

SILLIMAN JOURNAL

VOLUME 56 NUMBER 4 | OCTOBER TO DECEMBER 2015

**A JOURNAL DEVOTED TO DISCUSSION AND INVESTIGATION
IN THE HUMANITIES AND SCIENCES**

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The Silliman Journal is published quarterly under the auspices of Silliman University, Dumaguete City, Philippines. Entered as second class mail matter at Dumaguete City Post Office on 1 September 1954.

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ISSN 0037-5284

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Silliman University Main Library
6200 Dumaguete City, Negros Oriental
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Issues are also available in microfilm format from

University Microfilms International
300 N. Zeeb Road, Ann Arbor
Michigan 48106 USA

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Book design by Rigel dela Cruz Suarez
Layout by Elaine Pastor
Cover Art "*Andrew's Accent*" by Dr. Elizabeth Susan Vista-Suarez
Printing by SU Printing Press, Dumaguete City

SILLIMAN
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VOLUME 56 NUMBER 4
OCTOBER TO DECEMBER 2015

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SILLIMAN JOURNAL is especially receptive to the work of new authors. Articles should be products of research taken in its broadest sense and should make an original contribution to their respective fields. Authors are advised to keep in mind that Silliman Journal has a general and international readership, and to structure their papers accordingly.

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Manuscripts of up to 10,000 words, including tables and references, should conform to the conventions of format and style exemplified in a typical issue of Silliman Journal. Documentation of sources should be discipline-based. Whenever possible, citations should appear in the body of the paper, holding footnotes to a minimum. Tables must be held to a maximum of five. Pictures or illustrations will be accepted only when absolutely necessary.

All articles must be accompanied by an abstract of 200 words and keywords of not more than ten words, and must use gender-fair language.

SILLIMAN JOURNAL likewise welcomes submissions of “Notes,” which generally are briefer and more tentative than full-length articles. Reports on work-in-progress, queries, updates, reports of impressions rather than research, responses to the works of others, even reminiscences are appropriate here.

SILLIMAN JOURNAL also accepts for publication book reviews and review articles.

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Editorial Notes

“As human beings, we are vulnerable to confusing the unprecedented with the improbable. In our everyday experience, if something has never happened before, we are generally safe in assuming it will never happen in the future, but the exceptions can kill you, and climate change is one of those exceptions.”

– **Al Gore**

“Life’s most persistent and urgent question is, ‘What are you doing for others?’”

– **Martin Luther King, Jr.**

Welcome to the fourth issue of Silliman Journal on its first year as a quarterly publication. SJ 2015 1 was also primarily a science issue and we end the year again with the studies of our colleagues from the natural and allied sciences.

The first full-length article is one where biologists Robert Guino-o and his associates assessed the mariculture situation in Calape Bay, Central Philippines and found that, after three decades of mariculture activities, the Bay is threatened with organic pollution from internal and external sources. The authors recommend the establishment of a water monitoring system inside the bay the soonest possible time to regulate and maintain a healthy water quality standard for a sustainable aquatic ecosystem. In addition, still to be determined are the impacts of aquaculture-induced and river-carried sedimentation and organic matter on marine diversity and people’s fishing livelihood in and nearby Calape areas.

Similarly, marine science researchers Iday Reboton and Nida Calumpong compare the coral reefs at two sites from each of three regions in the Philippines: Masbate in Region 5, Negros Oriental in Region 7, and Davao Oriental in Region 11. Coral cover has increased in Masbate and Negros Oriental while remaining the same in Davao Oriental (declining even at one site). In addition, the Apo Chapel (Negros Oriental) has the highest species diversity. Reef development was good in Apo Chapel and

the sites in Davao Oriental. The authors discussed factors such as level of protection, exposure to natural and anthropogenic disturbances, and species composition that influence these changes.

Then, Adel Caburian and company investigate the “Antimicrobial Activity of the Volatile Oil from the Leaves of Piper betle Linn.” This study of the betel leaf was rationalized on previous literature indicating that antimicrobials are one of our most important weapons in fighting bacterial and fungal infections, greatly benefiting the health-related quality of human life. However, over the past few decades, these health benefits have been under threat as many commonly used antibiotics have become less and less effective against certain illnesses not only because many of them produce toxic reactions, but also due to the emergence of drug-resistant bacteria. In the Philippines, the authors add, traditional medicine is one of the primary healthcare systems; plant extracts are widely claimed to have a broad-spectrum antibacterial and are considered as a main source for the search of lead compounds. The results show active to very active inhibition of the bacterial and fungal growth against the test organisms, but the mechanism of its antimicrobial activity is not yet well understood.

The fourth paper, entitled “Morphological and Thickness Characterization of Spin Coated Nafion Thin Films on Glass Substrate” by Shirley Tiong-Palisoc, Stephen Tadios, and Michelle Natividad, is a study of sensors. According to the authors, a sensor is a device designed to respond and detect a physical quantity and convert it to an observable output. Mercury is one example and the most commonly used because in addition to being resilient and very conductive, it is also highly sensitive and reproducible. It is, however, highly toxic. Alternatively, because of its low cost compared to other deposition techniques, spin coating was chosen as the method of fabricating Nafion thin films in this study. Results show that thickness of Nafion films decrease with increasing angular velocity and increase with increasing concentration.

In a different context, psychologist Pierce Docena of the University of the Philippines in Tacloban, Leyte studies discharged youth offenders with crime desistance, looking particularly into their lives after rehabilitation. Docena interviewed ten male youth offenders in Eastern Visayas, finding that desistance from crime is a long and difficult process influenced by various factors such as family support, condition of one’s community, intervention of significant persons, having a job, getting married, and having children.

Finally, physical therapy professors Reynaldo Ramos and Cyflor Putong investigate musculoskeletal disorders among teachers vis-a-vis the demands of their work. Not surprisingly, results indicated that teachers in the study are at risk to work-related musculoskeletal disorder because the nature of their work demanded them to assume a variety of postures and activities that may be perpetuated by an improperly designed workstation.

NOTES SECTION

The two contributions to this issue's Notes Section are by biology researchers—Kathryn Jadloc and colleagues who studied the impact of the 2011 Typhoon “Sendong” (Washi) on the Coral Reef of Apo Island Marine Reserve in Central Philippines and Adonis Floren and associates write on a collection of Leptocephali from the Bohol Sea, also in Central Philippines.

REVIEW SECTION

The lone contribution to this issue's review section is by Literary studies assistant professor Lady Flor Partosa who reviews Joseph Legaspi's collection of poems, *Imago*.

ACKNOWLEDGMENTS

I would like to thank all contributors to this issue, acknowledging especially your trust and confidence in this publication. SillimanJournal is just beginning another 60 years of existence and is much dependent upon the continuing support of its authors, reviewers, staff, and board of editors, and especially its home base, Silliman University which celebrates its 115th founding anniversary in the next year. Lao Tzu said:“Life is a series of natural and spontaneous changes. Don't resist them—that only creates sorrow. Let reality be reality. Let things flow naturally forward in whatever way they like.”

Margaret Helen F. Udarbe
Editor



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Total Suspended Solids and Sedimentation Rate in Calape Bay (Bohol Island, Central Philippines) After Three Decades of Mariculture Activities

Robert S. Guino-o II

*Center for Tropical Conservation Studies, Department of Biology,
Silliman University, Dumaguete City, Philippines*

Mario N. Ruinata

*Bureau of Fisheries and Aquatic Resources
Region VII, Cebu City, Philippines*

Analyn M. Mazo

*Department of Biological Science, Visayas State University,
Baybay City, Philippines*

Joezen D. Corrales

*College of Arts and Sciences, Cebu Normal University,
Cebu City, Philippines*

Danilo T. Dy

*Marine Biology Section, University of San Carlos,
Cebu City, Philippines*

Calape Bay is a declared mariculture zone under the local government unit of Calape in Bohol Island, Central Philippines. A survey was conducted in December 2011 and January 2012 to evaluate its total suspended solids (TSS), sedimentation rate (SR), and suspended total organic matter (TOM). Results show that present TSS values (80-120 mg/L) were 30 to 80 times higher than the values obtained 10 years ago. High TSS values were recorded in areas where fish cages were located. Sedimentation rate showed highest value (18.8 mg/cm²/day) proximal to the river and lowest value (3.2 mg/cm²/day) at the marine sanctuary which is 4.2 kilometers from the river mouth. Kruskal-Wallis test established that there was a significant difference of the sedimentation rates among sites ($P=0.02$). The suspended total organic matter (2.0-8.9%) was higher at the center of the bay where the fish cages were located. The preceding values have exceeded the standards of sustainable water quality set by the Department of Environment and Natural Resources (DENR). This study confirmed that Calape Bay is threatened with organic pollution from internal and external sources

after three decades of mariculture activities. If the sustainability of this bay is of primary interest due to its economic benefits to the people who depend on it for fishing, mariculture and navigation, then there is a need to establish a water monitoring system inside the bay the soonest possible time to regulate and maintain a healthy water quality standard for a sustainable aquatic ecosystem. There is also a need to determine the impacts of aquaculture-induced and river-carried sedimentation and organic matter on marine diversity and people's fishing livelihood in and nearby Calape areas.

Keywords: aquaculture, organic matter, sedimentation rate, TSS

INTRODUCTION

Calape Bay is a semi-enclosed body of water in western Bohol Island, Central Philippines. It is a declared mariculture zone under the local government unit of Calape which is bounded on the north and west by Pangangan Island, on the south by the municipality of Loon and on the east by the municipality of Calape. The bay has an average depth of 12.4 m and a maximum depth of 40 m along the outer or mouth portion (Jacinto, 2002). The northern area is shallower between 1 to 3 m deep and gradually slopes at the middle of the bay with a depth of 21-31 m. The highest surface current was 1.6 m/s and predominantly flow out of the bay (UP-MSI, UP-VCC, 2002). The intertidal zone is characterized by muddy and sandy shoreline covered with seagrasses and the northwest portion of the bay is covered with mangroves.

The bay is often used for fishing activities, mariculture and navigation. The operation of fish cages in the bay started in 1982 when BFAR initiated the National Bangus Breeding Project. In 1987, Atlas Corporation established fish cages in the area for grouper culture which was followed by other private operators culturing milkfish broodstock and groupers (Corrales, 2005). Presently, there are forty-nine fish pens and fifty-five fish cages in the bay and the total commercial feeds being given to the caged stocks is approximately 220 kg daily.

Ecological concern on the sustainable use of Calape Bay led to studies by the University of the Philippines, Marine Science Institute (UP-MSI) and University of the Philippines in the Visayas - Cebu College (UPV-CC). Seventeen stations located within the bay were sampled for salinity, dissolved oxygen, phosphate, ammonia, nitrite, nitrate, chlorophyll a, transparency, and total suspended solids (UP MSI-UPVCC, 2002). Corrales (2005) assessed the mechanisms for fish cage operation in Calape Bay, Bohol to come up with a management and regulatory framework to ensure sustainable mariculture operation. Silapan and

Maeda (2007) studied the microbial organisms that can serve as indicator of organic enrichment in Calape, Bay. Average organic matter of surface sediment was 11.4% with maximum value of 15.3% at the mariculture zone located at the center of Calape Bay (Argente *et al.*, 2013). In contrast, Bohai Bay in China showed average suspended particulate matter of 13 ppm in the inshore area and a maximum 603 ppm at the bottom of the harbor area (Qiao *et al.*, 2011).

A decade had passed since the environmental studies on Calape Bay were done. It is time to revisit the area and collect new data to compare previous information. Four parameters are included in this study, namely: total suspended solids (TSS), sedimentation rate (SR), suspended total organic matter (TOM) and salinity which we believed are related to mariculture activities in semi-enclosed water bodies. Hence, a survey was conducted in December 2011 and January 2012, respectively.

MATERIALS AND METHODS

Fifty sampling stations, representing sites very proximal to fish pens, fish cages, river estuary and shore areas were chosen and their coordinates were recorded using an eTrek™ GPS unit. For each station, samples for surface salinity measurement (i.e., using a hand-held refractometer) and TSS were collected. Sediment traps were installed at the representative sites (i.e., five sets in fishpens/fish corrals, five near the river, five in fish cages, five in nearshore and marine sanctuary).

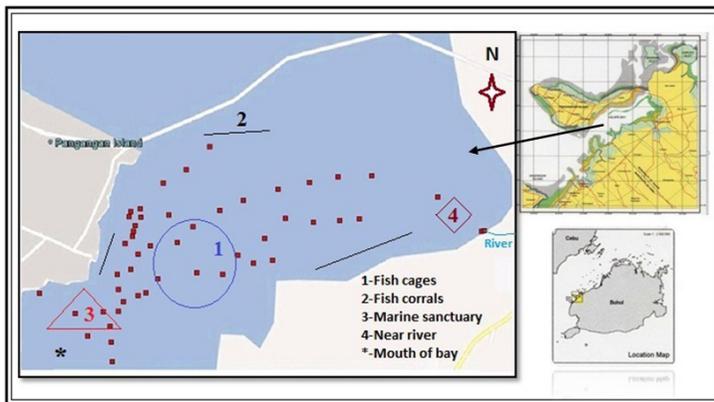


Fig. 1. Map of Calape Bay, Bohol, Central Philippines showing sampling stations in solid squares located near fish cages (1), fish corrals (2), marine sanctuary (3) and estuary (4).

Analysis of TSS followed the standard procedure for total filterable solid (APHA-AWWA-WPCF, 1989) using 4.3 cm diameter glass microfiber filters (GF/C). The residues were dried in an oven at 60°C to constant weight and expressed in mg/L or ppm. Residues were processed further by ashing them in a furnace at 500°C for 2 hours. The loss in weight after ignition over the initial weight represents the total organic matter of the suspended solids and expressed in percent.

Sediment traps made of PVC tubes (2.60 cm diameter and 20.3 cm long) were deployed across the sampling stations. Three adjoining traps were mounted in a pole that was vertically pushed into the substrate. The traps were retrieved after 24 hours. Retrieved traps were then brought to the laboratory and processed following the procedure for total filterable solids. Sedimentation rate expressed as mg/cm²/day was computed based on the dry weight of the trapped sediments divided by the area of the sediment trap divided by the period of deployment.

Spatial data for the parameters: salinity, TSS, and TOM were gridded and plotted using contour mapping program to generate isoline maps. Sedimentation rates per site were tabulated and graphed. To determine if there was a significant difference among sites, a non-parametric Kruskal-Wallis test was done on the sedimentation rate data at 95% significance level as data did not comply for the assumptions of normality test.

RESULTS

Total suspended solids in Calape Bay, Bohol ranged from 80–120 mg/L with a mean value of 97.6 mg/L (S.D.=9.7, N=50). Higher concentrations were observed near the center of the bay where fish cages were located, and the eastward area where fish corrals abound. The westward areas including the marine sanctuary showed the least concentration.

Surface salinity ranged from 20-34 PSU with a mean value of 28 PSU (S.D.=2.7, N=50). The highest salinity was nearest the mouth of the bay, while the lowest salinity was near Liboron River located east of the bay.

The TOM of Calape Bay ranged from 2.0-8.9% with a mean value of 5% (S.D.=1.5, N=50). Higher TOM concentrations were recorded at the center of the bay where the fish cages were located. The nearshore areas including the fish corrals showed low TOM concentrations between 2-4%.

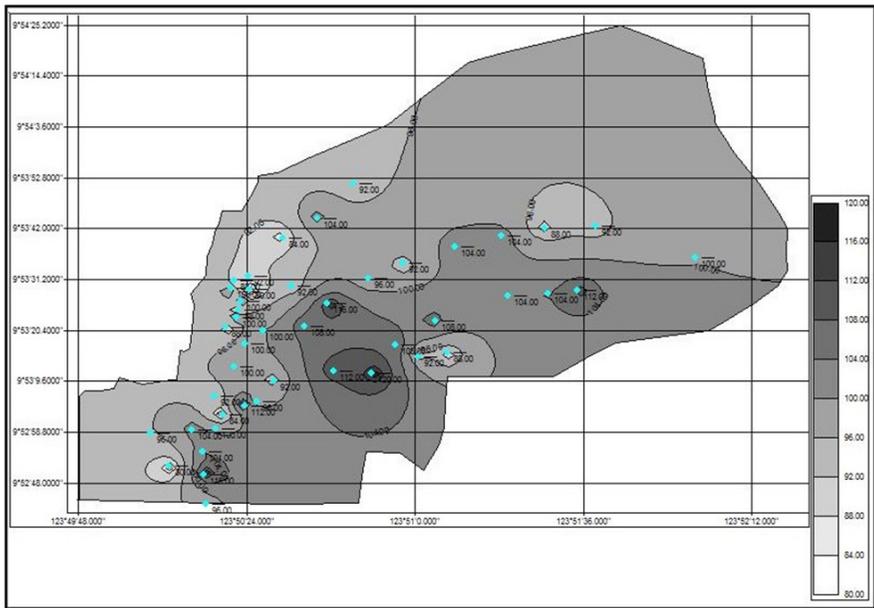


Fig. 2. TSS profile of Calape Bay, Bohol showing high concentrations at the fish cage areas located near the center of the bay.

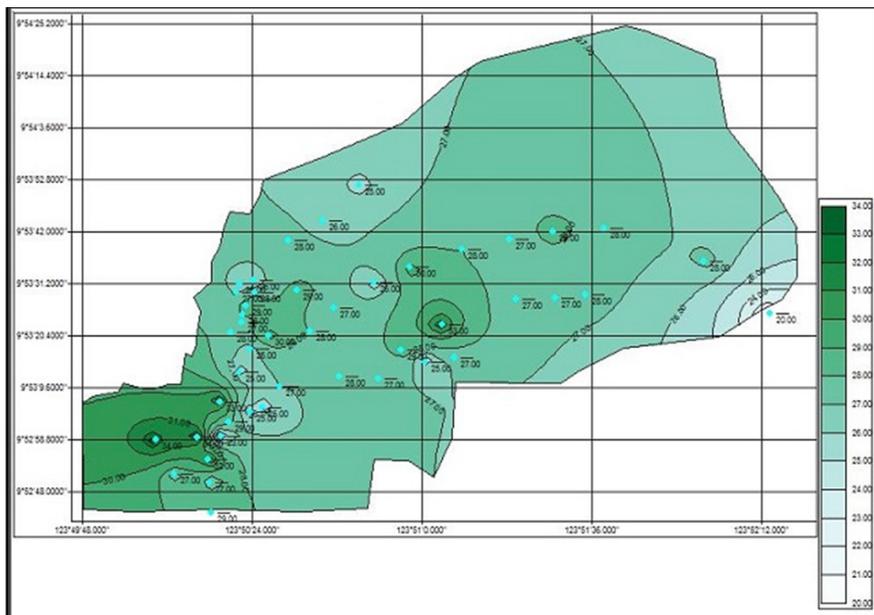


Fig. 3. Salinity profile of Calape Bay, Bohol showing high salinity at the mouth of the bay.

