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Community Structure of Phytoperiphyton in "Lab-lab" (Algal Mat) in Brackishwater Ponds in Relation to Water Depth

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The diversity, a univariate measure of both the number of genera present (richness) and their distribution (evenness), of the phytoperiphyton community of a brackishwater pond that received water from a river and the sea was studied during dry and wet seasons. The algal mat ("lab-lab") was sampled when the pond was filled to depths of 5, 10, 15, and 30 cm during 2 and 7 days of submergence to determine the effect of seasons, depth and submergence on the diversity and relate it to the trophic status of periphyton-based pond and quality of "lab-lab" as fish food. Generic diversity and evenness declined with increased depth and colonization time during the dry season but not during the wet season. Richness was affected by depth which was significantly different ($p \leq 0.05$) at 2 days submergence, and highly significant ($p \leq 0.01$) at 7 days submergence. The index of diversity was moderate ranging from 1.0 – 3.2 during dry season and 1.2 - 2.2 during wet season. Richness ranged from 0.7 - 1.4 during dry season and 0.7 - 1.0 during wet season. There were low stabilized genera with evenness that ranged from 0.3 - 0.5 during dry season and 0.2 - 0.5 during wet season. A more diverse community prevailed during the dry season than during the wet season due to differences in environmental conditions.

Key Words: Algal mat, diversity, evenness, phytobenthos, phytoperiphyton, richness

INTRODUCTION

"Lab-lab" is a local name in the Philippines for the algal mat adhering on the pond bottom like a green pasture under water. "Lab-lab" is technically known as periphyton which is a biological complex of minute plants (phytoperiphyton) and animals (zoooperiphyton) attached to submerged surfaces (Wetzel 1971). This was found in the stomach of milkfish and constitutes a large portion of its food (Vicencio 1977). It is a natural food propagated in a system called "lab-lab" method of culture, which is one form of extensive fish farming. It involves the drying of pond bottom, and conditioning and fertilizing the soil. The depth of water is raised gradually to 5, 10, 15 and 30 cm for "lab-lab" to stabilize before the stocking of fish. The pond is then kept relatively shallow (around 30 cm) for the duration of the entire culture period.

A list of genera found in "lab-lab" was previously reported and gave information on what and how many occur in the assemblage during dry and wet seasons (Fortes and Pinosa 2007). This paper listed the various genera and their corresponding count at various depths and days of submergence during dry and wet seasons. Diversity, which is a univariate measure constituting number of genera present (richness) and the distribution of abundances among each genera (evenness), was calculated. The effect of depth, submergence and seasons on diversity of the phytoperiphyton community was assessed. Some studies have shown that

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periphyton community structure, species composition respond to environmental conditions (Cascallar et al. 2003; De Nicola et al. 2004) while Komulaynen (2004) observed that it was mechanical impact of storm runoff rather than any chemical influence affected the periphyton. This study also measured various environmental parameters and correlated them with diversity, evenness, and richness. These indices have been useful to describe the ecological state, performances and sustainability of ecosystems (Naeem et al. 1994). The influence of anthrophogenic impacts on periphyton has been investigated in terms of richness, diversity and biomass in rivers (Komulaynen 2004). Diversity was used to assess water quality (Ngearnpat and Peerapornpisal 2007) and eutrophication (Hillebrand and Sommer 2000). According to De Nicola et al. (2004), there is a complex relationship between biological diversity and trophic structure in the ecosystem and algal communities has been used to assess trophic status.

This paper aimed to link these indices to the trophic status of periphyton-based aquaculture system and quality, quantity, and availability of "lab-lab" as fish food in brackishwater ponds during the wet and dry seasons. The quality and quantity of food is very important in the rearing of fish. During the last few decades, the natural food in fishpond was taken fore granted and many fish farmers shifted to the use of formulated artificial diets that gave higher production. But this caused environmental degradation and outbreak of disease. Hence, its timely and urgent to take a paradigm shift on the use of natural food. Therefore this study was undertaken to provide information on how to maximize the use of natural food and minimize or discard the use of formulated diets today. Moreover the use of natural food is environment friendly and may also alleviate the effect of climate change. The study somehow addressed the concern of fish farmers on the difficulty of growing abundant "lab-lab" during wet season.

