradation like conversion of shoreline into reclamation areas, beaches and residences which have push the ecosystem to their limits (Posa *et al.*, 2008) [30] that would result the population to decline, lost or even extinct. Hence, the study was conducted to know the species found and how the physicochemical factors like humidity, temperature, salinity, etc. affect their abundance and distribution in the area.

2. Methodology

2.1. Study Site

Study site is shown in Figure 1. It is located along the 12 km coastline of Badian, Southwestern part of Cebu, Philippines within the geographical coordinates of 9°51'53" North and 123°23'47" East, approximately 97 kilometers away from Cebu City. Badian has an approximate mangrove forest of 80 hectares along the coast. The place is now one of the tourist destinations because of the presence of the Kawasan Falls, Badian Island Resort, International Golf Course and many local beaches in the area

Figure 1. Map showing a portion of the five sampling stations established in Badian, Cebu, Philippines. (https://www.google.com/maps)

Five sampling stations were established. Station 1 is located in Kawasan river mouth, Matutinao, Badian within geographical coordinates of 9°81'0" N, 123°36'0" E. The station is near the school building and residential houses. It has mangrove stands with coralline substrate composed of coral rocks, sands and silt. Station 2 is located near the mouth of Buyawon Creek in Barangay Ginablan within geographical coordinates of 9°83'0" North, 123°37'0" East. A few residential houses the station had several stands of mangroves. The sediments are composed of coralline flat, silt, sand and coralline rocks. Station 3 is located in Barangay Bato with geographical coordinates of 9°83'0" North, 123°36'0" East. The station is approximately 1.5 km away from the national highway with few residential houses, farm lots, small spring and patches of mangroves. The sediments are composed of sand, silt and coral rocks. Station 4 is located in Barangay Lambug with geographical coordinates of 9°85'0" North; 123°36'0" East approximately 1.5 kilometers away from the national road. The station is near an international golf course, residential houses and cottages since it is a beach area and void with mangroves. The sediments are coralline sand and coral rocks. And Station 5 is located in Manduyong River mouth, Barangay Manduyong with a geographical coordinates of 9°89'0" North, 123°39'0" East and approximately 200 meters from the national road. The vegetation is characterized by few of mangroves. The sediment is coralline flat composed of silt, coral stones and rocks.

2.2. Sampling Method

A modified sampling plot area method (English *et al.*, 1997) [16] was used to collect the seawater bugs. As shown in Figure 2, the quadrats were laid 50 meters apart with an area of 500 sq. m. The entire stretch is approximately 10 meters from the intertidal area. Seawater bugs were collected at random during the day by sweeping the aquatic net on the water surface. Handpicked was also applied once the insects had to crawl on the sediments especially during low tide. The collected samples were placed inside a falcon tube with crumpled tissue paper impregnated with ethyl acetate used to kill the insects. Then samples were mounted in paper points using nail polished and paper points were pinned again and stored in boxes. Samples are now deposited in the USC Entomological Collection.