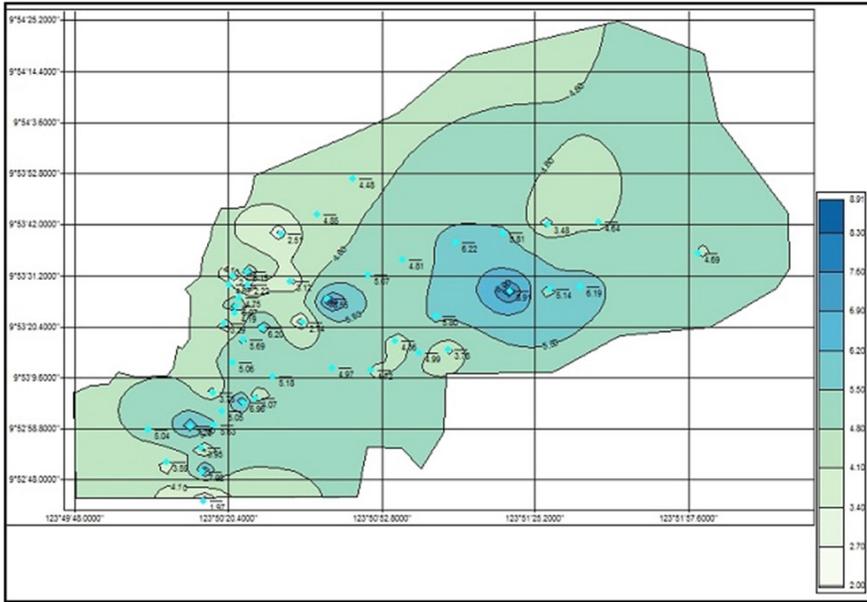


Fig. 4. TOM profile of Calape Bay, Bohol showing high concentrations at the center of the bay.

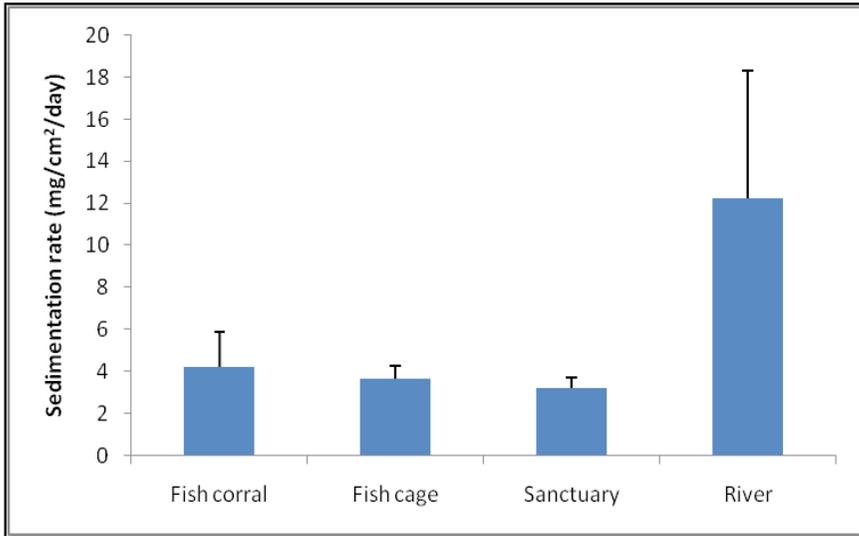


Fig. 5. SR of Calape Bay, Bohol showing highest value at the river area

Sedimentation rate (SR) was highest at the river mouth (18.8 mg/cm²/day). On the average, the sedimentation rate was 9.8 mg/cm²/day. The lowest SR was at the sanctuary (mean value=3.2 mg/cm²/day). Sedimentation rates were significantly higher (2-6 times) at the river mouth (P=0.02, Kruskal-Wallis test) compared to the other stations.

DISCUSSION

The sustainability of Calape Bay as a mariculture zone depends on its water quality which is currently threatened with organic pollution coming from internal (i.e., mariculture activities) and external sources (i.e. riverine inputs). Based on the water usage and classification guideline of the Philippines (DENR DAO # 34, series of 1990) a water body is sustainable if its qualities do not exceed the limit for water quality standard that it sets. Since Calape Bay is a mariculture zone, its water classification falls under Class SB (or fishery water class I for spawning of milkfish, *Chanos chanos* and similar species) and Class SC (or fishery water class II for commercial and sustenance fishing), respectively. In the light of this guideline, Calape Bay should not exceed the TSS level of 30 mg/L.

The TSS values in the present study range from 80-120 mg/L which are 30 to 80 times higher than the values obtained 10 years ago (UP MSI-UPVCC, 2002) which ranged from 0-4mg/L. The similarity of this study to the past study is that high TSS is still recorded in the areas where fish cages are located. The current data is comparable to the TSS levels of 76.6 mg/L in the highly impacted fish cage areas in Bolinao, Pangasinan ten years ago (UP-MSI and UPV-CC, 2002). The intensive fish farming practices in Bolinao, Pangasinan led to eutrophication and recurring fish kills (Reichardt *et al.*, 2006; Santander *et al.*, 2008).

The increased TSS in Calape Bay can be attributed to the increasing number of fish cages and fish corral. Daily feed volume seven years ago reached only 106 kg of commercial feed and trash fish were given to the stocks (Corrales, 2005) as compared to the present volume of 220 kg/day, a net increase of 107%. At the time of sampling, the TSS proximal to the river mouth was moderate. However, this might not be the case during heavy downpours in the uplands. River runoffs could be significant input of suspended materials depending on the types of development being done at the source of the river as shown in the study of Qiao *et al.* (2011).

The present surface salinity measurements showed a wider range (20-34 PSU) compared to the measurements ten years ago (34-35 PSU). This difference can be attributed to two factors, namely seasonal conditions and the number of sampling stations. The present study took place during the wet season between December 2011 and January 2012, while the previous study was conducted during the dry season (May 2002). Season plays an important role in the variation of the attributes of an aquatic system (Dudgeon, 1992). Furthermore, the present study had 50 sampling stations and five of these sites were near the river or estuary.

The TOM concentration at the surface water showed higher amount near the fish cages. This observation is correlated with the study of Tentia and San Diego-McGlone (2008) where organic matter in the sediments were higher near the cages in Bolinao, Pangasinan as compared to the area 25-50 meters farther. Organic matter accumulation is the result of feed wastage, fecal matter production and fish excretion from mariculture activities (Wu, 1995; Troell *et al.*, 1999). Its content in the sediments decreased with the distance from the fish cages. This condition could also be true for suspended organic matter if the tidal currents are weak.

As expected, the SR in the bay was higher near the river or estuary area. However, SR figures reported by Corrales (2005) underneath the fish cages showed even higher values (275 mg/m²/day) while those outside the bay were low (5 mg/m²/day) and comparable to the present values recorded near the fish cages, fish corrals and marine sanctuary. In addition, the study of Silapan and Maeda (2007) revealed that the sediments below the mariculture cages of Calape Bay tested positive for the filamentous bacteria, *Beggiatoa* sp. which thrived in H₂S-rich substrate and are indicators of organic pollution in the marine environment (Pereira *et al.*, 2004; Elliott *et al.*, 2006; Santander *et al.*, 2008) that favor bacterial and viral disease outbreaks (Vercelles *et al.*, 2000; Primavera *et al.*, 2006).

Mariculture activities in Calape Bay, if not regulated, can lead to increase in suspended solids concentrations due to the accumulation of feeds and fecal wastes in the area. Various studies (Jarboe, 1995; Wu, 1995; Tover *et al.*, 2000) showed that unregulated fish cultures result to significant amount of nutrients, TSS, and inorganic matter in the surrounding environment. The presence of fish cages and fish corrals could be contributory in hindering the flow of water in and out of the bay. The local government unit of Calape and the Protected Area Management Board (PAMB) should take an active

role in the management of the bay, not only in the licensing application of prospective fish cage operators but in the monitoring of water quality within Calape Bay. The TSS has exceeded the limit set by DENR for Class SC waters. Although suspended TOM is less than 10%, the sedimentation rates have increased significantly after three decades of mariculture activities, and should be a matter of some concern. Future studies need to investigate the impacts of high sedimentation and TSS load in Calape Bay on marine diversity, fisheries productivity, and fishers' livelihood.

Corresponding author: robert.guino@gmail.com

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Temporal Variation and Comparison of the Status of Coral Reefs in Selected Sites in the Philippines

Clarissa T. Reboton and

Hilconida P. Calumpong

*Silliman University-Institute of Environmental
and Marine Sciences,
Dumaguete City, Philippines*

This study investigates the temporal changes on the condition of coral reefs based on baseline surveys conducted as early as 1995 in two sites from each of three regions in the Philippines (V-Masbate), VII-Negros Oriental, and XI-Davao Oriental). Results showed a significant increase in coral cover in the southern side of Baladingan, Masbate from poor ($14\pm 4\%$) in 2009 to fair ($33\pm 3\%$) in 2013. Comparatively, coral cover in Guang-guang, Davao Oriental showed no significant difference despite the seeming increase from $27\pm 10\%$ in 2010 to $42\pm 3\%$ in 2013 while the northern side of Pujada I. experienced a decline from $75\pm 3\%$ to $40\pm 6\%$. In Negros Oriental, a long-term study of Apo Chapel revealed a significantly increasing trend over a 15-year period from $19\pm 8\%$ in 1999 to $60\pm 19\%$ in 2005 and since then, has remained in good condition. This site also has the highest species diversity. No change was observed in Bantayan marine sanctuary, Dumaguete for over 19 years with only $18\pm 15\%$ in 1995 to $20\pm 10\%$ in 2013. A comparison of current data between sites in each region showed statistically similar coral cover in Masbate and Davao Oriental. In Negros Oriental, Apo Chapel has significantly higher coral cover than Bantayan marine sanctuary. All sites exhibited good condition indices despite the low coral cover in some. Reef development was good in Apo Chapel and the sites in Davao Oriental. The high cover of abiotic-related components compared to coral-related components indicated poor reef development in Masbate and Bantayan. Mortality indices were highest and species diversities lowest in Davao sites and Bantayan. Factors such as level of protection, exposure to natural and anthropogenic disturbances and species composition that influence these changes are discussed.

Keywords: Philippine coral reefs, temporal variation, coral cover, diversity, disturbance.

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INTRODUCTION

The Philippines has about 26,000 km² of coral reef and is considered the center of highest marine biodiversity within the Coral Triangle (Wilkinson, 1992). Sixty per cent of the population reside in the coastal zone and are chiefly dependent on the sea for subsistence with >50% of the dietary requirements derived from municipal fisheries and the shallow coastal habitats (D' Agnes *et al.* 2005). Basically, coral reefs are one of the most important ecosystems in the world because of its ecological and economic functions (White, 1987). The value of coral reefs to fisheries and tourism has made great contributions to the nation's economy. Unfortunately, the escalating local and regional environmental pressures aggravating the effects of climate change have now extremely threatened this ecosystem leading to its accelerated deterioration (Hoegh-Guldberg *et al.* 2009). Burke *et al.* (2002) reported that more than 80% of Philippine reefs are threatened by overfishing, more than 70% by blast and poison fishing, more than 40% by coastal development pressures and approximately 35% are threatened by sedimentation and pollution associated with land-use changes. The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD, 2001) further reported that the 1997-1998 El Niño brought a production loss of 7,142 t and economic loss of Php 319.21M in marine fisheries in the country. In the past, typhoons are rarely experienced in the southern Philippines, but now these have become more frequent. Wilkinson (1992) indicated that the alteration in cyclonic storm patterns and frequencies as an effect of climate change can potentially impact latitudes that have not currently experienced them. According to Nañola *et al.* (2004), the percentage of excellent reefs suggests that the reefs in the country may be experiencing a steady state of decline, i.e. from over 5% in 1981 (Gomez *et al.* 1981) to 4% in 1997 (Licuanan and Gomez, 2000) to >1 % in 2000 to 2004 (Nañola *et al.* 2005; 2006).

Thus, this study was conducted to document changes in coral reef condition over time and compare current conditions between sites in the region that were identified as poor and good based on baselines. This study is built on the premise that well-managed reefs will exhibit improved coral condition as opposed to reefs that are poorly or not protected at all. Results can guide reef managers in determining the need for interventions.

This study is part of a larger project, STEWARDS (Science Towards Environmental Well-being and Resource Development for Society in a changing climate) funded by the Commission on Higher Education (CHED)- Philippine Higher Education Research Network (PHERNet) Program. The primary objective of this project is to compare the services and goods (i.e. fish standing stocks) between poor and good reef and seagrass habitats.

STUDY SITES

Two reef sites in each three regions, Regions V (Masbate), VII (Negros Oriental) and XI (Davao Oriental) were surveyed. These sites were previously assessed under several projects in different years: Region V in 2009 (Reboton and Candido, 2014), Bantayan in Region VII, in 1995 (Calumpang *et al.* 1997) and in 2009 (Reboton, unpublished) while Apo has been regularly surveyed since 1995 (Calumpang *et al.* 1997; UNEP-ICRAN, 2003-2007; DENR-ICRMP, 2010).

Two sites in Region V are located in Ticao I. which is one of the three major islands in the province of Masbate: Sitio Baladingan (12.62690° - 12.62758° N, 123.70632° - 123.70760° E) in Brgy. Famosa, Monreal and Brgy. Tacdogan (12.61577° - 12.61529° N, 123.71575° - 123.71714° E) in San Jacinto (Fig.1). Baladingan is characterized by a 3-km stretch of white sandy beach that is lined by a limestone cliff on its southern side. Here, the shoreline is fully covered with water during high tide except at the southern-most tip where beach formation is absent. Water visibility is up to ≥ 15 m deep. The Tacdogan site is located within a bay which consists of a 0.5-km stretch of sandy beach at the center of the bay and eastward, a limestone cliff that extends about 1 km seaward. Sediments are a combination of dark coarse and fine grains. Water visibility is poor at < 6 m deep as the area receives outputs from the adjacent Ighod River of Baladingan that is fringed by mangrove vegetation. Strong currents are experienced during ebb tide which increases water turbidity and decreases visibility to 0 m. Ticao I. is affected by the northeast monsoon from November to January. The intertidal areas are generally composed of narrow (5 m wide) and sparse seagrass beds that is followed by a narrow (< 20 m wide) and shallow (maximum 7 m deep) sandy-rocky reef flat with patchy coral communities. Toward the north of Baladingan and farther east of Tacdogan, the reef flat is highly covered by the algae *Padina* and *Sargassum*. There are

still no existing ordinances for the protection of marine environment in the area even though the concept of marine conservation has been continually introduced to the community. Transects were established at the southern side of Baladingan and east of Tacdogan.

Upland farming, cattle-raising and fishing activities are the major livelihood activities in the area. Generally, Ticao Pass serves as a major fishing ground for sardines. Gleaning for sea urchins *Diadema* is also practiced in Baladingan. Illegal fishing from different barangays and municipalities have been a problem.

In Region VII, the sites surveyed were Bantayan (9°19'15"N and 123°18'07"E), located in the mainland of Dumaguete City, and Apo I., off Dauin mainland, Negros Oriental (Fig. 1). A dense seagrass meadow extends approximately 150 m offshore, at which a narrow and patchy coral and rubble zone, approximately <50 m, occurs. Farther offshore, a mixed seagrass bed grows to about 10 m depth, and beyond a monospecific bed of *Halodule uninervis* down to 15 m depth. Sediments are predominantly volcanic in origin with dark coarse grains in the surface layer overlying finer sediments underneath. The area is exposed to the northeast monsoon. Depending on the tidal state, currents can be strong. Water visibility exceeds 10 m but can be very turbid during natural events associated with strong winds and waves (Tomasko *et al.* 1993). Turbidity may last for weeks following major storms. Bantayan Beach is a populated area where gleaning and fishing are commonly practiced by the residents. Other activities such as swimming and docking of dive boats are often carried out by non-residents. The transect station is inside the 1.2-ha marine sanctuary which was recently established in 2012 (Fig. 1). The sanctuary is actively managed by the city government, the barangay and the city fish wardens fisher's organization. Transects were established inside the sanctuary area.

The other site is the 74-ha volcanic island of Apo (9°5'N, 123°15'E) located off the southeastern tip of Negros Island, 25 km south of Dumaguete City (Fig. 1). A 1.06 km² of fringing coral reef surrounds the island down to the 60 m isobath (Russ and Alcala, 1989). Water current is non-reversing and flows in a consistently southwest direction (Calumpang *et al.* 1997). Water visibility reaches to depths of greater than 30 m (Smith *et al.* 1982 in UNEP/IUCN, 1988). The island has been protected for almost 30 years since the establishment of the 22-ha "no-take" marine zone on the southeastern side in 1984. On August 9, 1994, the whole island was declared a Protected Landscape

and Seascape (Apo Island Protected Landscape and Seascape or AIPLS) (total = 691.45 ha) under the NIPAS (National Integrated Protected Area System) and under the jurisdiction of the PAMB (Protected Area Management Board). Prior to Marine Protected Area establishment, dynamite fishing used to be rampant but now only traditional fishing methods are practiced outside the sanctuary. Since the late 80's, Apo is one of the favored diving destinations in the country where ten dive sites have been identified. Calumpong *et al.* (2005) estimated diving-associated damage levels not to have reached a threshold that can be interpreted as carrying capacity. A total of 15 guided divers and a maximum of 32 snorkelers per day (i.e. eight snorkelers per hour) inside the sanctuary were implemented by the PAMB in order to manage diving activities. Apo is considered as one of the world's best known community-organized marine sanctuaries. It has also been classified as among the four excellent reefs in the country together with Tubbataha Reef Marine Park in Palawan, Apo Reef in Puerto Galera in Mindoro and the Verde Island Passage in Batangas (Reef Check, 2007).