MATERIALS AND METHODS

Experimental Set-up

The study was conducted in a 1000-m^2 earthen pond of the Brackishwater Aquaculture Center, Institute of Aquaculture, College of Fisheries and Ocean Sciences, UP Visayas, Leganes, Iloilo located along the coast of Leganes, Iloilo Philippines. The pond had sources of water coming from a freshwater river (Jalaur) and the sea (Guimaras Strait). The pond was dried, leveled, and fertilized with 600 kg (2g/L) chicken manure. Water was admitted at 2 cm depth to initiate "lab-lab" growth then 5 kg of 16-20-0 (0.25g/L) commercial fertilizer was applied to sustain luxuriant growth before the stocking of milkfish. Twenty four artificial substrates were installed before filling up the pond with water following the method employed by Fortes and Piñosa (2007).

Algal Sampling and Counting

Three artificial substrates were randomly removed biweekly corresponding to 2 and 7 days submergence at water depths of 5, 10, 15, and 30 cm in the course of pond preparation prior to the stocking of milkfish (*Chanos chanos* Forsskal). Algal sampling was done as described by Fortes and Piñosa (2007). The "lab-lab" collected was thoroughly mixed and homogenized to uniform consistency and approximately 1 to 2 g were taken from the sample. One gram of the sample was diluted to 10 mL of water and a drop of it was examined qualitatively under a compound microscope. This was repeated several times to scan completely the organisms present. Fresh samples were examined on the same day of sampling but if this was not possible, these were stored in a freezer and analyzed within the week. Some samples were preserved in formalin solution for future use. The single and small-celled algae were counted using a haemacytometer following the method of Martinez et al. (1975) while the filamentous and bigger algae were counted using a Sedgewick rafter counting chamber (Welch 1949). Several counts were made on the sub-samples taken to obtain a reliable count and more accurate estimate of density. The number of cells per unit area, (cells/cm^{-2}) was calculated using the following formula:

$$N = (PxC)/S,$$

where P is the number of cells counted in the haemacytometer or sedgewick chamber
C is the volume of the concentrate (mL);
S is the scraped area in cm^{-2}
N is the number of organisms cm^{-2}

Community Structure Calculations

Community structure indices of diversity, richness, and evenness were computed based on the methods described by Ludwig & Reynolds (1988), which are as follows:

1. Shannon-Weaver Index of diversity

$$d = \Sigma (ni / N) \log_2 (ni / N)$$

where s = total number of genera collected
ni = number of individuals within a species
N = total number of the individuals collected

2. Species Richness

$$di = \frac{S - 1}{\text{Log } N}$$

where S = number of species
N = number of individuals

3. Evenness Index

$$E = \frac{H}{n(S)}$$

where H = Shannon index
S = number of species in the community

Water Analysis
The following water parameters were determined *in situ*: water salinity with an Atago refractometer, dissolved oxygen and temperature with YSI oxygen meter and pH with digital pH meter. All of these measurements were detectable and accurate within 0.1 unit. Water was sampled where the artificial substrates were installed. Three 1-L containers were filled with water before the substrates were lifted to obtain clear water samples. These were brought immediately to the laboratory for chemical analysis. The inorganic phosphate was determined using orthophosphate molybdate method, ammonia-nitrogen (NH_4-N) using phenol hypochlorite method, and nitrate-nitrogen (NO_2-N) by diazotization process (Strickland and Parsons 1972). Both water and "lab-lab" samples were taken between 07:30 and 08:30 hr during the dry season (March-April, 2003) and wet season (June-July, 2002).

Statistical Analysis
A 4 x 2 factorial experiment in a complete randomized design (Gomez and Gomez 1984) was used. The values obtained were compared using ANOVA with factors 5, 10, 15, 30-cm depths, and 2 and 7 days of submergence. The values between dry and wet seasons were compared using T-test. The Pearson's correlation coefficient between environmental parameters and community indices were also determined. The SPSS Version 10 statistical package was used to perform the analysis.