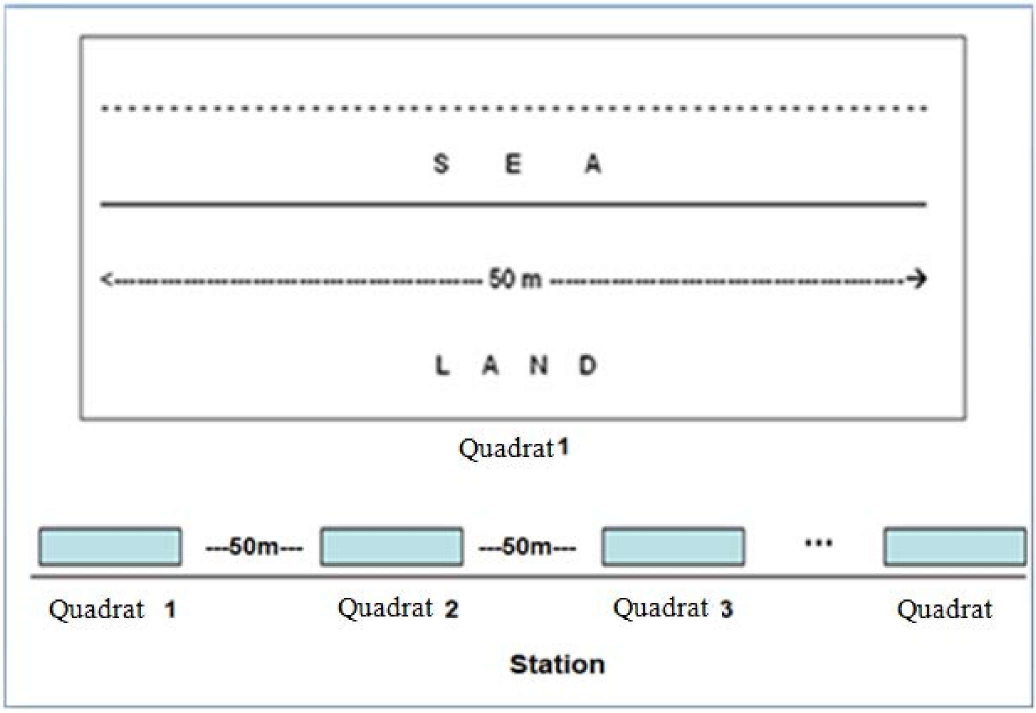

Figure 2. Modified lay-out of the quadrats established in each selected stations

2.3. Determination of Abundance and Distribution

Spatial and temporal abundance of seawater bug species was determined. Species distribution whether regular, random or clump (Cohen *et al.*, 1988) [14] and if they followed normal distribution using Poisson distribution (*E*) pattern was derived also. Pearson r-correlation coefficient (r) by Evans (1996) [17] was applied to determine the abundance of seawater bugs in relation to the effect of rainfall, light intensity, relative humidity, water temperature, pH, salinity, dissolved oxygen, nitrite, nitrate and phosphate level in the study sites.

2.4. Determination of Physicochemical Parameters

Rainfall data was taken in local weather bureau in Cebu City, Cebu.. Instruments used were the Light Meter Model LX-102 for light intensity, Sling Psychrometer for relative humidity, Thermometer for water temperature, pH meter for pH level, Arago Refractometer for salinity and DO meter for dissolved oxygen. A 100 ml seawater samples were taken in each sites to determine the nitrite, nitrate and phosphate level. NED Colometric Analysis for nitrite level, Ascorbic Acid, Colometric Analysis for phosphate level and Chromotropic-Colometric Analysis for the nitrate level were measured and determined, respectively.

2.5. Taxonomic Treatment

Samples of seawater bugs were focused under a light microscope then photograph in the ocular eyepiece using digital camera (Sanyo 7.0 megapixels, 3X optical zoom, 4x digital zoom, 2.5” large LCD) and classified using guide and taxonomic keys and descriptions of families, genus and species by Gapud (9186), Andersen (1989), Andersen (1999), Zettel (2001) and (Chen, Niesser & Zettel (2005) [1,2,13,39].

3. Result

3.1. Species Composition

Seawater bug species found in Badian, Cebu, Philippines are presented in Figure 3 and Figure 4. The species are composed of *Halobates calyptus* Herring, 1822, *Halobates hayanus* Buchanani-White, 1883, *Halobates proavus* Buchanani-White, 1883, *Pseudohalobates inobonto* Polhemus & Polhemus, 1995, *Stenobates sangihi* Esaki, 1926 of the Family Gerridae; *Haloveloides femoralis* Andersen, 1992, *Halovelia esakii* Andersen, 1926, *Halovelia malaya* Esaki, 1930, *Halovelia bergrothi* Esaki, 1926, *Xenobates* sp. 1 and *Xenobates* sp. 2 of the Family Veliidae; *Hermatobates marcheii* Courier & Martin 1901 of the Family Hermatobatidae and *Corallocoris marksae* Woodward 1958 of the Family Omaniidae, respectively.