Apo I. has been exposed to a number of natural occurrences like the 1997-1998 and 2010 El Niño events, and recently, Severe Tropical Storm Washi ("Sendong) in 2011 and Super typhoon Bopha ("Pablo") in 2012. The transect station was established in the Chapel (9.07717° - 9.07622° N, 123.26641° - 123.26623° E), west of the island facing the community area (Fig. 1). This dive site has an extensive reef flat (≥ 50 m) and a gradual to steep slope (40-70°). Like the other areas in the island, the shallower portion is dominated by soft corals while hard corals are concentrated near the reef slope. The Chapel site represents an area of good coral condition based on previous records. At present, the no-take sanctuary is temporarily closed for diving and snorkelling due to massive devastation brought by the typhoons.

The site in Region XI was in Pujada Bay (6°48'04"-6°54'25" N and 126°9'08"- 126°19'33" E), Mati, Province of Davao Oriental, located at the southern tip of Mindanao, 157 km east-southeast of Davao City (Jimenez *et al.* 2002). The bay was declared as the Pujada Bay Protected Seascape (PBPS) by Proclamation 431 on July 31, 1994, under the NIPAS, covering an area of 212 km² (<http://www.pawb.gov.ph>). The transect stations were in Sitio Guang-guang, Brgy. Dahican (6.91408° - 6.91279° N, 126.25706° - 126.25694° E), located along the mainland inside the bay, and Pujada I. (6.79690° - 6.79641° N, 126.25823° - 126.26016° E) which is situated at the mouth of the bay (Fig. 1). The marine environment is characterized by extensive seagrass beds that

thrive even beyond the intertidal zone down to a depth of 12 m (i.e. Pujada I.). Coral reefs are of fringing type. In Guang-guang, the reef occurs from about 3 m to ~13 m deep with coral growths mostly concentrated at around 6 m depth. The slope is gradual with a 20-30° angle. The area is quite silty with vertical water visibility of approximately 10 m due to the presence of an extensive mangrove forest (Guang-guang Mangrove Park and Nursery) that spans the whole length of the shoreline. The coral reef in Pujada I. extends some 30 m from the shoreline down to a depth of ~20 m. It slopes at about

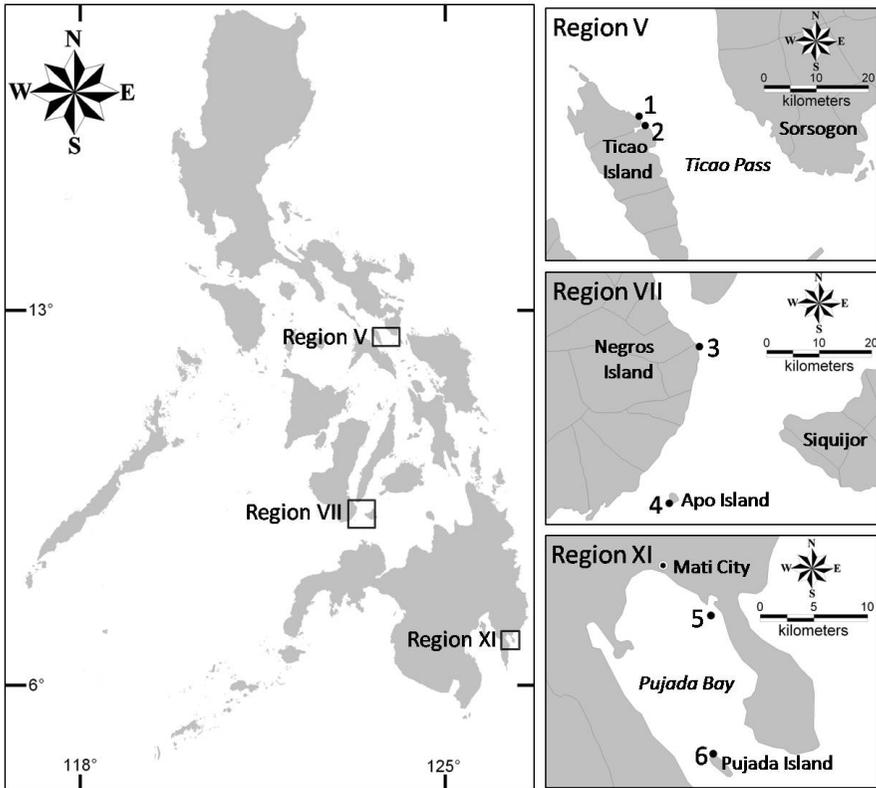


Fig. 1. Maps showing location of coral sampling stations. Region V (Ticao Island) – (1) Baladingan, (2) Tacdogan; Region VII – (3) Dumaguete, (4) Apo I.; Region XI (Pujada Bay) – (5) Guang-guang, and (6) Pujada I.

30° at 6-10 m deep. Coral growths are most abundant at shallower depths around 3-7 m. During low tide, the tidal flat is completely exposed (Jimenez *et al.* 2002). Water visibility is good exceeding 15 m. Pujada Bay is one of the major fishing grounds in the region (Jimenez *et al.* 2002). Gleaning for

molluscs and sea urchins is also a common practice in the intertidal area in Guang-guang. Illegal fishing and unsound upland practices have been reported to threaten the marine ecosystems within the bay (Jimenez *et al.* 2002). In Gguang-guang, transects were established in the reef between DENR and the cove in Maitum. The transects in Pujada I. were established in the northern side facing Lawigan.

METHODS

The manta tow technique was conducted to obtain a general description and condition of the site. Line-intercept transect (LIT) method (English *et al.* 1997) was used to determine the benthic cover composition. Five 20-m transects were established in each sampling site within the same locations used in previous surveys. Previous surveys, however, used fewer transects in most sites. Transects were laid at 5-6 m depth in Ticao sites and Bantayan marine sanctuary and at 7-10 m depth in Apo Chapel and Davao Oriental where hard coral growths are concentrated. Species of corals encountered were identified following the descriptions of Veron and Pichon (1976; 1979; 1982), Veron *et al.* (1977), Veron and Wallace (1984), Wallace (1999), Veron (2000), and Fabricius and Alderslade (2001). Reef condition was determined using the four categories of hard coral cover: poor = 0-24.9%, fair = 25-49.9%, good = 50-74.9%, excellent = 75-100% (Gomez, 1991). Reef quality assessment indices (i.e. condition, development, and succession of algae and other fauna) developed by Manthachitra (1994) and mortality index developed by Gomez *et al.* (1994) were further applied to provide a broader perspective of the actual reef condition. These indices allow for a more appropriate analysis as coral cover data alone may be misleading. Undisturbed coral communities may yield a low coral cover because certain large areas of the reef are unavailable or unsuitable for coral growth (Gomez *et al.* 1994).

The assessment indices used the formulae:

Condition index indicates the condition of coral reef assemblage,
 $CI = \log (LC/DRC)$

Development index indicates the degree of coral reef assemblage
development, $DI = \log (CRC/ARC)$

Succession index for algae indicates the level of succession by algae, $SI I = \log [ALGAE/(DC + OT)]$

Succession index for others indicates the level of succession by other fauna, $SI II = \log [OT/(DC + ALGAE)]$

where *LC* = live hard coral, *ALGAE* = algal assemblage + turf algae + macroalgae + coralline algae, *DC* = dead coral + dead coral with algae, *DRC* (dead coral related components) = *DC* + *ALGAE* + others including soft corals (*OT*) that only colonize dead corals, *ARC* (abiotic related components) = rubble + rock + sand + *ALGAE* + other fauna that do not colonize on coral component, and *CRC* (coral related components) = *LC* + *DC* + *OT* + *ALGAE* that only colonize live and/or dead corals.

The qualities for these indices are based on the following scale: very poor = < -0.602, poor = -0.602 to -0.176, fair = -0.175 to 0.176, good = 0.177 to 0.602 and very good = > 0.602.

Mortality index, $MI = \text{dead coral cover} / (\text{live} + \text{dead coral cover})$

Mortality index is gauged on its nearness to the value 1 such that the closer the value index to 1, the higher would be the theoretical mortality.

The Shannon-Weiner Index for diversity and Simpson's Index for dominance (Odum, 1971) were calculated to further describe the coral community. Measurements and counts limited only to colonies found under the transects. Rogers *et al.* (1983) and Arif Zainul Fuad (2010) used the same method in calculating species diversity in U.S. Virgin Islands and Bunaken National Park, Indonesia, respectively. Transect methods to assess coral diversity were also discussed by Beenaerts and Vanden Berghe (2005). Although this underestimates the actual value of the community compared to belt-transects (Nakajima *et al.* 2010), the LIT data was used due to time and effort constraints. Since we are using permanent transects, this will allow comparisons over time for the same areas. These indices were not calculated in the previous surveys due to insufficient information.

Simpson's Index of Dominance, $c = \sum (ni/N)^2$,

where ni = importance value for each species (number of individual), and N = total importance of values

Shannon-Weiner Diversity Index, $H' = - \sum Pi \log Pi$,

where Pi = importance probability for each species = ni/N

Relative composition of coral growth forms from cover data was also generated for all years at each site to determine changes apart from overall hard coral cover.

Rugosity was measured using a modified version of the Chain method of Hill and Wilkinson (2004) wherein a second tape was laid on the upper contour of the reef within the 20 m transect used for LIT. Rugosity was calculated as the length of tape used per 20-m transect. A rugosity index of 1 would mean a perfectly flat surface, with larger numbers signifying a greater degree of architectural complexity (Alvarez-Filip *et al.* 2009).

Analysis of data was conducted using appropriate statistical tools. Prior to analysis, percentage data were log-transformed (<https://www.ndsu.edu/ndsu/horsley/Transfrm.pdf>; <http://www.graphpad.com>) and tested for normality using Kolmogorov-Smirnov Test, and variance homogeneity using Bartlett's Test. One-way ANOVA F test was employed to determine significant differences between substrate categories or between more than two time periods. For data sets that show normal distribution but violate the assumption for homogeneity of variance, Welch's ANOVA (Welch's F) was used. Post-hoc analysis was carried out to further investigate differences between groups. Depending on the variance and sample size, Tukey's HSD was analyzed for data sets with equal variances and sample size, Games Howell for unequal variances and sample size, Gabriel's Test for unequal sample size with equal variances. Trend analysis for one way-ANOVA (F) was also applied to detect significance in patterns (Field, 2012). Only the p-values of linear contrast were included in this paper since all quadratic contrasts did not show any significance. Where the assumptions for normality and homogeneity are not met, the non-parametric equivalent Kruskal-Wallis H test was applied using untransformed data. Kruskal-Wallis multiple comparisons test was conducted as a post hoc test while Jonckheere-Terpstra (T_{JT}) test was used to analyze for trends.

To compare differences between the sites or between two time periods, the two-sample t-test was used with the two-tailed Mann-Whitney U test as the non-parametric equivalent. One-tailed Mann-Whitney U Test was used for trend analysis.

Because of the small sample sizes, correlation analysis was applied using Spearman's Rank Correlation Test to determine significant relationships between the number of years of protection and substrate cover. This test was only applied on Apo since data sets were sufficient enough.

Significance level was established at $p < 0.05$ for all tests. Minitab 14 and IBM SPSS Statistics 21 softwares were utilized for the analysis.

Connell's (1997) formula to estimate ecological significance of decline was also used to analyze coral cover. He estimated at least 33% decrease from the initial cover as a threshold to define an ecologically significant decline in coral cover (i.e. ratio of loss in cover to the amount of its original cover). Significance for recovery was not used as it cannot be applied on the available data sets.

Collection of data was carried out in October 2009 and June 2013 in Ticao, Masbate. In Negros, Bantayan data were obtained in December 1995, January 2009 and October 2013 while Apo data were taken in April 1999, April 2000, April 2003, July 2004, April 2005, May 2006, June 2007 and October 2013. In Davao Oriental, data collection was conducted in December 2010 and May 2013.

RESULTS

Region V.

Benchmark vs. Current Data. The LIT survey conducted in southern side of Baladingan indicated an increasing trend in hard coral cover over a 5-year period (U, $p = 0.004$, 1-tailed). Hard coral cover significantly differed between 2009, with poor cover ($13.8 \pm 4.4\%$), and 2013, with fair cover ($33.3 \pm 3.3\%$) (U, $p = 0.009$, 2-tailed). No significant difference between the study periods was detected in other categories. Similarly, cover of sand showed no significant difference between 2009 at $51.5 \pm 8.4\%$ and 2013 at $30 \pm 3.9\%$ (t, $p = 0.157$), but pattern of decrease proved to be significant with time. Rock, the second dominant abiotic component, remained almost constant at $19.7 \pm 3.4\%$ and $18.9 \pm 2.6\%$, respectively (Fig. 2). Within each study period, sand dominated

the substrate in 2009 ($H, p=0.000$) but was equally dominant with hard corals in 2013 ($F, p=0.000$). Cover of dead corals, soft corals, other fauna, algae and rubble fell to $\leq 8\%$.

Among hard corals, massive forms dominated the cover composition in both periods accounting for $\geq 69\%$. *Acropora* was reduced from 9 to 2% (Fig. 3).

Comparison of Current Data. In terms of species composition, Baladingan recorded a higher number of 120 hard coral species (118 scleractinia, two non-scleractinia) than Tacdogan with 111 (107 scleractinia, four non-scleractinia) (Table 1). However, from transects, Baladingan showed a lower diversity index in terms of percent cover ($H'=2.74$) and colony counts ($H'=3.20$). Consequently, index of dominance was higher ($c=0.18$) with *Porites lobata* as the most dominant species ($13.65 \pm 2.42\%$ cover at $c=0.17$; 51 colonies at $c=0.08$). Generally, massive corals account for almost 75% (or $24.4 \pm 3.28\%$ cover) of the total live hard coral cover. In Tacdogan, massive ($15.05 \pm 2.92\%$) (e.g. *P. lobata* - $4.6 \pm 1.49\%$ at $c=0.02$, *P. lutea* - $4.65 \pm 2.37\%$ at $c=0.02$) and branching ($10.6 \pm 5.54\%$) (e.g. *Montipora cactus* - $4.4 \pm 4.39\%$ at $c=0.02$ and *P. nigrescens* - $3.7 \pm 1.40\%$ at $c=0.01$) forms were most dominant in cover (Table 2). Except for *M. cactus* (2 colonies at $c=0.00$), these species

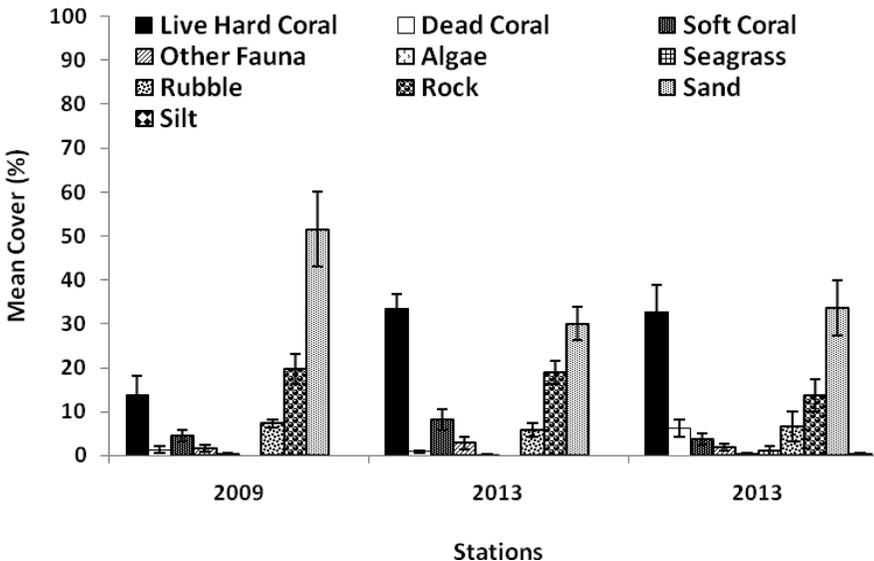


Fig. 2. Mean percent cover of substrate categories in Ticao I.
Data for 2009 from Reboton and Candido (2014; $n=6$); 2013 ($n=5$).

Table 1. Number of species and indices of dominance (c) and diversity (H') based on colony cover and counts in the surveyed sites in 2013.

Sites	Stations	General	Based on Transects						
			Total No. Species	No. Species	No. Colonies	%Cover		%Counts	
						c	H'	c	H'
REGION V MASBATE	Baladingan	120	56	182	0.18	2.74	0.10	3.20	
	Tacdogan	111	51	157	0.08	3.08	0.07	3.24	
REGION VII NEGROS ORIENTAL	Bantayan	53	18	56	0.38	1.59	0.15	2.29	
	Apo Chapel	121	51	198	0.16	2.54	0.12	2.91	
REGION XI DAVAO ORIENTAL	Guang-guang	42	12	109	0.78	0.57	0.58	1.03	
	Pujada I.	27	11	118	0.69	0.76	0.56	1.08	

were also numerically and almost equally abundant (*P. lobata* - 21 colonies at $c=0.02$, *P. lutea* - 25 colonies at $c=0.03$, *P. nigrescens* - 22 colonies at $c=0.02$). Four genera of soft corals were also noted. Table 3 shows the list of species identified.

Current survey revealed that there is no reef around Ticao that can be categorized under good. Broad observation using manta tow revealed similar condition of hard coral cover ($23 \pm 5.1\%$) with Tacdogan ($28.6 \pm 1.9\%$). Sand dominated in Tacdogan ($40 \pm 4.5\%$) while sand, rubble and rock occupied the same percentages with hard corals in Baladingan ($\geq 20\%$).

Detailed survey (using LIT) of the selected locations also showed similar hard coral cover at $33.3 \pm 3.3\%$ in the south of Baladingan and $32.7 \pm 6.2\%$ in the east of Tacdogan ($t, p=0.763$) (Fig. 2). The latter station was found to be more rugose with an index of 1.25 ± 0.06 while the former only had an index of 1.18 ± 0.02 (Table 4).