RESULTS

The list of organisms found in the "lab-lab" during the dry season are shown in Table 1. Results reveal a general decline in the number of genera with depth, but the number of individuals increased as depth was increased. There were five genera of cyanobacteria present and *Merismopedia, Oscillatoria, and Lyngbya* occurred throughout the period with *Oscillatoria* as the most dominant. *Spirulina* and *Plectonema* occurred only twice. There were six genera of Chlorophytes (green algae). *Ulothrix* was present throughout the period, while *Enteromorpha* occurred seven times. *Chlamydomonas* was the most numerous and ocurred on six occasions. Sixteen diatom genera were present and among them *Cymbella, Nitzschia, Pleurosigma,* and *Surirella,* were present throughout the period. *Nitzschia* was the most numerous among the diatoms. *Ceratium* occurred only once.

The pattern of algal distribution in "lab-lab" during the wet season differed from that of the dry season (Table 2). The highest number of genera was found at depths of 10 and 15 cm and the least at a depth of 30 cm. The total counts fluctuated irregularly. Seven genera of cyanobacteria were found and *Oscillatoria* occurred the most, followed by *Lyngbya*. There were four genera of Chlorophytes and *Chaetomorpha* were present all throughout. Fourteen diatom genera were found and *Amphora,Cymbella, Navicula, Nitzschia,* and *Pleurosigma* were present at all times while *Navicula* had the highest count.

Table 3 shows the values of the community structure indices for the dry and wet seasons and Table 4 presents the results of their ANOVA. During dry season, diversity and evenness indices differed with depth, highly significant at 2 days and 7 days of submergence at $p \leq 0.01$. The Pearson's correlation coefficient between diversity and evenness was high with a value of 0.974 and highly significant ($p \leq 0.01$) at 2 days of submergence; and a value of 0.606 significant ($p \leq 0.05$) at 7 days of submergence. The Pearson's correlation coefficient between evenness and diversity during the wet season were 0.977 and 0.967, highly significant at $p \leq 0.01$ for 2 and 7 days of submergence, respectively. Results reveal that species diversity and evenness were correlated and that both indices declined with depth during the dry season. The species richness was significantly different with depth ($p \leq .05$) at 2 days of submergence, and was highly significant ($p \leq 0.01$) at 7 days of submergence. The Pearson's correlation coefficient between indices of diversity and richness obtained were 0.596, ($p \leq 0.05$) during 7 days of submergence, but a value of 0.491($p \geq 0.05$) was noted at 2 days of submergence. Between evenness and richness indices, the Pearson's correlation coeffecient was 0.864 (at $p \leq 0.01$) at 7 days of submergence, and a value of 0.4 ($p \geq 0.05$) at 2 days of submergence. During the wet season, there was no significant differences among the indices with depth.

The ranges of values of various parameters and the Pearson's correlation coefficients between these and community indices during the dry season are shown in Table 5.

During dry season, dissolved oxygen was high initially and declined towards the end of the experiment and the same trend was observed during the wet season where the peak value was at depth of5 cm and 7 days of submergence and the lowest was at depths of 30 cm and 7 days of submergence. The pH during the dry season was relatively

Table 1. Density of algae in "lab-lab" (algal mat) at various depths in the course of pond preparation during dry period (March-April).