Figure 3. *Halobates calyptus* ♂ (a), ♀ (b), *Pseudohalobates inobonto* ♂ (c), ♀ (d), *Halobates hayanus* ♂ (e), ♀ (f), *Halobates proavus* ♂ (g), ♀ (h) and *Stenobates sangihi* ♂ (i), ♀ (j) found in Badian, Cebu, Philippines

Figure 4. a) Haloveloides femoralis, b) Xenobates sp. 1, c) Xenobates sp. 2, d) Halovelia bergrohii, e) Halovelia esaki, f) Halovelia malaya, f) Hermatobates marcheii and h) Corallocoris marksae found in Badian, Cebu, Philippines

3.2. Occurrence, Abundance and Distribution of Seawater Bugs in Badain, Cebu

3.2.1. Occurrence

Seawater bugs were monitored during the day. It was observed that *Halobates* and *Pseudohalobates* species fed on small ants and shell during sampling. Similarly, *Halobates* species was also fed on the sandworm larva, *Nereis* sp. in Olango Island, Cebu (FB personal observation). Moreso, an aggregation of *Halobates calyptus* was observed in Station 4 where both sexes still mated each other where brown algae, *Sargassum* species were found.

As shown in Table 1 that *H. calyptus* occurred in all stations and throughout the sampling period except station 1. *H. hayanus* occurred in stations and sampling period except station 1 and January to February 2011. *H. proavus* occurred throughout the season but absent in station 1. *P. inobonto* occurred in Stations 3 and 4 throughout the sampling period except in November 2010 while *S. sangihi* occurred in Stations 2, 3 and 5 and absent on November 2010. *H. femoralis* was very consistent because the species occurred in all stations and throughout the sampling period because the species is recognized as endemic in Cebu Island (Zettel, 2005). *H. esakii* occurred throughout the sampling period except in Stations 1 and 2. *H. malaya* also occurred throughout the sampling period and in Stations 2, 3 and 4. *H. bergrothii* occurred only in Station 4 and absent on January 2011. Similarly, *Xenobates* sp. 1 throughout the sampling period and in sampling sites except in Station 4. *Xenobates* sp. 2, *H. marcheii* and *C. marksae* had an unusual occurrence due to limited samples encountered in the area.

Table 1. Species occurrence of seawater bug species in each of the five station established in the study area in Badian, Cebu, Philippines as of October 2010 to March 2011

Species	Sampling Stations					2010			2011		
	S1	S2	S3	S4	S5	O	N	D	J	F	M
Halobates calyptus		+	+	+	+	+	+	+	+	+	+
Halobates hayanus		+	+	+	+	+	+	+			+
Halobates proavus		+	+	+		+	+	+	+	+	+
Pseudohalobates inobonto			+	+		+		+	+	+	+
Stenobates sangihi		+	+		+	+	+	+		+	+
Haloveloides femoralis	+	+	+	+	+	+	+	+	+	+	+
Halovelia esakii			+	+	+	+	+	+	+	+	+
Halovelia Malaya		+	+	+		+	+	+	+	+	+
Halovelia bergrothii				+		+	+	+		+	+
Xenobates sp. 1	+	+	+		+	+	+	+	+	+	+
Xenobates sp. 2		+					+		+	+	
Hermatobates marcheii					+		+				
Corallocoris marksae	+						+				

3.2.2. Spatial Abundance and Temporal Abundance

Table 2 showed that the most abundant species was *H. femoralis* with 34.22% or 282 individuals/15,000m² followed by *P. inobonto* with 80 individuals and *Xenobates* sp. 1 with 68 individuals in the same Station. *H. calyptus* was abundant in Station 4 with 62 individuals and *H. hayanus* with 39 individuals. *H. proavus* and *S. sangihi* were recorded in Station 3 with 38 and 37 individuals respectively. The three species *H. malaya, H. esakii* and *H. bergrothii* were abundant only in Station 4 and absent in rest of the stations. *Xenobates* sp. 2 was found only in Station 2, while *C. marksae* in Station 1 and *H. marcheii* in Station 5. Family Veliidae which is the most abundant at 56.55% followed by Family Gerridae (42.96 %), Family Omaniidae (0.36 %) and Family Hermatobatidae at 0.12%, respectively.