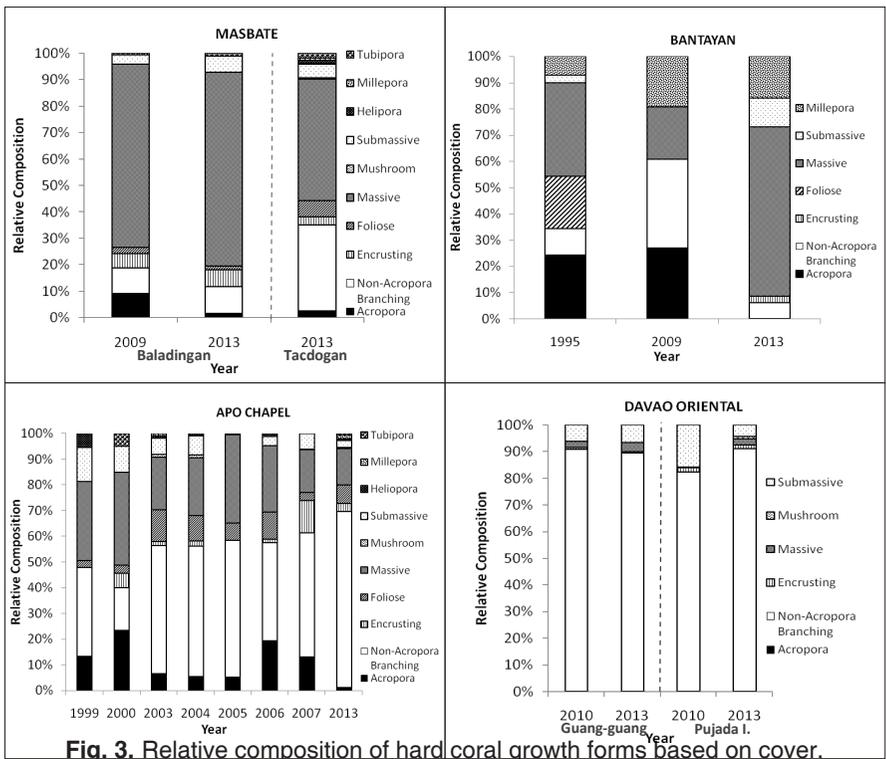


Fig. 3. Relative composition of hard coral growth forms based on cover.

Both areas also showed similar covers of rock ($18.9 \pm 2.6\%$ and

13.6±3.6%) (t, p=0.157) and sand (30±3.9% and 33.6±6.4%) (t, p=0.780). Cover of other components also did not vary between the stations but were significantly lower than hard corals, rock and sand (Baladingan: F, p=0.000; Tacdogan: H, p=0.000) (Fig. 2). Post-hoc analysis showed that the covers between the latter three categories were statistically similar in these sites. The only significant difference between stations was the higher cover of dead corals in Tacdogan (6.2±2% vs. 0.9±0.3%) (t, p=0.006) resulting in a higher mortality index. Generally, the areas had good condition indices but poor reef development indices (Table 5).

Table 2. Mean percent cover of hard coral growth forms
in the surveyed sites in 2013.

BENTHIC CATEGORIES	REGION V MASBATE				REGION VII NEGROS ORIENTAL				REGION XI DAVAO ORIENTAL			
	Baladingan		Tacdogan		Bantayan		Apo Is.		Guang-Guang		Pujada Is.	
	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.
LIVE HARD CORALS												
Scleractinia												
<i>Acropora</i>												
Branching	0.10	0.10					0.35	0.35				
Corymbose	0.25	0.11	0.40	0.29			0.30	0.30	0.10	0.10		
Encrusting							0.04	0.04				
Submassive			0.40	0.40								
Table	0.15	0.15										
Total <i>Acropora</i>	0.50	0.18	0.80	0.41			0.69	0.64	0.10	0.10		
Non- <i>Acropora</i>												
Branching	3.35	0.87	10.60	5.54	1.20	0.96	40.43	5.11	37.50	5.60	36.62	5.89
Encrusting	2.15	0.87	1.05	0.61	0.50	0.39	2.44	0.73	0.20	0.20	0.50	0.22
Foliose	0.50	0.21	2.00	1.17			3.55	3.13				
Massive	24.40	3.28	15.05	2.92	12.90	6.67	8.41	1.55	1.40	0.70	1.00	0.49
Mushroom			0.15	0.15			0.20	0.20			0.30	0.30
Submassive	2.05	0.95	1.65	0.53	2.20	1.16	1.60	0.86	2.85	2.85	1.80	0.60
Total Non- <i>Acropora</i>	32.45	3.11	30.50	5.57	16.80	8.66	56.63	6.35	41.95	3.47	40.22	6.23
Total Scleractinia	32.95	3.06	31.30	6.30	16.80	8.66	57.32	6.76	42.05	3.40	40.22	6.23
Non-Scleractinia												
<i>Heliopora</i>			0.50	0.50			0.46	0.35				
<i>Millepora</i>			0.30	0.30	3.20	1.62	0.70	0.70				

<i>Tubipora</i>	0.40	0.40	0.60	0.40			0.45	0.28				
Total Non-Scleractinia	0.40	0.40	1.40	0.43	3.20	1.62	1.61	0.92				
Total Live Hard Corals	33.35	3.31	32.70	6.17	20.00	9.86	58.93	7.21	42.05	3.40	40.22	6.23

Region VII.

Benchmark vs. Current Data. Hard coral cover in Bantayan marine sanctuary has been consistently poor without any significant difference between the years at $17.5 \pm 15\%$ in 1995, $26.9 \pm 4.69\%$ in 2009 and $20 \pm 9.9\%$ in 2013 (H, $p=0.668$). A loss of 7% between 2009-2013 indicates the decline to be ecologically non-significant (25.7%). Dead corals, algae, rubble and rock apparently increased from $2.8 \pm 2.8\%$ to $7 \pm 3.9\%$, $0.2 \pm 0.2\%$ to $11.7 \pm 3.1\%$, $7.2 \pm 1.2\%$ to $12.7 \pm 3.5\%$ and $1.5 \pm 1.5\%$ to $17 \pm 4\%$, respectively (Fig. 4). Except for algae, (Welch's F, $p=0.004$), statistical analysis revealed these differences to be non-significant (H, $p=0.447$; F, $p=0.396$; F, $p=0.133$, respectively). Cover of bare sand significantly decreased from $46.2 \pm 5.8\%$ to $13.9 \pm 1.6\%$ (F, $p=0.002$). Seagrass cover also lowered from $23.8 \pm 12.2\%$ to $16.8 \pm 10.6\%$, with much lower cover in 2009 at $4.7 \pm 3.7\%$, but values did not significantly differ (H, $p=0.331$). Trend analysis further indicates that algal and sand cover significantly increased (F, $p=0.002$) and decreased (F, $p=0.001$), respectively, with time. Within each study period, cover of substrate categories differed significantly in 1995 (F, $p=0.026$) and in 2009 (H, $p=0.000$) but not in 2013 (H, $p=0.174$). In 1995, sand dominated the substrate but towards 2013, all substrate components have not significantly varied.

Initially, hard coral composition was dominated by massive corals at 36% followed by *Acropora* and foliose forms at $\geq 20\%$. In 2009, *Acropora* and non-*Acropora* branching types dominated among the hard corals at 27-34% while massive forms only accounted for 20%. An increase in the relative cover of *Millepora* from 7 to 19% while the disappearance of foliose corals were noted. In 2013, massive corals predominated over the other growth forms at 64%. Composition of *Millepora* only slightly decreased to 16% while submassive types increased to 11% from 0-3% in the previous years. *Acropora* corals disappeared while non-*Acropora* branching forms were greatly reduced to 6% (Fig. 3).

Table 3. List of coral species in the surveyed sites. BAL = Baladingan, TAC = Tacdogan, BAN = Bantayan, APO = Apo Chapel, GUA = Guang-guang, PUJ = Pujada I. X indicates presence.

SPECIES	BAL	TAC	BAN	APO	GUA	PUJ	SPECIES	BAL	TAC	BAN	APO	GUA	PUJ
HARD CORALS: ORDER SCLERACTINIA													
I. FAMILY ACROPORIDAE													
<i>Acropora aspera</i>	X						<i>Acropora yongei</i>		X				
<i>Acropora batunai</i>	X						<i>Acropora sp.1</i>	X					
<i>Acropora brueggemanni</i>		X	X				<i>Acropora sp.2</i>		X				
<i>Acropora cerealis</i>					X		<i>Astreopora expansa</i>		X				
<i>Acropora convexa</i>		X					<i>Astreopora myriophthalma</i>	X	X	X			X
<i>Acropora divaricata</i>						X	<i>Montipora cactus</i>		X		X		
<i>Acropora exquisita</i>	X						<i>Montipora efflorescens</i>				X		
<i>Acropora florida</i>		X					<i>Montipora cf. floweri</i>				X		
<i>Acropora gemmifera</i>				X			<i>Montipora grisea</i>		X	X			
<i>Acropora grandis</i>		X					<i>Montipora hoffmeisteri</i>				X		
<i>Acropora hoeksemai</i>	X						<i>Montipora incrassata</i>				X		
<i>Acropora humilis</i>	X		X				<i>Montipora informis</i>	X	X		X		
<i>Acropora hyacinthus</i>	X						<i>Montipora malampaya</i>	X	X				
<i>Acropora indonesia</i>	X			X			<i>Montipora monasteriata</i>						X
<i>Acropora inermis</i>			X				<i>Montipora peltiformis</i>			X		X	

SPECIES	BAL	TAC	BAN	APO	GUA	PU	SPECIES	BAL	TAC	BAN	APO	GUA	PU
IV. FAMILY CARYOPHYLLIDAE													
<i>Euphyllia ancora</i>	X	X		X			<i>Favites sp.</i>	X					
<i>Euphyllia cristata</i>		X		X			<i>Goniastrea aspera</i>	X	X		X		
<i>Euphyllia glabrescens</i>	X	X		X			<i>Goniastrea australensis</i>		X				
<i>Physogyra lichtensteini</i>		X			X		<i>Goniastrea edwardsi</i>		X	X	X	X	X
<i>Pterogyra sinuosa</i>	X	X		X			<i>Goniastrea minuta</i>		X				
V. FAMILY DENDROPHYLLIDAE													
<i>Turbinaria frondens</i>	X	X		X			<i>Goniastrea pectinata</i>	X	X	X	X		X
<i>Turbinaria mesenterina</i>	X	X		X			<i>Goniastrea retiformis</i>	X	X	X	X	X	
<i>Turbinaria peltata</i>	X	X		X			<i>Leptastrea purpurea</i>	X	X	X	X	X	
<i>Turbinaria reniformis</i>		X		X			<i>Leptoria phrygia</i>						X
<i>Turbinaria stellulata</i>	X	X		X	X		<i>Montastrea colemani</i>	X	X		X		X
VI. FAMILY FAVIIDAE													
<i>Caulastrea tumida</i>	X						<i>Montastrea curta</i>			X			
<i>Cyphastrea chalcidicum</i>				X			<i>Montastrea magnistellata</i>	X	X				
<i>Cyphastrea microphthalma</i>	X	X		X			<i>Montastrea salebrosa</i>	X	X	X	X		
<i>Cyphastrea serailia</i>	X	X	X	X		X	<i>Montastrea valenciennesi</i>	X	X	X			
<i>Diploastrea heliopora</i>	X	X	X	X			<i>Oulastrea crispata</i>			X			X
<i>Echinopora gemmacea</i>	X						<i>Oulophyllia crispa</i>						
							<i>Oulophyllia bennettiae</i>			X			X
							<i>Platygyra acuta</i>	X	X	X	X		X

<i>Echinopora horrida</i>	X								X	X	X	X
<i>Echinopora lamellosa</i>	X	X	X							X	X	
<i>Echinopora pacificus</i>	X		X							X	X	X
<i>Favia danae</i>		X							X			
<i>Favia fava</i>	X	X	X	X					X	X	X	X
<i>Favia lizardensis</i>			X	X					X			X
<i>Favia maththaii</i>	X		X	X								X
<i>Favia pallida</i>	X	X	X	X					X			
<i>Favia rotundata</i>	X	X	X	X								X
<i>Favia speciosa</i>		X	X	X					X			
<i>Favia truncatus</i>	X	X	X	X				X	X			
<i>Favites flexuosa</i>				X						X		X
<i>Favia vietnamensis</i>	X	X	X	X						X	X	
<i>Favites abdita</i>	X	X	X	X					X	X	X	X
<i>Favites acuticollis</i>	X								X	X	X	X
<i>Favites chinensis</i>			X								X	
<i>Favites halicora</i>	X	X	X	X					X	X	X	X
<i>Favites micropentagona</i>									X	X	X	
<i>Favites pentagona</i>	X		X	X				X	X	X	X	X
<i>Favites stylifera</i>				X								X

VII. FAMILY FUNGIIDAE

Cycloseris costulata

Cycloseris cyclolites

Cycloseris patelliformis

Cycloseris vaughani

Gtenactic crassa

Gtenactic echinata

Fungia danai

Fungia fungites

Fungia paumotensis

Fungia repanda

Fungia cf. scabra

SPECIES	BAL	TAC	BAN	APO	GUA	PU	SPECIES	BAL	TAC	BAN	APO	GUA	PU
<i>Fungia scutaria</i>				X			<i>Pocillopora eydouxi</i>			X			
<i>Halomitra pileus</i>				X			<i>Pocillopora meandrina</i>				X		
<i>Heliopora actiniformis</i>						X	<i>Pocillopora verrucosa</i>	X	X	X	X	X	X
<i>Herpolitha limax</i>	X	X			X		<i>Seriopora caliendrum</i>	X	X				
<i>Herpolitha weberi</i>		X			X		<i>Seriopora hystrix</i>	X	X	X			
<i>Lithophyllon lobata</i>						X	<i>Stylophora pistillata</i>	X	X	X			
<i>Lithophyllon mokai</i>				X			XIII. FAMILY PORITIDAE						
<i>Litophyllon undulatum</i>	X	X		X			<i>Alveopora catalai</i>				X		
<i>Podabacia crustacea</i>	X						<i>Alveopora cf. spongiosa</i>			X			
<i>Polyphyllia talpina</i>	X	X					<i>Alveopora tizardi</i>				X		
<i>Sandalolitha dentata</i>				X			<i>Goniopora cf. burgosi</i>		X		X		
<i>Sandalolitha robusta</i>	X	X				X	<i>Goniopora columna</i>				X		
VIII. FAMILY MERULINIDAE							<i>Goniopora djiboutiensis</i>	X	X		X		
<i>Hydnophora exesa</i>	X	X					<i>Goniopora fruticosa</i>				X		
<i>Hydnophora microconos</i>	X		X				<i>Goniopora minor</i>	X	X				
<i>Hydnophora pilosa</i>		X					<i>Goniopora norfolkensis</i>			X			
<i>Hydnophora rigida</i>	X		X				<i>Goniopora sp.1</i>				X		
<i>Merulina ampliata</i>	X	X		X			<i>Goniopora sp.2</i>			X			
<i>Merulina serabacula</i>	X	X	X	X			<i>Goniopora tenuidens</i>	X	X	X			

SPECIES	BAL	TAC	BAN	APO	GUA	PUI	SPECIES	BAL	TAC	BAN	APO	GUA	PUI
ORDER STOLONIFERA													
III. FAMILY TUBIPIRIDAE													
<i>Coccinaraea exesa</i>	X						<i>Tubipora musica</i>	X	X		X		
<i>Psammocora contigua</i>			X				Total	2	4	3	3		
<i>Psammocora obtusangula</i>				X			TOTAL HARD	120	111	53	121	42	27
<i>Psammocora profundacella</i>	X	X					CORAL SPECIES						
<i>Psammocora superficialis</i>						X	SOFT CORALS: ORDER ALCYONACEA						
XV. FAMILY TRACHYPHYLLIDAE							<i>Briareum</i>				X		
<i>Trachyphyllia geoffroyi</i>	X	107					<i>Lemmalia</i>				X		
Total	118	107	50	118	42	27	<i>Lobophytum</i>	X	X	X	X		
ORDER COENOTHECALIA													
I. FAMILY HELIOPORIDAE													
<i>Heliopora coerulea</i>							<i>Nephthea</i>	X	X	X	X		
ORDER MILLEPORINA:													
II. FAMILY MILLEPORIDAE													
<i>Millepora exaesa</i>			X				<i>Sarcophyton</i>			X	X		X
<i>Millepora platyphyllia</i>	X	X	X				<i>Simularia</i>	X	X	X	X	X	
<i>Millepora sp. (CB)</i>		X	X				<i>Xenia</i>	X	X			X	
TOTAL SOFT													
CORAL GENERA													
								4	3	4	6	2	2

Table 4. Rugosity index in the surveyed sites in 2013.

Sites	Stations	Rugosity Range	Average Rugosity \pm S.E.
REGION V MASBATE	Baladingan	1.14-1.24	1.18 \pm 0.02
	Tacdogan	1.15-1.39	1.25 \pm 0.06
REGION VII NEROS ORIENTAL	Bantayan	1.04-1.50	1.27 \pm 0.09
	Apo I.	1.30-1.71	1.45 \pm 0.07
REGION XI DAVAO ORIENTAL	Guang-Guang	1.18-1.57	1.40 \pm 0.07
	Pujada I.	1.29-1.43	1.37 \pm 0.02

Table 5. Theoretical Mortality Index (MI) and index quality for Condition (CI), Development (DI), Succession by Algae (SI I) and Other Fauna (SI II) in three surveyed reef sites using the Manthachitra Index (1994). Quality of index: VP = very poor, P = poor, F = fair, G = good, VG = very good.