	Mean counts (org x $10^5/m^2$) at different depths							
Depths	5 cm		10 cm		15 cm		30 cm	
Period(week)	1		2		3		4	
Days of submergence	2 days	7 days	2 days	7 days	2 days	7 days	2 days	7 days
Algae								
Blue green (Cyanobacteria)								
Lyngbya	164	8046	3307	1549	3155	2695	6796	2961
Merismopedia	0	594	3	2	7	781	25	16
Oscillatoria	13513	31579	5016	5712	18901	9471	46541	12118
Plectonema	378					1623		
Spirulina	1209				1464			
sub-total	15264	40219	8326	7263	23526	14569	53362	15095
Green (Chlorophyta)								
Chlorella	677			1418	2127		14498	
Clamydomonas	14530	4116			43159	71344	237299	125688
Chaetomorpha	113	502	666	691			1063	
Enteromorpha	0	560	1342	1443	24	1486	4	
Spirogyra	0							
Ulothrix	4607	6315	1475	709	9	918	1207	11
sub-total	19927	11493	3483	4261	45320	73747	254072	125699
Diatoms(Bacillariophyta)								
Amphora		559				918		
Amphiprora	378					3950		
Chaetoceros	414	485			1064	1698		
Coscinodiscus	1612		666					
Cyclotella		5750	788	1418	1796			
Cymbella	8688	16562	15504	12819	17304	36959	76171	9933
Diatoma	1134	485						
Fragilaria			788					
Mastogloia	1512		29594	5694	2527	2616		
Navicula	15802	19091	43966	42791	25089			2527
Nitzschia	22430	18354	34385	91806	311197	314592	455448	685467
Pinnularia			788		3326	1486		
Pleurosigma	10618	2263	1986	4288	2670	7286	8119	12747
Surirella	2796	4467	1864	2151	3991	4314	2340	1435
Tabellaria								2185
Thallasiothrix		593						
sub-total	65386	68609	130328	160966	368963	373819	542078	714294
Dinoflagellates(Phyrrophyta)								
Ceratium			533					
	0	0	533	0	0	0	0	0
Total Count	100577	120321	142669	172490	437810	462136	849512	855088
Total # of genera	21	17	17	14	17	15	12	10

stable but during the wet season lower pH was observed at depth of 5 cm and highest at depths of 15 cm and 30 cm. The temperature during dry season was higher and relatively stable but during the rainy season it fluctuated irregularly. The inorganic phosphate during both dry and wet season declined with increase in depth. The same is true with nitrite during the dry season, however during the wet season high concentrations were observed at depths

Table 2. Density of algae in "lab-lab" (algal mat) at various depths in the course of pond preparation during wet period (June-July).

	Mean Counts (org x $10^5/m^2$) at different depths							
Depths	5 cm		10 cm		15 cm		30 cm	
Period (week)	1		2		3		4	
Days of submergence	2 days	7 days	2 days	7 days	2 days	7 days	2 days	7 days
Algae								
Blue green (Cyanobacteria)								
Anabaena	530	236			936	322	1167	
Lyngbya	1124	236	647	561		894		3271
Merismopedia	59		417					
Oscillatoria	15697	238746	256420	69559	209532	95007	90352	53664
Nodularia							677	
Plectonema				2988				
Spirulina	72					322		
sub-total	17482	239218	257484	73108	210468	96545	92196	56935
Green (Chlorophyta)								
Chaetomorpha	1533	97	4692	4541	11411	9797	11064	1588
Chlamydomonas				620				528
Enteromorpha					300		3873	
Ulothrix				4559	18797	572		
sub-total	1533	97	4692	9720	30508	10369	14937	2116
Diatoms(Bacillariophyta)								
Amphora	1326	1849	1049	1284	2066	2435	1198	1541
Coconeis		188						
Coscinodiscus		97	632		636	514		528
Cyclotella					936	643	677	
Cymbella	1012	1659	8675	2819	3392	514	3074	5754
Dactyliosolen				332				
Mastogloia			834					
Navicula	1447	15531	9985	7792	10648	5584	10323	11645
Nitzschia	376	9970	3138	2442	4659	1921	3323	2138
Pinnularia			1211	2921		1407		1610
Pleurosigma	881	2127	3926	2008	1924	572	4678	1635
Rhizosolenia					300			
Stauroneis	59		1022	893	494			
Surirella	764	4573	1912	332	300	835	1937	
sub-total	5865	35994	32384	20823	25355	14425	25210	24851
Total Count	24880	275309	294560	103651	266331	121339	132343	83902
Total # of genera	13	12	14	15	15	15	12	11

Table 3. Variation in the indices of diversity, evenness, and richness with depth at 2 days submergence (A) and 7 days submergence (B).