Table 2. Spatial abundance of adult seawater bugs in Badian, Cebu, Philippines from October 2010 to March 2011

Species	Station 1 Matutinao (1,500 m²)	Station 2 Ginablan (1,500 m²)	Station 3 Bato (5,000 m²)	Station 4 Lambug (5,000 m²)	Station 5 Manduyong (2,000 m²)
Halobates calyptus		8	7	62	8
Halobates hayanus		6	9	39	9
Halobates proavus		5	38	18	
Pseudohalobates inobonto			80	5	
Stenobates sangihi		21	37		2
Haloveloides femoralis	72	36	159	4	11
Halovelia esakii			1	28	1
Halovelia Malaya		14	4	21	
Halovelia bergrothii				17	
Xenobates sp. 1	12	10	68		2
Xenobates sp. 2		6			
Hermatobates marcheii					1
Corallocoris marksae	3				
Total # of bugs/station	87	106	403	194	34
Total # of bugs/500 m²	29	35	40	19	9
Total # of bugs/15,000 m²	824				

As shown in Table 3 also that still *H. femoralis* had the highest average density count of 47 individuals/15,000 m² in December at Station 3. Over six months, this species showed a relatively higher population density except in March 2011. On the other hand, *Xenobates* sp. 1 had relatively higher in all population density except in January and March where their population counts decreased to 2. *P. inobonto* was high in October then the number was reduced to 1 in December and January and increased slightly in February to March. *H. calyptus* occurred in all sampling months with the highest record (32 individuals) in November and lowest (1) in February. *H. hayanus* was high (22) only in November. *H. proavus* occurred throughout the sampling period with the highest record in January with 36 individuals but declined in November. *S. sangihi* was abundant only in October and February. *H. malaya* also occurred throughout the sampling period with the highest abundance in December but undergone decline to only 1 individual in November. *H. esakii* occurred throughout the sampling period at a lower count from 2-7 individuals. *H. bergrothii* was relatively low with only 5 individuals in October and March while *Xenobates* sp. 2 was very low in November comparable to *H. marcheii* and *C. marksae*.

Table 3. Temporal abundance of adult seawater bugs in Badian, Cebu, Philippines from October 2010 to March 2011

	October 2010	November 2010	December 2010	January 2011	February 2011	March 2011
Halobates calyptus	8	32	16	3	1	25
Halobates hayanus	9	22	14			18
Halobates proavus	4	2	8	36	6	5
Pseudohalobates inobonto	48		1	1	20	15
Stenobates sangihi	18	7	13		14	8
Haloveloides femoralis	61	36	95	37	42	11
Halovelia esakii	7	6	2	5	3	7
Halovelia malaya	11	1	14	7	3	3
Halovelia bergrothii	5	1	2		4	5
Xenobates sp. 1	12	25	26	2	25	2
Xenobates sp. 2		3		1	2	
Hermatobates marcheii		1				
Corallocoris marksae		3				
Total # of bugs/month	183	139	191	92	120	99
Total # of bugs/15,000 m²	824					

3.2.3. Species Distribution

The Dispersion Index Value (DIV) indicated that above 3.84 the species showed clumped pattern of distribution and if DIV below 3.84 the species showed normal distribution. Among the 13 species, *H. femoralis* was the highest DIV at 67.65 followed by *P. inobonto* (37.5) then *Xenobates* sp. 1 (30.62), *H. calyptus* (27.17), *S. sangihi* (17.06), *H. hayanus* (15.63), *H. proavus* (15.65), *H. esakii* (13.5) and *H. malaya* (8.11) This indicated that the each species showed clumped pattern of distribution (Cohen, 1998) [14] except for *H. bergrothii*, *Xenobates* sp.2, *H. marcheii* and *C. marksae*. Then the expected frequency of each species showed that followed the Poisson distribution since the value was nearly equal to 2.718 (Table 4).