Sites	Stations	MI	CI	DI	SI I	SI II
MASBATE	Baladingan	0.025	1.594 (VG)	-0.284 (P)	0.000 (F)	
	Tacdogan	0.175	0.682 (VG)	-0.185 (P)	0.000 (F)	-1.336 (VP)
NEGROS ORIENTAL	Bantayan	0.259	0.432 (G)	-0.423 (P)	0.024 (F)	
	Apo I.	0.026	1.158 (VG)	0.244 (G)	-0.032 (F)	-0.150 (F)
DAVAO ORIENTAL	Guang-Guang	0.330	0.302 (G)	0.232 (G)	-0.006 (F)	-1.839 (VP)
	Pujada I.	0.283	0.281 (G)	0.345 (G)	0.018 (F)	-0.933 (VP)

In contrast, an increasing hard coral cover was documented at Apo Chapel. Hard coral cover started to rise from $18.8 \pm 7.8\%$ in 1999 to $37 \pm 15\%$ in 2003 and remarkably increased in 2005 at $60.4 \pm 19.5\%$. Since then, it has remained stable (Fig. 5). Although the p-value in Welch's ANOVA indicates no significant overall difference between mean coral cover at each year ($p=1.50$), trend analysis implies a significant linear pattern suggesting that coral cover increased with time (F , $p=0.010$). Dead coral cover was consistently low at less than 2% except in 2003 and 2004 where it increased to $6.2 \pm 0.7\%$ and $7.8 \pm 2.6\%$, respectively (H , $p=0.016$). There was no significant trend observed with time (T_{jt} , $p=0.466$). The increase in hard coral cover is accompanied by the decline in other categories. Cover of soft corals declined particularly from 1995 to 2007 at $28 \pm 22.5\%$ to $9.4 \pm 2.4\%$, respectively, after which it increased to $22.1 \pm 2.6\%$ after 6 years. During this time hard coral cover slightly decreased from $69.2 \pm 16\%$ to $58.9 \pm 7.2\%$ but was not ecologically

significant (14.8% or 10.2% loss). Rubble cover significantly dropped from $16.6 \pm 10.4\%$ to $2 \pm 1.4\%$ (Welch's F, $p=0.025$) showing a significant negative declining trend with time (F , $p=0.004$). Sand also exhibited a noticeable decrease from $28.4 \pm 24.1\%$ to $6.2 \pm 4.6\%$ although values did not statistically differ. Between 1999-2000, the substrate consisted mostly of soft corals and sand. Hard corals started to dominate the substrate in 2003, significantly dominating over the other categories by 2007 (H, $p=0.028$) and 2013 (H, $p=0.001$).

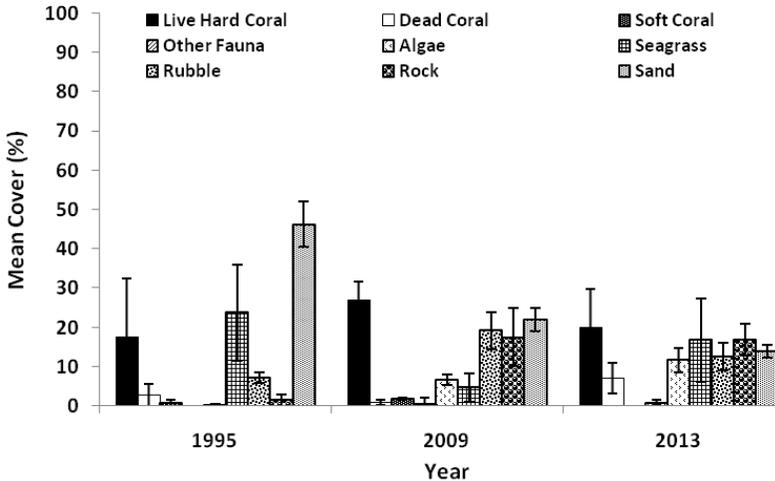


Figure 4. Mean percent cover of substrate categories in Bantayan Data for 1995 from Calumpong et al. (1997; $n=2$); 2009 from Reboton (2009 $n=5$); 2013 ($n=5$).

Spearman's rank correlation analysis further indicates that coral cover and the length of years of protection is significantly and positively correlated ($r_s=0.547$, $p=0.007$) (Fig. 6).

Hard coral composition is consistently dominated by non-*Acropora* branching corals from 35 to 69% except in 2000 wherein relative cover decreased to 17% while *Acropora* increased from 13% in 1999 to 23%. *Acropora* decreased in 2003 to 2005 at $\leq 7\%$, increasing again in 2006 at 19% but was greatly reduced by 2013 with only 1%. Massive corals ranked second in relative cover throughout the study period although percentages exhibited a decrease from $>30\%$ to 14% (Fig.3).

Comparison of Current Data. The station in Apo Chapel supported a much higher number of 121 hard coral species (118 scleractinia, three non-

scleractinia) compared to Bantayan marine sanctuary (Table 1). Bantayan had less than half the number in Apo Chapel with only 53 species (50 scleractinia, three non-scleractinia). Expectedly, diversity index (cover, $H^2=2.54$ and counts, $H^2=2.91$) in Apo Chapel was also higher. Massive

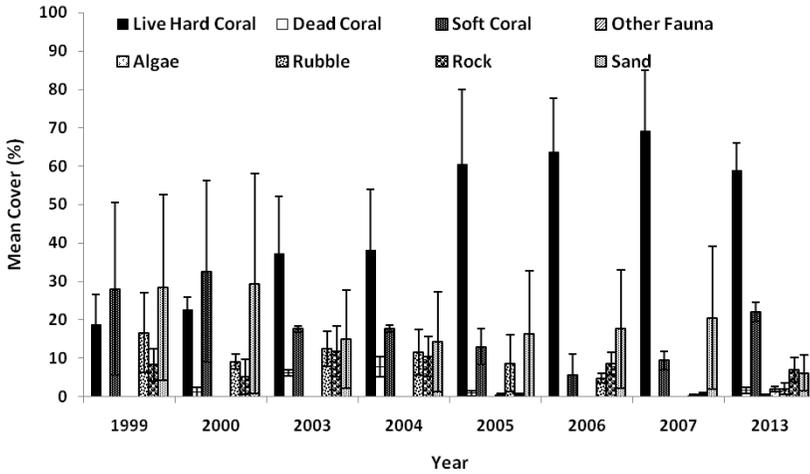


Fig. 5. Mean percent cover of substrate categories in Apo Chapel. Data for 1999-2000 from USAID-SU COE-CRM Project 1999-2000 (n=2); 2003-2007 from UNEP-ICRAN 2003-2007 (n=3); 2013 (n=5).

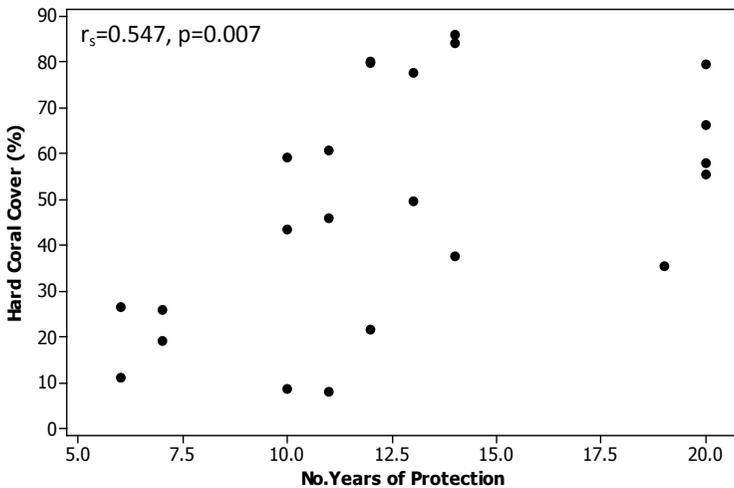


Fig. 6. Scatterplot showing relationship between hard coral cover and the number of years of protection in Apo Chapel.

forms ($12.9 \pm 6.67\%$ cover or 60% of the total hard coral cover) dominate the coral composition in Bantayan resulting in a higher dominance index (cover, $c=0.38$ and counts, $c=0.15$) contributed mostly by *P. lobata* in terms of cover ($11.90 \pm 6.36\%$ cover at $c=0.35$) and number of colonies (11 colonies at $c=0.04$). Smaller submassive *Pocillopora verrucosa* (16 colonies at $c=0.08$) and fire coral *Millepora platyphyllia* (7 colonies at $c=0.02$) colonies were also numerically abundant. In Apo Chapel, branching corals ($40.43 \pm 5.11\%$ cover or 69% of the total hard coral cover) were the most dominant growth form, particularly *Porites nigrescens* ($16.89 \pm 3.84\%$ cover at $c=0.08$ and 56 colonies at $c=0.08$) and *P. cylindrica* ($14.65 \pm 4.26\%$ cover at $c=0.06$ and 30 colonies at $c=0.02$) (Table 2). Massive *P. lobata*, submassive/encrusting *Pavona varians* and branching *Montipora cactus* were also common in terms of colony number, though less abundant. Four soft coral genera were listed in Bantayan and six in Apo Chapel.

Manta tow survey revealed a poor hard coral cover of only $8 \pm 2.1\%$ in Bantayan while a greater portion of the area is occupied by rubble ($23.5 \pm 7.2\%$), seagrasses ($23.8 \pm 9.4\%$) and algae ($36.1 \pm 8.6\%$). Apo Chapel, on the contrary, showed better hard coral growths at $33.3 \pm 15.9\%$ with $47.5 \pm 12.5\%$ recorded from deeper area. Soft corals and sand also contributed a relatively high percentage with $26.2 \pm 8.7\%$ and $20 \pm 15.2\%$, respectively.

Results of the LIT further confirmed that Apo Chapel had a significantly higher hard coral cover at $58.9 \pm 7.2\%$ compared to Bantayan marine sanctuary which only had $20 \pm 9.9\%$ (U, $p=0.016$, 2-tailed) (Figs. 4-5). Moreover, it is more structurally complex (1.4 ± 0.1) than the latter (1.3 ± 0.1) (Table 4). Algae and rubble only covered 2% in Apo Chapel while contributing more than 11% in Bantayan (t, $p=0.009$ and t, $p=0.020$, respectively). Seagrasses were absent in Apo Chapel. Cover of dead corals was also higher in Bantayan ($7 \pm 3.9\%$ vs. $1.6 \pm 0.8\%$) while soft corals, dominated by *Briareum* spp. ($12.6 \pm 2\%$), comprised a relatively high percentage in Apo Chapel ($22.1 \pm 2.6\%$). Soft coral cover appeared to be naturally low in Bantayan with only $<2\%$ in 1995-2009 and none was recorded in 2013. Bantayan showed a higher mortality index compared to Apo Chapel (Table 5). Reef condition in both sites was generally good. However, development index was poor in Bantayan while good in Apo Chapel.

Region XI.

Benchmark vs. Current Data. In Guang-guang, hard coral and dead coral cover appeared to increase from 2010 to 2013 ($27.2 \pm 10.2\%$ to $42 \pm 3.4\%$ and $7.5 \pm 4\%$ to $20.7 \pm 4.4\%$, respectively) (Fig. 7). In reverse, covers of abiotic components were found to have lowered especially sand ($21. \pm 1.2\%$ to $10.4 \pm 2.4\%$) and rock ($18.5 \pm 7.9\%$ to $4.9 \pm 3\%$). Statistically, these differences were not significant (U, $p=0.143$, 2-tailed; t, $p=0.178$; t, $p=0.054$, respectively) except for rock (t, $p=0.046$). Trend analysis, however, showed significance in pattern with time for sand (U, $p=0.018$, 1-tailed) but not for rock (U, $p=0.071$, 1-tailed), hard corals (U, $p=0.071$, 1-tailed) and dead corals (U, $p=0.071$, 1-tailed). Within time periods, hard coral cover dominated significantly from soft corals ($0.2 \pm 0.2\%$) and silt ($1.6 \pm 1.6\%$) (F, $p=0.000$) in 2010 and over all the other components in 2013 (H, $p=0.000$).

In comparison, the northern side of Pujada I. showed a significant decrease in hard coral cover over the 4-year period (U, $p=0.018$, 1-tailed) with higher hard coral cover recorded in 2010 ($74.8 \pm 2.5\%$) compared to 2013 ($40.2 \pm 6.2\%$) (t, $p=0.012$). On the other hand, other fauna ($0.7 \pm 0.4\%$ vs. $4.9 \pm 1.6\%$) (t, $p=0.028$), algae ($1.2 \pm 0.9\%$ vs. $10.7 \pm 1.3\%$) (t, $p=0.050$) and rubble ($1.7 \pm 0.6\%$ vs. $25.2 \pm 3\%$) (U, $p=0.036$, 2-tailed) exhibited an opposite pattern with significant trend p-values (U, $p=0.036$, $p=0.018$, $p=0.018$, 1-tailed, respectively) (Fig. 7). Hard corals significantly dominated the substrate in 2010 (H, $p=0.032$) while in 2013, values did not differ statistically from dead corals and rubble except from the rest of the categories (Welch's F, $p=0.000$). Ecologically, the decline in hard coral cover was also significant (46.3% or 34.6% loss).

Hard coral composition in both sites was dominated by branching corals (82-91%) during the study periods (Fig. 3).

Comparison of Current Data. Forty-two hard coral species were recorded from Guang-guang whereas the northern side of Pujada I. only had 27 species (Table 1). However, higher diversity index for both cover ($H'=0.76$) and counts ($H'=1.08$) were obtained in Pujada I. Consequently, index of dominance ($c=0.78$ and $c=0.58$, respectively) was higher in Guang-guang with branching *P. cylindrica* as the dominant species ($36.90 \pm 5.75\%$ cover at $c=0.77$; 82 colonies at $c=0.57$) constituting 88% of the total hard coral cover. *Porites cylindrica* was also abundant in Pujada

I. ($33.12 \pm 6.23\%$ at $c=0.68$; 87 colonies at $c=0.54$) accounting for 82% of the hard coral cover. Other numerically common but less abundant species were *P. rus* in both stations and *P. nigrescens* in Pujada I. Total percentages of branching corals in these stations were $37.5 \pm 5.6\%$ and $36.6 \pm 5.9\%$, respectively. Two soft coral genera were noted from each station.

Manta tow survey revealed that almost half of the area in Guang-guang is occupied by sand at $47.2 \pm 3.3\%$ while hard corals covered only $27.2 \pm 5.4\%$. Pujada, on the other hand, showed better coral growths at $47.4 \pm 9.9\%$ with smaller sandy patches occupying $16.4 \pm 2.4\%$. The tow which was conducted in a west to east direction showed a change in coral composition, from an area that is primarily reef and dominated by branching *Porites* to an extensive seagrass bed, $30.4 \pm 11.6\%$, frequently interspersed by large coral patches dominated by massive *Porites*. At the transition zone, these forms are almost equally abundant.

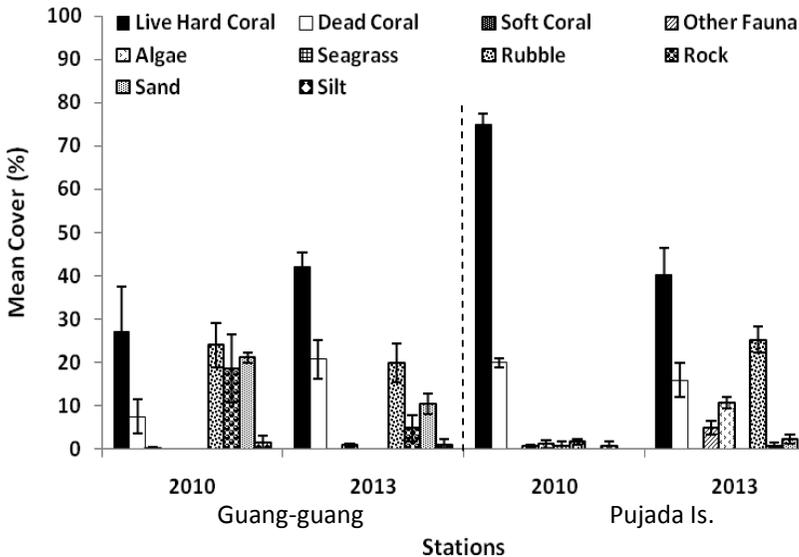


Fig. 7. Mean percent cover of substrate categories in Davao Oriental.

Data for 2010 from DENR-ICRMP (2010; $n=3$); 2013 ($n=5$).

Survey by LIT revealed that the current hard coral cover did not significantly differ between Guang-guang ($42 \pm 3.4\%$) and the north of Pujada I. ($40.2 \pm 6.2\%$) ($t, p=0.667$) (Fig. 7). Reef complexity was slightly

higher in Guang-guang at 1.4 ± 0.1 than Pujada, 1.4 ± 0 (Table 4). In Pujada, calcareous algae, *Halimeda* (7%), as well as, algal assemblage, turf- and macroalgae have been found growing between branches of some live and dead colonies of *P. cylindrica*. Dead corals ($20.7 \pm 4.4\%$) and rubble ($19.9 \pm 4.5\%$) in Guang-guang were not significantly different from Pujada ($15.9 \pm 4\%$ and $25.2 \pm 3\%$, respectively) (t , $p=0.516$ and t , $p=0.245$, respectively), both of which accounted for almost half the cover of live corals. Stations significantly differed in cover of other fauna which was higher in Pujada ($4.2 \pm 1.6\%$ vs. $0.9 \pm 0.4\%$) (t , $p=0.015$) and cover of sand found to be higher in Guang-guang ($10.4 \pm 2.4\%$ vs. $2.4 \pm 0.9\%$) (t , $p=0.017$). Mortality index was slightly higher in Guang-guang compared to Pujada (Table 5). Reef condition and development indices were good. Total coral-related components were twice the cover of abiotic-related components.

DISCUSSION

Studies investigating changes in coral communities have mostly cited a declining coral cover trend. These findings have been associated with increasing human activity and recently as a synergistic effect with climate change. Time-series data from the Great Barrier Reef indicated a major decline in hard coral cover over 27 years (28% in 1985 to 13.8% in 2012 or 50.7% loss of the initial cover) with an increasing rate of decline at approximately $1.45\% \text{ yr}^{-1}$ since 2006 (De'ath *et al.* 2012), similar to Caribbean reefs (50% in 1977 to 10% in 2002 or 80% loss, $\sim 1.4 \text{ yr}^{-1}$ rate of decline) (Gardner *et al.* 2003). Contrasting processes led to the decline in these reef systems. The Great Barrier reef experienced periodic COT infestation and cyclones but only few losses to bleaching (De'ath *et al.* 2012), while the Caribbean reefs suffer from a combination of coral diseases and storms, mass die-off of *Diadema antillarum* resulting in phase shifts from coral to algal-dominance, and more likely from overfishing, sedimentation, temperature stress, habitat destruction and eutrophication (Gardner *et al.* 2003). Although water quality does not directly affect coral cover in the Great Barrier Reef, elevated nutrient runoff and sediment loads from urbanized catchments are already significantly increasing macroalgal cover while diminishing coral species richness and recruitment (De'ath *et al.* 2012). Cleary *et al.* (2014) likewise reported an overall decline in hard coral cover in the Jakarta Bay-Thousand Islands reef

system from ~50 to ~60% in 1985 to ~40% in 2011 with significant shifts in coral generic composition. Here, pollution, coral extraction, blastfishing and the bleaching event in 2010 are the major causes of degradation.