	Diversity		Evenness		Richness	
Depth (cm)	Wet	Dry	Wet	Dry	Wet	Dry
A. 2 days submergence						
5	2.2±1.1	3.2±0.1a **	0.7±0.2	0.5±0.1 a **	0.89±0.9	1.4±0.2 a*
10	1.2±0.9	2.5±0.3 b **	0.5±0.2	0.4±0.1a b**	0.9±0.9	1.2±0.1 a b*
15	1.7±0.7	1.5±0.3bc **	0.6±0.2	0.2±0.1 c **	1.0±1.0	1.0±0.3 a b*
30	1.7±0.4	1.8±0.1 c **	0.7±0.04	0.2±0.04 cb **	0.7±0.7	0.8±0.01 b*
B. 7 days submergence						
5	1.3±0.6	2.9±0.2a **	0.3±0.2	0.5±0.04a **	0.7±0.1	1.2±0.1 a **
10	1.8±0.7	2.0±0.2b **	0.7±0.1	0.3±0.4b**	0.9±0.2	1.0±0.1b **
15	1.7±0.9	1.8±0.9c**	0.5±0.05	0.21±0.1bc**	0.9±0.2	1.0±0.2ab **
30	1.8±0.5	1.0±0.2 c**	0.6±0.01	0.2±0.02c**	0.7±0.2	0.7±0.01 c **

** Values with different superscript are significantly different at $P \leq 0.01$
* Values with different superscript are significantly different at $P \leq 0.05$

Table 4. Summary of the analysis of variance for the community structure indices.

A. 2 days submergence		Season	Sum of square	df	Mean square	F	Sig
Evenness	Between groups	Wet	0.095	3	0.032	1.53	0.280
	Within Groups		0.166	8	0.021		
	Total		0.261	11			
	Between groups	Dry	0.153	3	0.051	8.98	0.006
	Within Groups		0.045	8	0.006		
	Total		0.193	11			
Diversity	Between groups	Wet	1.483	3	0.494	0.76	0.546
	Within Groups		5.182	8	0.648		
	Total		6.665	11			
	Between groups	Dry	5.184	3	1.728	29.74	0.000
	Within Groups		0.465	8	0.058		
	Total		5.649	11			
Richness	Between groups	Wet	0.16	3	0.053	1.36	0.324
	Within Groups		0.316	8	0.039		
	Total		0.476	11			
	Between groups	Dry	0.443	3	0.148	3.90	0.055
	Within Groups		0.303	8	0.038		
	Total		0.746	11			
B. 7 days submergence							
Evenness	Between groups	Wet	0.214	3	0.071	3.86	0.056
	Within Groups		0.148	8	0.018		
	Total		0.361	11			
	Between groups	Dry	0.137	3	0.046	21.95	0.000
	Within Groups		0.017	8	0.021		
	Total		0.153	11			
Diversity	Between groups	Wet	0.58	3	0.193	0.40	0.757
	Within Groups		3.872	8	0.484		
	Total		4.452	11			
	Between groups	Dry	5.644	3	1.881	7.82	0.009
	Within Groups		1.924	8	0.24		
	Total		7.567	11			
Richness	Between groups	Wet	0.105	3	0.035	1.13	0.394
	Within Groups		0.249	8	0.031		
	Total		0.354	11			
	Between groups	Dry	0.466	3	0.155	10.15	0.004
	Within Groups		0.122	8	0.015		
	Total		0.588	11			

of 5 cm and 15 cm. Ammonia concentration during wet season was highest at depth of 5 cm but during the dry season it was low and stable. The salinity was high with minimal fluctuations with the highest value at depth of 5cm during dry season. Lower salinity with wider irregular fluctuations was observed during the wet season.

DISCUSSION

The Effect of Seasons

The higher values of the indices obtained during the dry season compared to the wet season suggests the effect of the differences in climate. The amount of rainfall recorded

Table 5. Ranges of environmental parameters and Pearson's correlation coefficient between community indices during wet and dry season at 2 and 7 days submergence.