Table 4. Distribution of seawater bug species found in Badian, Cebu, Philippines as of October 2010 to March 2011

Species	Dispersion Index Value (DIV)	Poisson Distribution (λ) *X*	Poisson Distribution (λ) *E*
Halobates calyptus	27.17	2.83	2.715
Halobates hayanus	15.63	2.13	2.714
Halobates proavus	15.65	2.03	2.713
Pseudohalobates inobonto	37.5	2.83	2.715
Stenobates sangihi	17.06	1.9	2.718
Haloveloides femoralis	67.66	3.07	2.718
Halovelia esakii	13.5	0.2	2.718
Halovelia malaya	8.11	9.4	2.718
Halovelia bergrothii	1.0	1	2.704
Xenobates sp. 1	30.62	1.3	2.721
Xenobates sp. 2	1.0	0.63	2.718
Hermatobates marcheii	1.0	0.03	2.446
Corallocoris marksae	1.0	0.1	2.718

DIV > = 3.84 clumped; < 3.84 not clumped

3.2.4. Physicochemical Parameters

Tides indicated that low tide ranged from 0.03 m to 0.6 m on February to March 2011 while high tide ranged from 0.75 m to 1.8 m on October to December 2010. Tidal fluctuation did not affect the abundance of bugs because even during high tide species such as *H. esakii*, *H. malaya*, *H. bergrothii*, *H. marcheii* and *C. marksae* would hide on sediments in crevices of coral rocks and came out when water receded during low tide (Andersen, 1999; Cheng, *et al.*, 2005) [2,13]. while other species such as *H. calyptus*, *H. hayanus*, *H. proavus*, *P. inobonto*, *S. sangihi*, *Xenobates* sp. 1 and *Xenobates* sp. 2 would not be affected by the tidal cycle since these species were found mostly on the water surface (Zettel, 2001; Andersen, 1999) [39] [2] showing that seawater bug species have different adaptation in the marine ecosystem.

The volume of rainfall would trigger the amount of water in the river or spring to increase in each site. The amount of rain was varied throughout the sampling period. The amount of rain recorded in October was 12.7 mm but decreased to 5.61 mm in November and increased again to 15.8 mm in January (Table 5). Meanwhile, the amount of light was relatively increased its intensity from Station 2 to 5 at 265.17 lux to 505.79 lux but the trend of intensity was increased in October at 253.66 lux to 620.35 lux in March (Table 5 and Table 6). Tait (1986) [34] mentioned that the variation of the intensity of light may due to the canopy of mangroves and clouds formation that may affect the distribution of bugs in the area. And patches of mangroves are densely found in Stations 2, 3 and 5 than in Stations 1 and 4, respectively.

Meanwhile, humidity in Station 2 was at 91.5 % while high in Station 3 at 92.73 %. An increased of humidity occurred at 89.83 % to 93.53 % in November to February and decreased slightly in March at 91.17 % (Table 5 and Table 6). Variation in humidity in the study area could be due to the low or high amount of moisture suspended in air due to rapid evaporation of seawater due to high water temperature. For the water temperature, an increased from Stations 1 to 4 at 29.56°C to 31.33 ºC but decreased to 29.94°C in Station 2. A decreasing trend was observed in October from 32.7°C to 29.08 ºC in January (Table 5 and Table 6). There was a decrease of water temperature even during dry season probably because of the intrusion of underground spring water or upstream water down to the sea.

On the other hand, pH level increased from Station 2 at 6.81 to Station 3 at 7.12 but it decreased at 6.83 in Station 1 and 5. A decreasing trend was observed in October from 7.22 to 6.59 in March (Table 5 and Table 6). The abundance of bugs was indirectly affected by the level of pH since seawater bugs lived on the water surface. It is known that the normal salinity of seawater is 35 ppt. In the study area, salinity increases from Station 1 at 6.0 ‰ to 32.18 ‰ in Station 4 but decreases slightly at 19.38 ‰ in Station 5. A decreasing trend was observed in November at 22.67 ‰ to 19.55 ‰ in March (Table 5 and Table 6). There was a low in salinity in Station 1 and slightly in Station 5 due to the intrusion of water from Kawasan River and Manduyong River but the effect of salinity could be also indirect since bugs are neuston type of marine organisms.