Results of this study show contrasting patterns in coral cover changes with significantly increasing trends over time at the south of Baladingan (14 to 33%) and Apo Chapel (19 to 59%), while decreasing in the north side of Pujada I. (75 to 40%). Guang-guang and Bantayan marine sanctuary did not show any change over the study period.

Of these sites, only Apo I. and Pujada Bay have been legally protected as a Protected Landscape and Seascape and Protected Seascape, respectively, for over 20 years. The only contrast was that Apo I. has been strictly protected, with an MPA rating of level 4 as of 2005 (<http://www.coast.ph/>), which in effect has positively increased the coral cover over years of protection. In contrast, Pujada Bay only reached level 1 (MPA established) up to this day (Dizon *et al.* 2011). Although Mati municipality is part of the PBPS, no sites, including Guang-guang, have reached the requirement for MPA establishment (<http://www.mpa.msi.upd.edu.ph/mpa>). The Protected Area Management Board has been reported to be non-functional (Dizon *et al.* 2013). Coastal pollution from unmanaged aquaculture and agricultural run-off and mining operations, weak law enforcement, lack of public awareness and destructive fishing are major environmental issues (Jimenez *et al.* 2002; ADB, 2006).

Previous studies have shown that Apo I. suffered from the 1998 and 2010 bleaching events and recently, from the sequential Severe Tropical Storm Washi in 2011 and Super Typhoon Bopha in 2012. Divinagracia (2000) reported that the 1997-1998 El Niño event resulted in coral bleaching that affected 35% (0.37 km²) of the total reef area (1.06 km² to the 60 m isobath). The eastern side where the sanctuary is located is the most impacted with 90% of the dominant massive *Galaxea fascicularis* bleached (Raymundo and Maypa, 2002). Cover dropped from 75.1% in 1995 to 40.2% in 1999 (Calumpong *et al.* 1997; USAID-SU COE-CRM Project 1999-2000). Raymundo (Reef Check 6-year Report) also recorded a drop from 62% during the bleaching period to 40% the following year. Cover rapidly recovered in 2003 at 63% and after the 2010 bleaching event, has declined to 21.1% early in 2011 (Reboton and Rosell, unpublished). Although there was no data specific for Apo Chapel prior to 1999, coral cover in the western side of the island ranged from 15.4% in 1983 (White, 1984 in MCDP, 1985 and Pialago *et al.* 1991) to 35.2%

in 1992 (White and Calumpong, 1992) showing only a difference of 16% from 1999 Chapel data. Unlike the sanctuary, Apo Chapel is dominated by branching *Porites* species. From our study at the sanctuary in 2010 (Reboton and Rosell, unpublished), these species were found to be less susceptible to bleaching although some colonies temporarily developed white spot disease. Between 2007 and 2013, the relative composition of branching *Porites* in Apo Chapel suggests no negative impacts from bleaching. *Porites* species are tolerant to bleaching due to its symbiont *Symbiodinium* C15 and a high concentration of host proteins (Fitt *et al.* 1993; Faxneld, 2011; Tonk *et al.* 2013). In the succeeding years, Apo was struck by typhoons that decimated the eastern side, leaving less than 1% of hard coral cover (Reboton, in DENR, SU-IEMS and CCEFI on-going-project). On the contrary, the western side was sheltered from the typhoons. As shown by the slight decrease in hard coral cover between 2007 and 2013, it may suggest that both El Niño and typhoons generally had very minimal impact on Apo Chapel, except for *Acropora* which are more fragile and highly susceptible to bleaching (Loya *et al.* 2001; Maynard *et al.* 2008; Obura, 2008; Li *et al.* 2011; Putnam *et al.* 2012). These accounts are further reflected by the high structural complexity, low mortality as well as good condition and development qualities of the area. Live coral cover and rugosity are important influential factors to coral reef fish abundance and species diversity (Bell and Galzin, 1984; Nguyen and Phan, 2008; Komyakova *et al.* 2013).

There are no available earlier data that are specific to the sites in Pujada Bay but Jimenez *et al.* (2002) mentioned that about 22% of the reefs exhibit excellent condition, 30% are good, over 20% are fair while 28% are in poor condition. Similar to Apo Chapel, Guang-guang and the north of Pujada I., which are also dominated by branching *Porites*, did not show noticeable signs of bleaching in 2010. Covers were found to be in fair to almost excellent condition. Although, typhoon Bopha has also affected the municipality of Mati in 2012 (PDNA, 2013), the contrasting pattern in coral cover is more likely attributable to the location of the sites. Guang-guang is more protected inside the bay while Pujada I. is likely to suffer the consequences of the typhoons being located at the mouth of the bay that faces the Pacific Ocean. Previous report by Jimenez *et al.* (2002) indicates that Pujada Bay used to be rarely visited by typhoons. Of note, there are also anecdotal reports of dynamite fishing that is more rampant in areas far from the mainland. Altogether, these factors cause a remarkable decline in

coral cover (46%). It is expected that with the decrease in hard coral cover, particularly due to physical damage, cover of rubble and algae also increase. Cleary *et al.* (2014) documented similar patterns in Jakarta wherein coral cover decrease was accompanied by the increase in rubble cover. Hughes and Connell (1999) and Kuo *et al.* (2012) also demonstrated that the impact of recurrent typhoons combined with overfishing and the influence of growing human population resulted in macroalgal blooms. Of all the sites surveyed, the sites in Pujada Bay exhibited the highest mortality index. While coral mortalities in Pujada I. could be mostly attributed to mechanical damage due to typhoons and destructive fishing, majority of mortalities in Guang-guang are likely due to elevated siltation associated to high energy disturbances especially that this site fronts the Guang-guang Mangrove Park and Nursery. In Pujada I., rubble cover has significantly increased while the cover of dead standing corals remained stable. In contrast, dead coral cover increased in Guang-guang while no change was observed in the cover of rubble. Despite the robust appearance of *Porites cylindrica* in the latter site, the colonies were actually very fragile. According to Rogers (1990), heavy sedimentation causes coral mortality due to smothering and is further linked with low coral diversity, greater abundance of branching forms and decreased calcification. Nevertheless, dead corals will eventually collapse to rubble. It should also be noted that both areas have the lowest diversity among the sites.

Comparatively, there was no notable change in coral cover in Bantayan for over 19 years, even after experiencing the brunt of the two typhoons. Growing human population in the coastal area and increasing human activity have been a persistent threat in this site. The sanctuary was just recently implemented in 2011, a few months after typhoon Washi, and any signs of improvement are not yet visible. Unlike Apo Chapel, diversity and rugosity indices were low. Coral cover has remained poor as abiotic components comprised the bulk of the substrate, thus the poor development index. The effect of human disturbance and previous storms (e.g. typhoon Frank in 2008) were likely the cause in the decrease in seagrass cover and the increase in algae, rubble and rock covers in 2009. Moreover, foliose corals which are fragile had disappeared. Increase in dead coral cover and significantly in algal cover occurred after the recent bleaching event and the two major typhoons resulting in a high mortality index. These typhoons also caused elevated sedimentation that lasted for weeks. Although coral cover did not change significantly, these disruptions caused a shift in coral composition

from finer *Acropora* and branching coral-dominated to more hardy massive coral-dominated habitat. In fact, live *Acropora* colonies were no longer seen in the transects. Massive corals are less susceptible to bleaching because of their high concentration of fluorescent pigment granules, low colony integration and thicker tissues (McClanahan *et al.* 2004). Submassive corals also increased in cover while robust forms of *Millepora* persisted since 2009. Shifts in the coral composition due to warming events in the Arabian Gulf, such as spatial replacement of *Acropora* to *Porites*, was reported by Sheppard *et al.* (2010). The long-term study of Edmunds (2013) in the U.S. Virgin islands and Cleary *et al.* (2014) in Indonesia similarly demonstrated changes in community structure and coral composition associated to environmental stresses.

Meanwhile, Ticao I. is one of the five geographic units in the Pacific coast that have been identified as high priority site for conservation (Licuanan *et al.* 2011). Participatory coastal resource assessments rated most coastal habitats around Ticao as fair to good. Unfortunately, weak management of the marine resources, localized population pressure, domestic pollution, coral quarrying, illegal fishing (e.g. dynamite, superlights, cyanide, compressor, Danish seine) pose threats to the coral reefs (GEF Project Executive Summary). The sites in this study are not directly along the path of typhoons, however, they are at greater risk of inundation from probable sea level rise (The World Bank in the Philippines, 2012). Moreover, blastfishing is not practiced here but poaching by fishers from different municipalities/barangays is a major concern in Baladingan. Despite the fact that no sanctuary has yet been established, the southern side of Baladingan exhibited an increase in coral cover over the 5-year period. The introduction of the concept of conservation by Silliman University has raised the level of awareness of the community that, at some point, perhaps produced positive impacts to the marine habitats. Massive corals which are more hardy and resilient to mechanical stresses consistently dominated the hard coral composition with >69% relative cover. *Acropora* species which are more delicate and sensitive to increased water temperature may have been reduced by both fishing disturbances and bleaching. Current data shows Tacdogan to exhibit similar conditions except for the higher cover of dead corals and mortality index, and the almost equal dominance of massive and branching forms. While Baladingan is far from the effect of sedimentation, Tacdogan experiences regular bouts of siltation from the nearby river and mangrove forest during ebb tide. The dominant *Porites* and

Montipora species, both of which have small calices, are reportedly tolerant to high sedimentation levels (Rogers, 1990).

Even though sites varied in their hard coral cover, overall, they exhibited good condition, however, poor reef development indices are noted for some where cover of abiotics is relatively high (i.e. Baladingan, Tacdogan, Bantayan). Highest mortalities are observed in sites that experience high anthropogenic and natural pressures (i.e. Guang-guang, Pujada I., Bantayan). Likewise, these areas have the lowest coral diversity. Hutchings *et al.* (2008) suggested that coral diversity is low in low and high disturbance regimes which result in monospecific stands of competitively dominant fast growing species or encrusting algal and coral forms that provide little to structural heterogeneity. The “intermediate disturbance” hypothesis of Connell (1978) states that at the intermediate scales and frequency of disturbance, diversity is higher. Regular wave action and storms are not necessarily detrimental to the overall health of a reef as they clear up space for recolonization by other species (Huston, 1994; Hutchings *et al.* 2008). Connell (1978) clearly explained that at low disturbance levels, the processes of succession will eventually lead to a climax community predominated by fewer species of substantial biomass. Disruption of this state will provide potential space for colonization by opportunistic species. As a result, the assemblage is modified and now consists a combination of climax and opportunistic species, thus increasing the diversity. Such could be the case in Apo Chapel. But at higher disturbance severities and frequencies, the time for recolonization is brief and will allow only a few species that quickly reach maturity to thrive. The resulting community is an assemblage of low diversity (Connell, 1978).

The chance of coral recovery from acute disturbances is higher than chronic disturbances, but is prolonged when the physical environment becomes altered (Connell *et al.* 1997). Changes in the habitat, hence new conditions, may also favor a different larval pool of recruits causing change in species composition and abundances (Hughes and Connell, 1999). According to Johnson and Preece (1992), recovery from disturbance events depend on both large-scale and smaller scale level properties so that even in systems with identical reef state (=coral cover) but with different state variances, the abilities to recover may be dissimilar. For instance, a change in the community structure occurred at the Glovers Atoll due to massive bleaching and hurricane (“Mitch”) in 1988 (Mumby, 1999) while lack of recovery from recurrent typhoons (i.e. Allen in 1980 and Gilbert in

1989) was experienced in Jamaica due to the scarcity of herbivores from overfishing, and hence, a prolonged macroalgal bloom. This exemplifies that coral assemblage recovery from natural catastrophes can be hindered by anthropogenic impacts (Hughes and Connell, 1999; Berumen and Pratchett, 2006), or rendered impossible (Stobart *et al.* 2002) leading to phase shifts, i.e. usually a transition from hard coral- to algal- dominance (Berumen and Pratchett, 2006), that are already irreversible (Knowlton, 1992). In the Philippines, dynamited reefs take 38 years to recover to 50% areal cover, but reports on certain reefs with no significant recovery in 9-10 years after blasting imply that this figure may be underestimated (Alcala and Gomez, 1979).

Marine protected areas do not actually provide a refuge from bleaching or typhoons. The differences in species composition determine the susceptibility of the area to the disturbance (Hughes *et al.* 2003; Cote and Darling, 2010) but potential for recovery of colonies that are already under pressure from anthropogenic factors is reduced (Wilkinson *et al.* 1999). Moreover, they protect food webs and key functional groups (e.g. reef constructors, herbivores, and bioeroders) and act as larval sources to facilitate recovery of nearby affected areas (Johnson and Preece, 1992; Hughes *et al.* 2003). At Pescador, Philippines where the reef is within a MPA, recovery from <5% to 45% was observed four years after typhoon “Nitang” (Alcala and Gomez, 1990). Rapid recovery of *Acropora* and massive corals in Florida was also observed within 5 years after decimation by hurricane (Shinn, 1976 in Alcala and Gomez, 1979). A study in Banilad Sanctuary, Dumaguete projected about 4 years of recovery to pre-disturbance cover from a grounding incident (Reboton, 2009). It should be noted that various mechanisms may cause coral mortality over a brief period, and the rate of this routine mortality (due to smothering/abrasion, predation, shading by competitors) are usually high even in the absence of a major disturbance. As such, periodic censuses only provide a snapshot of the actual sequences of events (Hughes and Connell, 1999).

SUMMARY, CONCLUSION AND RECOMMENDATION

Several factors can influence the state of a reef. Results of the study indicate that the level of protection, exposure to natural and anthropogenic factors and species composition influence the reef’s condition. Improvement in

coral cover can be attributed to strict protection of reef areas such as in the case of Apo I. On the contrary, Bantayan which has not been protected for years showed no improvement at all. The sites in Davao Oriental, though within the Pujada Bay Protected Seascape, do not receive ample protection and combined with the effects of typhoons and sedimentation resulted in coral cover decline and mortalities. The sites in Masbate may be protected from typhoons such that they show improved coral cover yet fishing practices caused some changes in coral composition. In spite of the good condition exhibited by all the sites, the natural makeup of the substrate can also influence the degree of reef development (i.e. high cover of abiotic-related components causes poor degree of development). In addition, coral cover may also be influenced by the composition of species depending on their tolerance to these disturbances.

As the severity and frequency of the impacts of climate change continues to increase, it is therefore important that reefs be protected from human-related destructions in order to improve the well-being of our environment.

The lack of previous and sufficient information in most of the sites surveyed is the limitation of this study such that extensive comparisons cannot be fully achieved. Long-term studies are recommended to fully understand the actual trends in the condition of these reefs.

ACKNOWLEDGMENT

This study is funded by the Philippine Higher Education Research Network of the Commission on Higher Education (CHED – PHERNet). Special thanks to Dr. Aileen Maypa, Mr. Roy de Leon and Dr. Janet Estacion for their guidance in the data analysis and to Persie Mark Sienes for the map.

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Antimicrobial Activity of the Volatile Oil from the Leaves of Piper betle Linn.

Adeltrudes B. Caburian

Saint Louis University

Marina O. Osi

University of Santo Tomas

Reiner E. Belardo

Saint Louis University

The study was carried out with the objective of evaluating the antibacterial and antifungal potentials and non-mutagenic activity of the pure volatile oil from the leaves of Piper betle vine, a traditional antimicrobial medicine. It was also the purpose of the study to determine the physicochemical properties and composition of the pure oil. The determined physical constants were congealing temperature (-4° C), melting point (8°C), specific gravity (0.9313), optical activity (+4.2307), and refractive index (1.4525). Twenty oil components were identified by gas chromatography-mass spectroscopy (GC-MS) analysis – among them are: 5-(2-propenyl)-1,3-benzodioxole, eugenol isomers, 3-carene and caryophyllene. In this study, the microbial activity of the pure oil from the leaves of P. betle was evaluated for potential antimicrobial activity using agar-well diffusion method. The antibacterial activity of the oil at 100µg/mL concentration were tested against Staphylococcus aureus, Escherichia coli and Bacillus subtilis while 20µg/mL, 30µg/mL and 40µg/ml concentrations of the oil were used against Streptococcus pyogenes. The antifungal activity of the oil at 100µg/mL was tested against Candida albicans and 2µg/mL, 10µg/mL and 15µg/mL concentrations against Trichophyton mentagrophytes. Zone of inhibition of the pure oil was compared with standards mupirocin for antibacterial activity and clotrimazole for antifungal activity. The results show active to very active inhibition of the bacterial and fungal growth against the test organisms. The antimicrobial action of the P. betle oil is due to bioactive constituents such as isosaffrol, eugenol and caryophyllene among others which are well known for their antibacterial and antifungal properties. P. betle oil does not possess carcinogenic and/or mutagenic activity as evident of lower number of micronucleus formed in rat bone marrow cells after treatment of the pure oil when compared to cyclophosphamide. The

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mechanism of its antimicrobial activity is not yet well understood. Further studies on the pathway of microbial growth inhibition are recommended and preformulation data obtained in this study should be validated to establish specifications of the oil.