		D.O (mg/L^{-1})	Salinity (ppt)	NO_2-N (ppm)	Soluble-P (ppm)	Temperature (^oC)	pH	NH_3-N (ppm)
Ranges	Dry Season	2.8 - 9.5	35 - 72	0.003 - 0.025	0.153 - 0.643	26.3 - 32.2	8.2 -8.7	0.01 - 0.05
	Wet Season	2.3-9.0	15 - 40	0.0008 - 0.027	0.0029 - 1.38	27.7 - 30.2	7.2 - 8.4	0.03 - 1
Dry Season Indices	Days of submergence	Pearson correlation coefficient						
Diversity	2	0.646**	0.833**	0.812**	0.569	-0.222	0.352	-0.46
	7	0.812*	0.767**	0.719**	0.791**	0.512	-0.039	0.38
Evenness	2	0.567	0.725**	0.719**	0.519**	-0.195	0.217	-0.501
	7	0.919**	0.902**	0.884**	0.867**	0.436	0.329	0.52
Richness	2	0.539	0.708**	0.649**	0.712*	-0.124	0.266	-0.531
	7	0.711**	0.862**	0.654*	0.850**	0.573	0.528	0.213
Wet Season								
Diversity	2	-0.164	-0.094	0.111	0.12	-0.296	-0.121	0.432
	7	-0.336	-0.096	-0.522	-0.132	-0.474	0.33	-0.44
Evenness	2	0.147	-0.274	-0.029	0.072	-0.193	-0.113	0.379
	7	–.654*	-0.052	-0.822**	-0.078	-0.836**	0.657*	-0.699
Richness	2	-0.47	0.373	0.602*	0.236	-0.313	-0.1	0.173
	7	0.116	-0.077	-0.165	0.208	-0.275	0.38	-0.199

by Philippine Atmospheric Geophysical and Astronomical Administration (PAGASA) weather bureau at Manduriao, Iloilo City during the wet season (June–July 2002) were 192 mm and 598 mm, respectively while no amount of rainfall was recorded during the dry season (March-April 2003). Species diversity is generally related to climate conditions (Kiffney & Bull 2000; Weckstroem & Korhola 2001). During the wet season, the rain intermittently disturbed the bottom and dislodged the "lab-lab", and sediments also became suspended in the water column. This may have affected the distribution that resulted in lower values of the indices. It was reported that periphyton community stucture was influenced by disturbance, substratum, water flow regulation and sediment flushing (Collier 2002; Luttenton & Baisden 2006). Biggs & Smith (2002) reported that moderate fluctuations and reduced richness was partly a result of flood disturbance and flow perturbations. They further observed that highest richness occurred in low flood frequencies. It has also been reported that species diversity is lower in areas of high ecological stress and disturbance (Riis & Hawes 2002). The same phenomena are noted in this study where richness and diversity indices were reduced during rainy season.

Effect of Depth and Submergence

Species richness and diversity in phytoplankton were also observed to exhibit significant patterns of variations in space and time (Vadrucci et al. 2003). This could be true also with phytoperiphyton. Significant decline among the community indices with depth during the dry season could be due to colonization time. It is possible that at the beginning of the period, many organisms tried to colonize themselves and compete for the space, but only the resistant species survived. It was theorized that increase in diversity during the early stages is caused by the arrival of many new organisms that would try to colonize themselves (new colonists) while competition would decrease the diversity during the later stages (Valiela 1995). As a result, the rare and sensitive species disappeared and only the resistant ones proliferated. The increased dominance of few species reduced evenness and offset the increase in species number of new colonists. The diversity index therefore influenced evenness more than richness (Sager and Hasler 1969). This was likewise observed in this study.

The organisms that were transported with the incoming water during flooding of the ponds cannot immediately effect a change in richness because ample time is probably needed before they are able to withstand the new environment. The longer the submergence the more established the organisms become to increase level of richness. Results of this study show that richness was affected by the number of days of submergence. Richness therefore appears to have been influenced by the period of colonization. On the other hand, it was also reported that the rate of colonization maybe important for short periods following exposition of substratum afterwards, since algae grow rapidly on substrata and that specific growth rates maybe more influential on periphytic composition than colonization time (Peterson 1996). This study demonstrates that richness correlates with diversity and evenness indices. Variation in biodiversity is necessarily associated with changes in composition, and affect ecosystem attributes and trophic interaction among species that are characteristics of natural complex ecosystem (Downing and Leibold 2002).