Meanwhile, the saturation level of dissolved oxygen in water is 100%. In the study site, it was obtained that the saturation points of dissolved oxygen was high in Station 1 at 102.35 % but lower in Station 3 at 99.99 % and slightly higher in Stations, 2, 4 and 5. The trend of dissolved oxygen increased in October at 103.74 % then decreased to 99.28 % in February. From November to January the amount was slightly equal at 100 % (Table 5 and Table 6). Whereas, the amount of nitrite in Stations 2, 3 and 5 was similar at 0.01 mg/L and higher than in Stations 1 and 4 at 0.003 mg/L and 0.002 mg/L. Meanwhile, the amount of nitrate in Stations 2 and 4 was low (0.01 mg/L) as compared in Station 5 (0.5 mg/L). However these values are much higher than the values in Stations 1 and 3 at 0.34 mg/L and 0.4 mg/L, respectively. On the other hand, the amount of phosphate was high in Station 3 (0.08mg/L) which higher compared to Stations 2 and 4. The lowest value was in Station 5 at 0.001mg/L (Table 5).

Table 5. Average light intensity, relative humidity, water temperature, pH, salinity, dissolved oxygen, nitrite, nitrate and phosphate per sampling station in Badian, Cebu, Philippines from October 2010 to March 2011

Physicochemical Parameters	Station 1 Matutinao	Station 2 Ginablan	Station 3 Bato	Station 4 Lambug	Station 5 Manduyong
Light Intensity (Lux)	273.72	265.17	291.63	484.2	505.79
Relative Humidity (%)	92	91.5	92.73	91.73	91.83
Water Temperature (ºC)	29.56	29.94	30.26	31.33	29.99
pH level	6.83	6.81	6.94	7.12	6.83
Salinity (‰)	6.0	21.39	25.38	32.18	19.38
Dissolved oxygen (100 % Sat)	102.35	102.12	99.99	100.52	100.61
Nitrite (mg/L)	0.003	0.01	0.01	0.002	0.01
Nitrate (mg/L)	0.34	0.1	0.4	0.01	0.5
Phosphate (mg/L)	0.02	0.03	0.08	0.01	0.001

Table 6. Monthly average rainfall, light intensity, relative humidity, temperature, pH, salinity and dissolved oxygen in Badian, Cebu, Philippines from October 2010 to March 2011

Physicochemical Parameters	October 2010	November 2010	December 2010	January 2011	February 2011	March 2011
Rainfall (mm)	12.7	5.61	12.2	15.8	7.6	10.7
Light intensity (Lux)	343.42	313.14	306.58	253.66	347.46	620.4
Relative humidity (%)	91.67	93.63	93.44	92.41	89.53	91.17
Water temperature (ºC)	32.7	31.03	29.94	29.08	29.13	29.44
pH level	7.22	7.19	6.74	6.73	6.94	6.59
Salinity (‰)	20	22.67	22.17	20.13	20.49	19.55
Dissolved oxygen (100 % Sat)	103.74	101.15	101.35	101.53	99.28	99.64

3.2.5. Correlation

As shown in Table 7, pearsons' r- correlation indicated that regardless positive or negative, the higher the value the stronger the effect of physicochemical parameters to the abundance of bugs and the lower the value the weaker the effect (Evans, 1996) [17]. As shown in Table 7 that light intensity (-0.728), relative humidity (0.796), dissolved oxygen (-0.796) and phosphate level (0.894) constituted stronger effect to the abundance of bugs as compared to other parameters. It was observed however, that the effect of parameters to the abundance and distribution could be indirect since these insects were considered as pleuston type of organism in the marine ecosystem.

Table 7. Pearson r-correlation coefficient (r) of the physicochemical parameters to the abundance of seawater bugs in Badian, Cebu, Philippines from October 2010 to March 2011

Physicochemical Parameters	Pearsons' r- correlation Coefficient	
	Positive (+)	Negative (-)
Rainfall (mm)		0.032
Light Intensity (Lux)	0.278	0.728
Relative Humidity (%)	0.796	0.652
Water Temperature (ºC)	0.39	0.614
pH level	0.48	0.53
Salinity (‰)	0.49	0.44
Dissolved oxygen (100 % Sat)	0.192	0.796
Nitrite (mg/L)		0.356
Nitrate (mg/L)	0.0089	
Phosphate (mg/L)	0.894	

4. Discussion

4.1. Species Composition

The *H. femoralis* was reported by Zettel (2001) [39] as a species endemic to Cebu while *P. inobonto, S. sangihi, H. marcheii* and *C. marksae* to other islands of the Philippines. Other species identified in the area like *H. calyptus, H. hayanus, H. proavus, H. esakii, H. malaya* and *H. bergrothii* are known from tropical regions of the world (Andersen, 1999) [2]. In comparison with the existence of the seawater bugs in various places of the tropical region, the number of species identified in Badian, Cebu was relatively low as compared to other island like Langkawi, Island, Kedah Malaysia which composed of 55 genera (Zettel and Tran, 2009) [42].