Keywords: Piper betle L. volatile oil, antibacterial activity, antifungal activity, GC-MS, non-mutagenic activity

INTRODUCTION

A large number of medicinal plants have been used for scientific researches in different areas of medicine. Researches are still underway for the discovery of their active constituents responsible for their medicinal and curative values. The latter part of the 1990s up to the present showed an unprecedented increase in the use of herbal remedies and herbal food supplement in the treatment as well as prevention of diseases. Global interest in traditional medicine has increased significantly in recent years, driven by global trends in health care (Yuan & Lin, 2002). Antimicrobials are one of our most important weapons in fighting bacterial and fungal infections and have greatly benefited the health-related quality of human life (Hsouna & Hamdi, 2012). However, over the past few decades, these health benefits are under threat as many commonly used antibiotics have become less and less effective against certain illnesses not only because many of them produce toxic reactions, but also due to emergence of drug-resistant bacteria (Bhalodia & Shukla, 2011). Drugs derived from natural resources play a significant role in the prevention and treatment of human diseases. In the Philippines, traditional medicine is one of the primary healthcare systems. Natural products of plants may give a new source of antibacterial and antifungal agents with possible novel mechanisms of action (Bhalodia & Shukla, 2011). Plant extracts are widely claimed to have a broad-spectrum antibacterial and are considered as a main source for the search of lead compounds (Hsouna & Hamdi, 2012).

Piper betle L. according to Concha (1982) is locally known as buyo (Bik.), gaoed (Pang.), gaued (Ilk.), and ikmo (Tag.); in English it is known as betel leaf. It is a twining vine, climbing plant slightly woody at the base. It is probably a native of Malaysia but cultivated in India and most parts of the Philippines. The inflorescence is a spike; the male spikes are spendulous and slender. The female spikes when mature are red, fleshy and oblong to elongate. The leaf is simple, glabrous, broadly ovate, base

cordate, apices rounded. Size and color of leaves are affected by light during cultivation. Odor is tar-like; taste pungent (Philippine pharmacopoeia 1, 2004).

P. betle L. commonly known as betel leaf has been used since ancient times. A mixture of betel leaf, betel nut and lime is still being used by old folks as a masticatory; it is believed to strengthen the teeth and protect the teeth from decay. It is useful in arresting secretions and is used in several common household remedies. The leaves have been used as an antiseptic for wounds and cuts and poultice for boils, used for relief of coughs, as an expectorant, for stomach ailments, diphtheria and inflammation (Quisumbing, 1978). The development of *P. betle* as a drug can contribute to the treatment of diseases caused by bacteria and fungi.

Previous studies on betel leaves, roots and whole extract showed a very strong antimicrobial activity (Jenie et al., 2001). The betel leaves contain a beneficial volatile oil and is known as the betel leaf essential oil. It is valued in Ayurveda as a stimulant, carminative, aromatic, and antiseptic. Volatile oils are usually obtained from plant parts containing the oil by steam distillation. The volatile oils are composed of several chemicals that form the odoriferous essences of a number of plants. They are also known as ethereal oils or essential oils (Tyler, Brady, & Robbers, 1988). This research utilized the extracted pure volatile oil from the leaves of *P. betle* to develop an antimicrobial agent. The betel plant grows abundantly in the Philippines thus it can be locally procured and processed. The volatile oils are composed of several chemicals that form the odoriferous essences of a number of plants.

Many studies proved that volatile or essential oils have potential use as antimicrobial agents whose importance grows as microbial resistance to antibiotics increases. Because of their potency and documented pharmaceutical efficacy, essential oils represent an important allopathic and herbal system of medicine. An antimicrobial agent is a substance that kills or inhibits the growth of microorganisms. This may be categorized on the basis of their antibacterial activity as either bacteriostatic or bactericidal and likewise antifungal activity as either fungistatic or fungicidal.

This research is specifically aimed to determine the percentage of oil that can be obtained from the leaves, and the quality characteristics of the volatile oil in the areas of physicochemical analysis, microbiological activity and antimutagenic activity. In this current investigation, a screening of the

volatile oil against pathogenic bacteria and fungi is done in order to detect new sources of antimicrobial agents.

MATERIALS AND METHODS

Collection of Plant Material

The mature Piper betle L. leaves were collected from La Union, Abra, Iloilo City, Palawan and Malaybalay. A representative of the whole plant was brought to the Philippine National Museum for authentication. The collected leaves were washed, dried and cut into small pieces.

Isolation of the Volatile Oil

One hundred sixty grams of cut leaves were subjected to hydro distillation using a Clavenger-type apparatus to extract the volatile oil. The volume of the oil was measured directly using a graduated cylinder. A small quantity of anhydrous sodium sulphate was added to remove any traces of water. The percentage yield (w/w) of the essential oil was calculated on dry basis, using the formula:

$$\% \text{ yield} = \frac{\text{weight of the volatile oil}}{\text{weight of the air-dried leaves}} \times 100$$

Characterization of the Volatile Oil

Organoleptic Properties

The color and clarity of the volatile oil placed in transparent bottles were observed over a white background. The characteristic odor was determined by sniffing.

Solubility

The solubility of the oil was determined by mixing incremental volumes of the volatile oil on a 1:1 ratio of the following solvents: water, chloroform, ethyl alcohol, anhydrous ether and petroleum ether.

Specific Gravity

The determination of specific gravity was based on the procedures by Knevel and DiGangi (1977). The measurement of weight was performed using a Sartorius CP 135 balance. Three trials were conducted and the mean of the reading is considered as the specific gravity of the volatile oil.

Congealing Temperature

Congealing temperature was determined based on the procedures in United States Pharmacopeial Convention (2002). Ten millilitres of the volatile oil was placed in a test tube. The temperature was raised 4-5 degrees above the expected saturation point, allowed to cool, and the temperature at which the first crystals appear was noted as the congealing temperature.

Specific Rotation

The extent of optical activity of the oil was determined following the procedures of Knevel and DiGangi (1977) using an E. Harnack 220 polarimeter. The specific rotation was calculated using the formula provided by the United States Pharmacopeial Convention (2002). Determinations were done at 25°C. Readings from three conducted trials were obtained and the computed average was recorded as the specific rotation of the volatile oil.

Refractive Index

The refractive index of the volatile oil was measured using an Atago TM1 refractometer following the procedure provided by Knevel and DiGangi (1977). Three trials were performed and the mean of the readings was regarded as the refractive index of the volatile oil. The expected values are between 1.46 and 1.61 at 25°C (Tyler et al., 1988).

Chemical Analysis of the Piper betle Volatile Oil

The volatile oil was submitted to the National Chemistry Instrumentation Center (NCIC) at Ateneo de Manila, Quezon City for its chemical characterization by gas chromatography – mass spectrometry (GC-MS). The

analysis used a Hewlett Packard 5890 Series II gas chromatograph, equipped with a DB-1 fused silica capillary column (60m length; 0.25mm internal diameter; 0.25 μ m phase thickness), coupled with a Finnigan-MAT 95ST high-resolution mass spectrometer (70eV ionization voltage; 35-350 amu mass range; 1sec/decade scan rate). The carrier gas was used at 4mL/min purge flowrate and 10mL/min splitless flowrate. The temperature program is as follows: 50°C initial temperature, held for 1min, 50°C to 250°C at 4 °C/min. The NIST mass spectra library was used to match the mass spectra and only identities with Rfit values greater than 800 were considered as an acceptable match of identity. The reported amounts were based on the area of the identified peak relative to the area of all identified peaks. The mass spectrum and a list of possible identities of peaks were provided by NCIC after the analysis.

Antimicrobial Susceptibility Assay of the Piper betle Volatile Oil

Preparation of Volatile Oil Suspension and Controls

A 500mL volatile oil suspension with a concentration of 1000 μ g/mL was made by suspending an equivalent volume of 500 mg of the volatile oil in isotonic saline containing 0.2% Tween 80. One hundred micrograms of this suspension was withdrawn to test the activity of the oil against *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* and *Candida albicans*. Previous tests of the activity of 100 μ g/mL volatile oil against *Streptococcus pyogenes* and *Trichophyton mentagrophytes* resulted to the formation of a zone of inhibition exceeding the size of a 90-mm petri dish, making it impossible to be measured pragmatically; thus, equivalent amounts of 20 μ g/mL, 30 μ g/mL, and 40 μ g/mL dilutions were prepared for *S. pyogenes* while corresponding dilutions of 2 μ g/mL, 10 μ g/ml, and 15 μ g/mL were prepared for *T. mentagrophytes*.

The positive controls for the antibacterial and antifungal susceptibility tests were 2% (w/w) mupirocin cream and 10% (w/w) clotrimazole cream, respectively. Five hundred milligrams of each of the positive controls was suspended in 0.2% Tween 80 in saline solution to produce 10 mL of stock suspension with a concentration of 1000 μ g/mL. Dilutions of the suspension were prepared matching the concentration of the volatile oil. An isotonic 0.2% Tween 80 solution served as the negative control.

Preparation of Bacterial and Fungal Cultures

Pure cultures of bacteria and fungi were obtained from the University of the Philippines Research Institute, Diliman, Quezon City. The test organisms included the bacteria *Staphylococcus aureus* UPCC 1143, *Bacillus subtilis* UPCC 1295, and *Escherichia coli* UPCC 1195; and the fungi *Candida albicans* UPCC 2168 and *Trichophyton mentagrophytes* UPCC 4193. The pure culture of *Streptococcus pyogenes* was obtained from the Benguet State University Microbiology Laboratory.

Mueller-Hinton broth cultures of *S. aureus*, *E. coli*, *B. subtilis*, and *S. pyogenes* were prepared and incubated for 18-24 hours at 35°C to allow sufficient growth. A vortex-mixed spore suspension of *T. mentagrophytes* in sterile isotonic Tween 80 solution was prepared from Sabouraud glucose slant culture incubated at room temperature for 3-5 days. A Sabouraud glucose broth culture of *C. albicans* was prepared and incubated for 18 hours at room temperature. The turbidity of the broth cultures and spores suspension was adjusted in comparison with the 0.5 McFarland standard prior to testing.

Antimicrobial Susceptibility Testing

The antimicrobial susceptibility assay (agar-well diffusion method) was performed based on the procedures by Quinto and Santos (2006). The bacterial isolates (*S. aureus*, *S. pyogenes*, *E. coli*, and *B. subtilis*) and fungal isolates (*C. albicans* and *T. mentagrophytes*) were inoculated on Mueller-Hinton agar and Sabouraud glucose agar plates, respectively. Three trials were prepared for each microorganism. Three 6-mm wells were created, each delivered with 100µL of either the oil or one of the controls using a micropipette. The plates were incubated for 18-24 hours at 35°C and at room temperature for plates containing bacteria and *C. albicans*, respectively, and at room temperature for 2-3 days for the plates containing *T. mentagrophytes*. After incubation, the size of zones of inhibition around the agar well was measured using a ruler. The zone of inhibition produced by the volatile oil suspension was compared with the positive and negative controls using statistical methods. The assessment of zone of inhibition diameters were based on the criteria by Quinto and Santos (2006).

Minimum Inhibitory Concentration Assay

Preparation of Piper betle Volatile Oil

Approximately 40 mg of the volatile oil was added to 10 mL Mueller-Hinton broth with a small amount of 0.1% Tween 80 to enhance the solubility of the volatile oil. The mixture was swirled, transferred to sterile test tubes, and agitated using a vortex mixer for 15sec. One millilitre of the suspension contains 4 mg of the volatile oil.

Preparation of Test Organisms

Five millilitres of Mueller-Hinton broth was inoculated with a loopful of the bacterial isolates (*B. subtilis*, *E. coli*, *S. aureus*, and *S. pyogenes*). A spore suspension of *T. mentagrophytes* using 0.05% Tween 80 saline solution was prepared. A loopful of *C. albicans* was inoculated into 5mL of Sabouraud glucose broth. The turbidity of each preparation was adjusted in comparison with 0.5 McFarland standard. The standardized inoculums were diluted to 20mL with Mueller-Hinton broth and 200mL with Sabouraud glucose broth for the bacterial and fungal isolates, respectively.

Determination of the Minimum Inhibitory Concentration, Minimum Bactericidal Concentration, and Minimum Fungicidal Concentration

The minimum inhibitory concentration (MIC) was determined by measuring the ability of a bacterial or fungal strain to grow in broth cultures containing different concentrations of the volatile oil. The turbidimetric method or tube dilution method, based on the procedures of Quinto and Santos (2006), was used to determine this parameter. Serial dilutions of decreasing concentrations of the volatile oil were first prepared in tubes containing Mueller-Hinton and Sabouraud growth medium. Then a known concentration of the prepared microorganism was added to each tube. The tubes were incubated and were examined for visible growth or turbidity. The lowest concentration of the volatile oil that prevents the growth of the microorganisms, seen as the absence of turbidity, is the MIC of the volatile oil (Nester et. al., 2004)

The minimum bactericidal concentration (MBC) of the volatile oil on the bacterial isolates was carried out by sub-culturing a small amount of the content of the tubes showing absence of visible growth or turbidity into Mueller-Hinton agar plates, incubation for 10-24 hours at 35°C, and observation for colonies after incubation period. The volatile oil concentration of the tube producing one colony or no colony on the Mueller-Hinton plates is the MBC of the volatile oil.

The minimum fungicidal concentration (MFC) was determined using similar procedures with MBC determination but using Sabouraud glucose agar and incubating *T. mentagrophytes* plates at 30°C for 3-5 days and *C. albicans* plates at 35°C for 18-24 hours.

Micronucleus Test for the Piper betle Volatile Oil

The assay was performed according to procedures by Bernas et al. (2005). Six healthy 8-week old laboratory-acclimatized mice were randomly grouped into 3, each receiving one of the preparations. The preparations used in the test were 2 mL of *P. betle* oil in 1 mL of 0.2% Tween 80 as test solution, 500 mg of cyclophosphamide powder in 20 mL of saline solution as positive control, and 5% Tween 80 solution as negative control. The preparations were administered intramuscularly to the mice at a volume not exceeding 2 mL/kg body weight for the test solution and 6 mg/kg body weight for the positive control. After two administrations of the preparations, the bone marrows of the test animals were collected, made into a smear and stained, followed by examination and scoring of the slides and computation of the mitotic index.

Statistical Analysis

The experimental results in the study were expressed as mean and standard deviation of three parallel measurements. The significance of differences was calculated using either Student's t-test or one-way analysis of variance at 0.05 level of significance. Regression equations were calculated by method of least squares and the differences between slope and elevations of the regression equations were tested using analysis of covariance. All graphical representations and statistical analysis were carried out using Excel® (Microsoft Corporation, USA).

RESULTS AND DISCUSSION

Extraction Yield and Physical Properties of the Volatile Oil

The air-dried leaves of *P. betle* were utilized to obtain the volatile oil by means of hydro distillation using Clavenger apparatus. The yield of the volatile oil depended on the situation of the vine, time of plucking, and the nature of material distilled. It was made sure that the leaves were taken from the upper part of the plant, were green, and have a soft texture. The essential oil yield was 1.4431%. The oil is colorless to pale yellow when freshly extracted, has a strong aromatic tar-like odor and pungent taste. It is miscible in organic solvents in the ratio of 1:1, but sufficiently soluble in water at 1:5 oil-water ratio to form a saturated solution and imparts its odor to water (Tyler et al., 1988).

Physical constants serve as a means of assessing the purity and quality of the volatile oil as well as for identification. Among the physical constants determined were: congealing temperature at -4°C (with a melting point of 8°C); specific gravity at 0.9313, optical activity at $+4.2307$. Specific gravity and optical activity both showed precision of tests based on the average which did not exceed the maximum of 2% relative standard deviation. The refractive index of 1.4525 slightly exceeded the limit due to changing temperature of the sample during the analysis.

Table 1. Specific gravity, refractive index, and optical activity of Piper betle volatile oil at various sample sites

Sample Site	Specific Gravity		Refractive Index		Optical Activity	
	Average	SD	Average	SD	Average	SD
Abra	0.9313	0.0053	1.4404	0.0141	+4.1877	0.1074
Iloilo	0.9313	0.0055	1.4535	0.0435	+4.2235	0.0620
La Union	0.9313	0.0054	1.4526	0.0327	+4.2235	0.0620
Malaybalay	0.9313	0.0056	1.4600	0.0479	+4.2593	0.0620
Palawan	0.9313	0.0053	1.4562	0.0377	+4.2593	0.0620
Mean	0.9313		1.4525		+4.2307	
%RSD	0.49%		2.21%		1.60%	

All physical data were measured at 25°C

SD – Standard deviation; %RSD – Relative standard deviation

The analysis (see Table 1) showed that the specific gravity, refractive index, and optical activity of the volatile oil from different collection sites were comparable.

Chemical Analysis of the Piper betle Oil

The GC-MS analysis of the volatile oil led to the identification of 20 different compounds (see Table 2) with the highest relative amount being 5-(2-propanol)-1,3-benzodioxole, also known as isosaffrol (48.37%), eugenol isomers (14.03% & 8.07%) and 3-carene (7.83%). Caryophyllene (1.76%) and α -caryophyllene (0.59%) were also found to be present.

Table 2. Chemical composition of Piper betle volatile oil

Retention Time (min)	Possible Identity	Relative Amounts (%)
11:05	2-methyl-5(1-methylethyl)- bicyclo[3.1.0] hex-2-ene	1.99
11:20	Alpha-pinene	1.42
11:51	Camphene	2.83
12:42	Beta-phellandrene	3.44
13:20	Beta-myrcene	0.41
13:55	Alpha-phellandrene	0.17
14:12	3-carene	7.83
14:32	1-methyl-4-(1-methyl ethyl)benzene	1.56
14:51	1-methyl-5-(1-methyletenyl)cyclohexene	1.03
15:59	1-methyl-4-(1-methylethyl)-1,4-cyclohexadiene	0.51
17:09	2-carene	0.08
17:29	3,7-dimethyl-1,6-octadien-3-ol	0.18
20:32	4-methyl-1-(1-methylethyl)-3-cyclohexen-1-ol	2.12
23:33	4-(2-propenyl)phenol	2.92
24:26	5-(2-propenyl)-1,3-benzodioxole	48.47
26:50	Eugenol isomer	14.03
27:15	Eugenol isomer	8.07
28:17	Copaene	0.59
29:46	Caryophyllene	1.76
30:42	Alpha-caryophyllene	0.59

Antimicrobial Activity of the Piper betle Oil

Antibacterial Activity

Volatile oils are plant extracts that are widely claimed to have broad spectrum antibacterial activity. The activities of the *P. betle* oil against the test

microorganisms were qualitatively and quantitatively assessed by the size of the inhibition zones, minimum inhibitory concentration, and minimum bacterial/fungal concentration values. The mean of the zones of inhibition of *S. aureus*, *B. subtilis*, and *E. coli* including are shown in Figure 2.