The Effect of Various Environmental Parameters

The environmental parameters may also have affected the changes in richness, diversity and evenness as evidenced by their significant relationship with salinity, nitrate, inorganic phosphate, and dissolved oxygen during the dry season. Studies have shown that periphyton community structure, species composition, and succession respond to environmental conditions (Cascallar et al. 2003; De Nicola et al. 2004).

The decrease in the number of genera and total community counts towards the end of the study could be due to decrease in inorganic phosphate and nitrite concentrations. It was reported that the increasing supply of limiting nutrients led to the decrease in marine microphytobenthic diversity with time due to competitive displacement (Hillebrand and Sommer 2000). It is also possible that nutrient limitation towards the end resulted in the elimination of the more sensitive species and in the dominance of few resistant ones. The parameters that did not show significant relationships with diversity, evenness and richness during dry season were pH, temperature, and ammonia.

The correlation coefficients obtained between the indices and the environmental parameters such as dissolved oxygen, salinity, nitrite, and inorganic phosphate, were low although to some extent some of these values were significant during the dry season. There is likely an effect of these environmental parameters especially during dry season but not during the wet season. According to Komulaynen (2004) mechanical disturbance caused by storm run-off, retarded the colonization of periphyton rather than any chemical influence. In this study, the disturbance of the pond bottom due to rain during the wet season could have affected our results more than the water quality parameters. During the rainy season, it was observed that some algae got dislodged from its substrate. It is also possible that their recolonization and recovery were difficult because of the silt and sediments in suspension caused the water turbid. In this study we also observed snails crawling on the "lab-lab" and it is possible that these grazers have affected and altered species diversity of the "lab-lab". Sommer (1999) found low abundances of grazers caused increase diversity which was prevalent at the onset of the study. Grazers reduced biomass and richness of algae (France and Duffy 2006). This could have affected the results towards the end of the period where diversity declined.

SUMMARY AND CONCLUSION

This study has provided the scientific basis for recommending and using "lab-lab" during dry season and an alternative deep-water plankton method during wet season. During the dry season, the significant effect of depth on community structure indices was demonstrated. This implies the importance of regulating depth in the process of growing "lab-lab" during dry season. Depth regulation decreases richness and increases biomass and low evenesss with few dominant species and exclusion of less resistant ones. The results indicate a more stable condition and more available food for the cultured fish during dry season. The effect of depth is not significant during wet season, the disturbance due to intermittent rain is more influential on the colonization of "lab-lab". The community indices of diversity, richness, and evenness of the phytoperiphyton in "lab-lab" vary between the dry and the wet seasons, thus "lab-lab" composition and quality as well as its density are seasonal in brackishwater ponds. A more diverse assemblage of algae with higher degree of evenness and distribution prevails during dry season because of undisturbed conditions.

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REFERENCES

BIGGS BJF, SMITH RA. 2002. Taxonomic of stream benthic algae, effect of flood disturbance and nutrients. Limnol Oceanogr 47:1175-1186.

CASCALLAR L, MASTRANDUONO P, MOSTO P, REINFFELD M, SANTIAGO J, TSOUKALIS C, WALACE S. 2003. Periphytic algae as bioindicators of nitrogen inputs in lakes. J Phycol 39:7-8.

COLLIER KJ. 2002. Effects of flow regulation and sediment flushing on instream habitat and benthic invertebrates in a New Zealand river influenced by a volcanic eruption. River Research and Applications 18:213-226.

DE NICOLA DM, EYTO ED, WEMAERE A, IRVINE K. 2004. Using epilithic algal communities to assess trophic status in Irish lakes. J Phycol 3:481-495.