4.2. Species Occurrence, Abundance and Distribution

Time of collection was done at 6:30 in the morning and end up at 5:30 in the afternoon. Sampling activity was mostly carried out for at least three stations per day in a month and other stations resulting to no synchronization of collection of bugs in a daily period. The time lapse varied because the distance of each station varied from 3 to 5 km along the coastline of Badian.

Based on the 80 hectares of mangrove forest in the study area, the seawater bugs contributed only 18.75% of the species abundance. This value is equivalent to 28 individuals per 500m². The low count may be attributed to the close association of the seawater bugs to the mangrove vegetation, low water current nature of the area and the time of collection. For example, *S. sangihi, H, femoralis, Xenobates* sp. 1, *Xenobates* sp. 2 are only adapted to below canopy mangroves and low current waves hence few in terms of the total count. The characteristic of *H. marcheii, C. marksae, H. esakii, H. malaya* and *H. bergrothii* to hide on crevices of stones and coral rocks (Gapud 1986; Andersen, 1989, Zettel, 2001; Andersen *et al*,. 2004) [1,3,20,39] may also contribute to the low count of the seawater bugs during the sampling time especially when high tide occurs. In the case of *Halobates* species, Cheng (1972) [10] indicated that the frequency of occurrence of *Halobates* species was lower in daytime than nighttime. Seawater bug species formed a clumped pattern of distribution. In this study, this was observed in the tidal flat area of station 4 in summer were mating was observed. Andersen and Cheng (2004) [3] stated that this mating aggregation was formed by the species with definitive breeding season. Such clumped distribution may also be attributable to the dispersal habit especially in the genus *Halobates* which are wingless species and the species are dispersed only by water and air currents.

4.3. Correlation

It was noted that light intensity was pronounced in Station 5 (505.79 lux) and the relationship was inversely proportional because at high intensities of light the number of bugs decreased while at low intensities their number increased. This variation could be habitat selection of the seawater bugs, for example *S. sangihi* sp. *Xenobates* sp. 1, *Xenobates* sp. 2 and *H. femoralis* are adapted to the canopy of mangroves hence require low light intensities while *P. inobonto, H. calyptus, H. hayanus and H. proavus* are found in the open sea requires high light intensities (Cheng *et al*, 1978; Damkaer 1980; Andersen and Cheng 2004) [3,11,15]. It was noted that the spatial abundance of seawater bugs was affected by relative humidity, temperature, salinity, pH and dissolved oxygen in the study area particularly in Station 3 where most of the population of species were located. The result of study in Badian would reflect the statement of Savopoulou, *et al.*, (2012) [32] that the abundance and distribution of insects is affected by temperature and humidity. Palumbo (2011) [28] also said that temperature is the driving force behind insect development, growth and behavior although these factors did not observed in the species. This was implied by Cheng *et al*., (1990) [12] that the abundance **of *H. germanus* in Indo-Pacific was affected by the surface seawater temperature at 29 ºC which was supported by Andersen and Cheng (2004) [3] that the *Halobates* species are** abundant when seawater temperature was above 20°C.

Anthoni (2006) [4] noted that the amount of salinity usually at 35 ppt made up by all dissolved salts and the differences are caused by either evaporating freshwater or adding freshwater from streams, creeks, and rivers. This would influence the growth and survival of mangroves and accounted for the disposition of silt as determined by the amount of weathering which reduces the incidence of hyper-salinity when high rainfall occurred (FAO, 1994) [18]. In Station 1, salinity was low and the abundance of bugs was also low. Conversely in all Stations 2, 3, 4 and 5 the salinity is within the normal level at 33ppt where the abundance of the bugs was also relatively high. This clearly depicts that seawater bugs are marine adapted organisms that are affected by rainfall-salinity gradient. At pH the range of 6.0 to 7.0 the variation of the seawater bugs was observed. The most abundant species was found in Station 3 where pH level reached to 7.12. Valenzuela *et al.*, (2013) [36] made a study that the pH value of the coastal area in Badian ranged from 7.1 to 8.4 which is correlated with increase number of seawater bugs. Meanwhile, the adequate dissolved oxygen is necessary for good quality of water. The amount of dissolved oxygen harmful to marine organisms is below 110 % saturation point Harris and Vinobaba (2012) [21] and no production impairment at 8 mg/L, moderate production impairment at 5 mg/L and limit to avoid acute mortality at 4 mg/L of aquatic invertebrates. In the case of the amount of dissolved oxygen in Station 1 (102.35 % saturation) was high compared to other stations and the spatial (r= -0.796) and temporal abundance (r= 0.192) of seawater bugs was correlated indicated and the amount was still suitable for the seawater bugs.

In seawater, normal concentration of nitrite is 0.5 ppm, nitrate is 0.7 ppm and phosphate is 0.1ppm (https://web.stanford.edu/group/Urchin/mineral.html). In the sampling sites, the nitrite (0.003 mg/l to 0.0105 mg/L) and nitrate (0.01 mg/L to 0.493 mg/L) were observed to be at tolerable levels. Specifically, the amount of nitrite at Stations 1, 3 and 5 supported the existence of the bugs. Bhatnagar and Devi (2013) [5] stressed out that the amount of nitrite which is equal to zero is still tolerable to the marine organisms. Camargo, *et at*., (2004); Camargo and Alonso (2006) [6,7] proved that seawater bugs were sensitive to nitrate toxicity hence the lower the nitrate level supported the existence of the bugs in all the areas sampled. The amount of phosphate was high in station 3 (0.08 mg/L) where abundance of bugs was also high (403 ind/5,000 m²). There was a high concentration of phosphates because the area is near the farmlot where agricultural crops were planted such as coconut, cassava, corn and fruit trees applied with fertilizer. Rissik *et al.*, (2009) [31] stated that the phosphate level might have increased due to fertilizer application and the chemicals carried during rainfall.

5. Conclusion

There were only 13 species of seawater bug were found in Badian, Cebu Philippines namely Halobates calyptus, Halobates hayanus, Halobates proavus, Pseudohalobates inobonto and Stenobates sangihi of the Family Gerridae; Haloveloides femoralis, Halovelia esakii, Halovelia malaya, Halovelia bergrothii, Xenobates sp. 1 and Xenobates sp. 2 of the Family Veliidae; Hermatobates marcheii of the Family Hermatobatidae and Corallocoris marksae of the Family Omaniidae, respectively. And four species are new record to the province of Cebu that includes H. proavus, P. inobonto, S. sangihi, H. marcheii and C. marksae, respectively.

It was found out that higher the relative humidity, temperature, salinity and phosphate concentration the higher was the number of bugs. The lower dissolved oxygen, nitrate and nitrite concentration the higher the number of bugs. In terms of light intensity some species require lower intensities especially those that are adapted under mangrove canopy while some require higher intensities.

The pH value which correlated with the higher abundance of the bugs ranges from 6.59-7.2 or within the neutral range. Salinity affect the distribution of bugs because some species tend to live near the river mouth or freshwater where salinity was low like *Stenobates sangihi* and *Haloveloides femoralis* while some species tend to live high saline water like *Halobates* and *Pseudohalobates* species.

Pearson's r-correlation coefficient showed that the effect of light, temperature, dissolved oxygen and phosphate level had a strong relationship with the abundance and distribution of bugs. This means that the higher the relative humidity, temperature, dissolved oxygen and phosphate concentration the higher was the number of bugs. The lower the pH, salinity, nitrate and nitrite the higher the number of seawater bugs. However, the mangrove forest in Badian is still stable.

6. Recommendations

Further study on the molecular identification of *Xenobates* species, *Hermatobates marcheii* and *Corallocoris marksae* is recommended due to limited number of samples. Moreover, the study recommends further analysis on the economic value of the seawater bugs as prospective food for fishes and as biological control of harmful insects and other pests.

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