DOWNING AL, LEIBOLD MA. 2002. Ecosystem consequences of species richness and composition in pond food webs. Nature 416:837-840.

FORTES NR, PIŇOSA LAG. 2007. Composition of phytobenthos in "lab-lab", a periphyton-based extensive aquaculture technology for milkfish in brackishwater ponds during dry and wet seasons. J Appl Phycol 19:657-665.

FRANCE KE, DUFFY JE. 2006. Consumer diversity mediates invasion dynamics at multiple trophic levels. Oikos 113:515-529.

GOMEZ KA, GOMEZ AA. 1984. Statistical Procedures for Agricultural Research, 2nd ed. New York: John Wiley and Sons. 680p.

HILLEBRAND H, SOMMER U. 2000. Diversity of benthic microalgae in response to colonization time and euthrophication. Aquat Bot 67:221-236.

KIFFNEY PM, BULL JP. 2000. Factors controlling periphyton accrual during summer in headwater streams of southwestern. J Freshwater Ecol 3:339-351.

KOMULAYNEN S. 2004. Experience of using phytoperiphyton monitoring in urban watercourses. Oceanological and Hydrobiological Studies 33: 65-75.

LUDWIG JA, REYNOLDS JF. 1988. Statistical ecology: A primer on methods and computing. New York: John Wiley. 337p.

LUTTENTON MR, BAISDEN C. 2006. The relationships among disturbance, substratum size and periphyton community structure. Hydobiologia 561:111-117.

MARTINEZ MR, CHAKROFF CL, PANTASTICO JF. 1975. Direct phytoplankton counting techniques using the haemacytometer. Philipp Agric Sci 55:43-50.

NAEEM S, THOMPSON LJ, LAWLER SP, LAWTON JH, WOODFIN RM. 1994. Declining biodiversity can alter the performance of ecosystems. Nature 368:734-737.

NGEARNPAT N, PEERAPORNPISAL Y. 2007. Application of desmid diversity in assessing the water quality of 12 freshwater resources in Thailand. J Appl Phycol 19:667-674.

PETERSON CG. 1996. Response of periphyton communities to natural physical disturbance. In: Algal Ecology. Freshwater Benthic Ecosystem. Stevenson RJ, Bothwell ML, Lowe RL, eds. San Diego: Academic Press. p375-402.

RIIS T, HAWES I. 2002. Relationships between water level fluctuations and vegetation diversity in shallow water of New Zealand lakes. Aquat Bot 74:133-148.

SAGER PE, HASLER AD. 1969. Species diversity in lacustrine phytoplankton: the components of the index of diversity from Shannon's formula. Am Nat 103:51-59.

SOMMER U. 1999. The impact of herbivore type and grazing pressure on benthic microalgal diversity. Ecol Lett 2:65-69.

STRICKLAND JDH, PARSONS TR. 1972. A Practical Handbook of Seawater Analysis, 2nd ed. Ottawa Canada: Fisheries Research Board of Canada. 310p.

VADRUCCI MR, VIGNES F, FIOCCA A, BASSET A, SANTARPIA I, CARRADA GC, CABRINI M, UMANI SF. 2003. Space-time patterns of co-variation of biodiversity and primary production in phytoplankton guilds of coastal marine environments. Aquatic Conservation: Marine and Freshwater Ecosystems 13:489-506.

VALIELA I. 1995. Marine Ecological Processes. New York: Springer. 686p.

VICENCIO ZT. 1977. Studies on the food habits of milkfish *Chanos chanos* (Forsskal) Fish. Res J Philipp 2:1-18.

WECKSTROEM J, KORHOLA A. 2001. Patterns in the distribution, composition and diversity of diatom assemblage in relation to ecoclimate factors in Artic Lapland. J Biogeography 28(1): 31-45.

WELCH P. 1949. Limnological Methods. New York: Mc Graw Hill. 380p.

WETZEL RG. 1971. Periphyton: Methods of measuring production rates. In: A Manual on Methods of Measuring Primary Production in Aquatic Environments. Vollenweider RA. ed. Edinburg: Blackwell Scientific Publications Oxford. p.41-133.