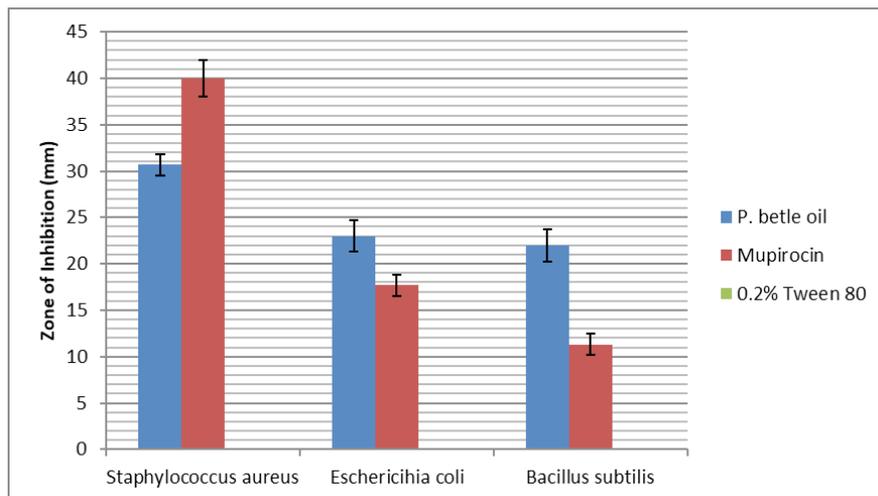


Figure 2. Inhibition sizes produced by 100µg/mL *P. betle* volatile oil, mupirocin, and 0.2 % Tween 80 on *S. aureus*, *E. coli* and *B. subtilis*.

The inhibition zone is the result of the interaction between the treatment and bacteria; its mean determines the effectiveness of the treatment against the target bacteria. All zones of inhibitions in the test bacteria due to either *P. betle* volatile oil and mupirocin were higher than or equal to 10mm which indicates its effectiveness against the test bacteria. No zone of inhibition was observed for the negative control.

The volatile oil exhibited a potent antimicrobial activity against both Gram-positive bacteria and Gram-negative bacteria – having inhibition zone diameters in the range of 20-32mm for former and 22-25mm for the latter. To determine if there is a significant difference in the efficacy of mupirocin and the *Piper betle* volatile oil against the test bacteria, t-test was performed.

The initial analysis showed that the *P. betle* volatile oil treatment had the largest inhibition diameter against *S. aureus* among the test bacteria but this activity is significantly lesser compared to mupirocin. On the other hand, the volatile oil exerted significantly greater activity against *E. coli* and *B. subtilis* compared to mupirocin treatment. The results partially agree with the findings of Hussain, et. al. (2010) as cited by Hsouna and Hamdi (2012) who

reported that Gram-positive bacteria are more sensitive to plant essential oils than Gram-negative bacteria. An exception is the Gram-positive *B. subtilis*, whose infections are among the most difficult to treat with conventional antibiotics, especially if complicated by multi-drug resistance; however, its potent inhibition by the volatile oil shows the latter's use to minimize drug resistance problems and protect foods from multiple pathogenic bacteria.

Table 2. Student's t-test analysis comparing inhibition sizes of *P. betle* oil and mupirocin (positive control) treatments

Bacteria	Piper betle Oil		Mupirocin		t	df	p-value*
	Mean	SD	Mean	SD			
Staphylococcus aureus	30.67	1.15	40.00	2.00	-7.00	4	0.002
Escherichia coli	23.00	1.73	17.67	1.15	4.44	4	0.011
Bacillus subtilis	22.00	1.73	11.33	1.15	8.88	4	0.001

Mean and standard deviation (SD) in mm

* Significant at $p < 0.05$

Previous tests of the activity of 100 $\mu\text{g/mL}$ volatile oil against *S. pyogenes* resulted to the formation of a zone of inhibition exceeding the size of a 90-mm petri dish, making it impossible to be measured pragmatically. It revealed that the volatile oil is very active against the Gram-positive streptococci. Therefore, further dilutions to 20 $\mu\text{g/mL}$, 30 $\mu\text{g/mL}$, and 40 $\mu\text{g/mL}$ of the volatile oil were necessary to compare with the same concentrations of the positive control (mupirocin) to assess its activity.

Table 3. Assessment of activity of *P. betle* oil and mupirocin against *S. pyogenes*

Concentration	Piper betle Oil		Mupirocin	
	Mean \pm SD	Assessment†	Mean \pm SD	Assessment†
20 $\mu\text{g/ml}$	18.13 \pm 0.42	Active	21.33 \pm 1.53	Very active
30 $\mu\text{g/ml}$	26.5 \pm 0.62	Very active	27.07 \pm 1.01	Very active
40 $\mu\text{g/ml}$	35.47 \pm 0.68	Very active	35.83 \pm 0.76	Very active

Mean and standard deviation (SD) in mm

†Inferential assessment based on following criteria by Quinto & Santos. (2006): <10mm – inactive; 10-13mm – partially active; 14-19mm – active ; >20mm – very active

The assessment of *Piper betle* oil reveals it to be active at 20 $\mu\text{g/mL}$ and very active at 30 $\mu\text{g/mL}$ and 40 $\mu\text{g/mL}$ as shown in Table 3. It also shows that

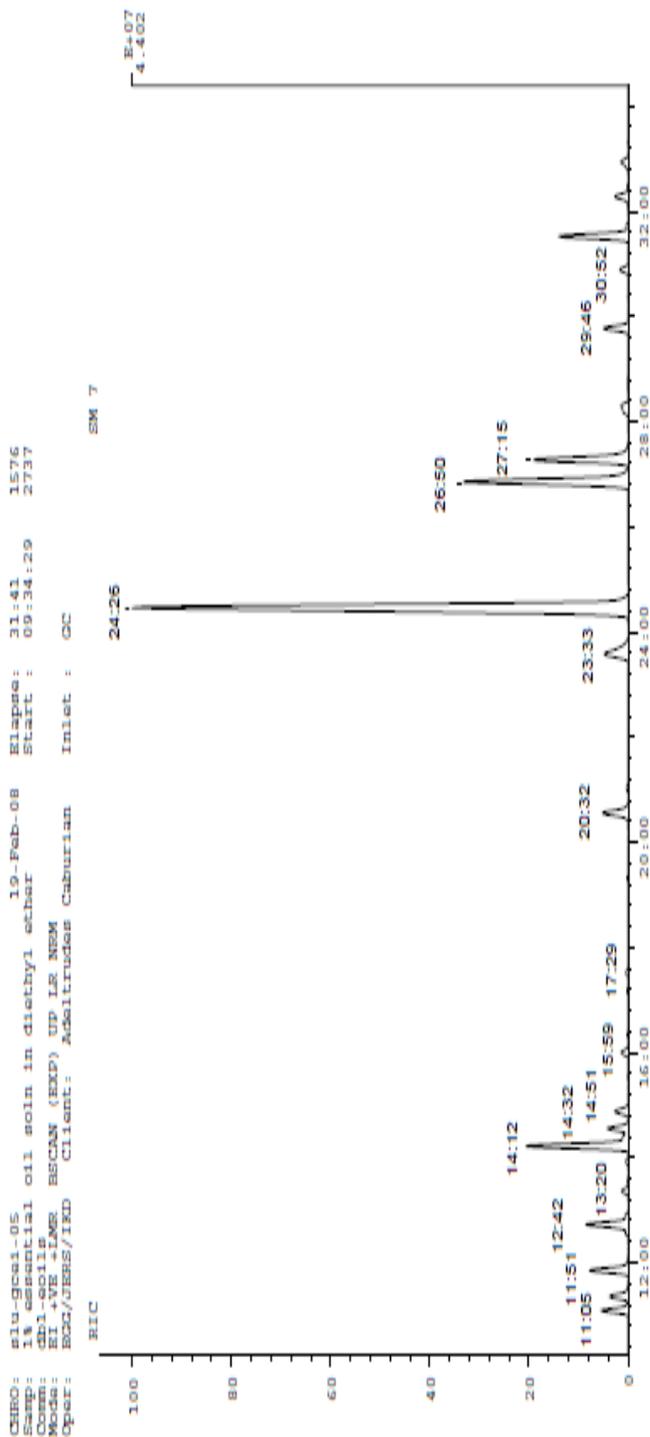


Figure 1. GC-MS spectrum of Piper betle volatile oil.

the antibacterial activity in terms of inhibition diameter is proportional to the concentration of the volatile oil.

A linear regression analysis was done to show similarities in slope and elevations of the lines representing the activity of *P. betle* oil and mupirocin against *S. pyogenes*. The regression lines are shown in Fig. 3.

For both *P. betle* volatile oil and mupirocin, there is a significant relationship between concentration and inhibition size, ($F(1,7)=1412.537$, $p<.001$; $F(1,7)=184.4217$, $p<.001$), and all regressions have the same slope ($F(1,14)=4.446$, $p=.053$). The mupirocin treatment has a statistically higher elevation, ($F(1,15)=7.694$, $p=0.014$) with a magnitude of difference of 1.4889. This indicates that the two treatments have the same increase in inhibition size per unit change in concentration with a 1.5mm difference in inhibition diameter at the same concentration. Since the difference in elevation is small, it still shows that the two treatments are still comparatively similar in their activity against *S. pyogenes*.

The antimicrobial action of the *P. betle* oil is due to bioactive constituents such as isosaffrol, eugenol, and caryophyllene among others which are well known for their antibacterial property (Evans, 2009). The intense antimicrobial activity of the volatile oil is in agreement with many studies in other plant species such as *Pelargonium graveolens*, *Eucalyptus alba*, *E. robusta* and *E. globulus* (Hsouna & Hamdi, 2012). Another theory in the study of Chakraborty and Shah (2011) cited in Pradhan, et.al. (2013) tried to explain that the bioactive molecule responsible for antibacterial activity is sterol which was obtained in large quantities in Piper betel extracts. The mode of action may be due to surface interaction of sterol molecules present in the extracts with the bacterial cell wall and membrane leading to alteration in the primary structure of cell wall and membrane permeability, ultimately leading to pore formation and degradation of the bacterial components. This mechanism is highly effective against the single-layered Gram-positive bacteria compared to Gram-negative bacteria with a multi-layered complex cell wall structure.

Antifungal Activity

The *P. betle* oil was also tested against fungal organisms *C. albicans* and *T. mentagrophytes*. The activity of 100 μ g/mL *P. betle* oil against *C. albicans* was compared with that of 1% clotrimazole (positive control). No

zone of inhibition was detected in 0.2 Tween 80 (negative control). The analysis found that *P. betle* volatile oil has significantly higher inhibition diameters (35.3333 ± 0.3333 mm) compared to clotrimazole (18 ± 7 mm), $t(4)=11.0864$, $p<.001$. This significant difference in treatment revealed that the fungal organism has higher susceptibility to the *P. betle* oil than to clotrimazole.

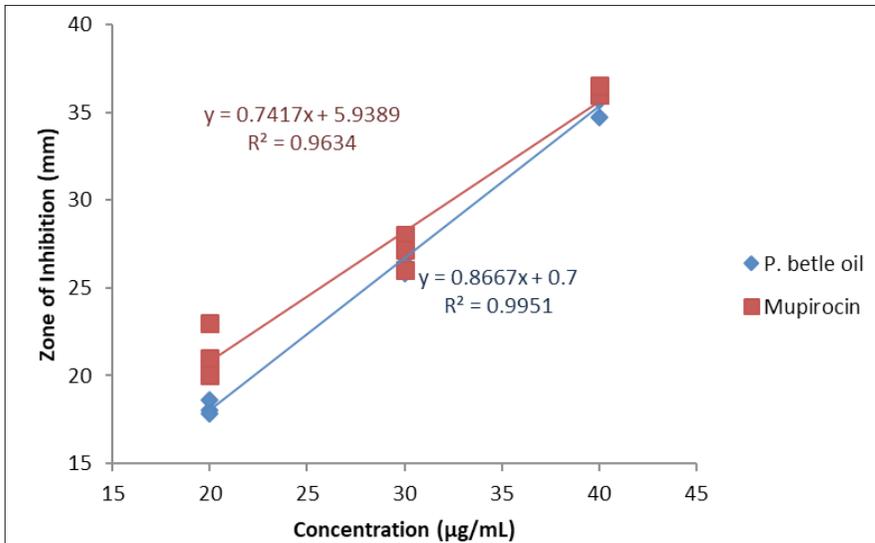


Figure 3. Scatter plot of inhibition zone produced by *P. betle* oil and control (mupirocin) on *S. pyogenes*.

Like its activity against the *S. pyogenes* bacteria, the pure volatile oil demonstrated a very high activity against *T. mentagrophytes*. Likewise, the size of the zone of inhibition produced by a concentration of 100 µg/mL of oil theoretically exceeded the size of the 90-mm Petri dish. For practical measurements, 2 µg/mL, 10 µg/mL, and 15 µg/mL were prepared to assess the activity of the oil when compared to the same concentration of the clotrimazole (positive control).

Table 4 shows the zone of inhibition of *T. mentagrophytes* as affected by different concentrations of the *P. betle* oil and the assessment of its activity.

The table above shows that *T. mentagrophytes* was found to be very susceptible to *P. betle* oil and clotrimazole in all concentrations. It also shows that the concentration of the treatments is proportional to the zone of inhibition diameter.

Table 4. Assessment of the activity of *P. betle* oil and clotrimazole against *T. mentagrophytes*

Concentration	Piper betle Oil		Clotrimazole	
	Mean \pm SD	Assessment	Mean \pm SD	Assessment
2 μ g/ml	23.13 \pm 1.03	Very active	24.5 \pm 0.5	Very active
10 μ g/ml	25.57 \pm 0.55	Very active	25.4 \pm 0.53	Very active
15 μ g/ml	34.73 \pm 1.67	Very active	32.36 \pm 1.15	Very active

*Mean and standard deviation (SD) in mm

†Inferential assessment based on following criteria by Quinto & Santos (2006): <10mm – inactive; 10-13mm – partially active; 14-19mm – active ; >20mm – very active

A regression analysis was performed to check if the two treatments are similar in terms of the slope and elevation of their regression lines. The resultant lines are shown in Fig. 4.

A significant relationship between concentration and inhibition size has been found for both *P. betle* oil ($F(1,7)=24.4770$, $p=.002$) and clotrimazole ($F(1,7)=16.3559$, $p=.005$), and all regressions have the same slope ($F(1,14)=3.424$, $p=.085$), and elevation ($F(1,15)=0.130$, $p=.724$). The analysis shows that the two treatments have same rate increase in inhibition zone per change in concentration and exhibit no significant difference in inhibition diameter at the same concentration. It means that *P. betle* oil and clotrimazole are comparatively similar in their antifungal activity against *T. mentagrophytes*.

The mean values of the diameters of the zones of inhibition were greater than 10 mm for a 6 mm diameter agar well (Quinto & Santos, 2006) for both bacteria and fungi; they are effective against the test microorganisms. The activity is due to the constituents isosaffrole, eugenol isomers and caryophyllene. In one study, eugenol was identified as the antifungal principle in the oil (Pradhan, et.al., 2013). The *P. betle* oil may have the ability to permeate into the cell walls of the organisms or it has the ability to inhibit protein synthesis in the cell of the test organisms thereby inhibiting their growth and proliferation.

Minimum Inhibitory Concentration (MIC) of *P. betle* oil

Minimum inhibitory concentration is the lowest concentration that kills 99.9% of a bacterial or fungal population. Using the microdilution method,

the lowest concentration of the *P. betle* oil that inhibited the growth of the test organisms are: 62.50 µg/mL for *S. aureus*, 31.25 µg/mL for *S. pyogenes*, 125 µg/mL for both *E. coli* and *B. subtilis*, 250 µg/mL for *C. albicans*, and 1.95 µg/mL for *T. mentagrophytes*.

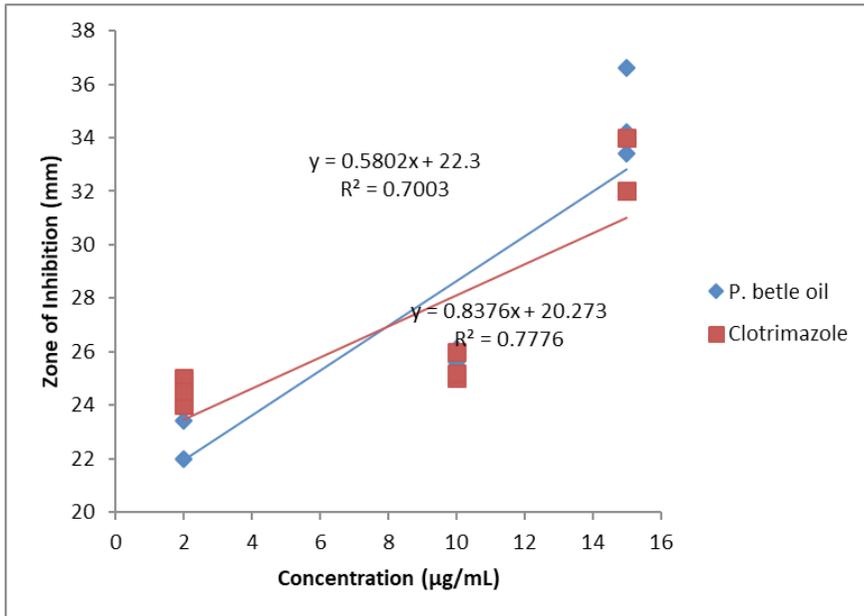


Figure 4. Scatter plot of inhibition zones produced by *P. betle* oil and control (clotrimazole) on *T. mentagrophytes*

The higher the value of the MIC for the test organism, the less resistant is the organism to the volatile oil, the lower the value the more sensitive is the organism to *P. betle* oil (Quinto & Santos, 2006). The findings specifically those for *S. pyogenes* (31.25 µg/mL) and *T. mentagrophytes* (1.95 µg/mL) are very useful in demonstrating the comparative activity of the volatile oil and the controls.

Minimum Bactericidal and Fungicidal Concentrations of *P. betle* Oil

The MBC and MFC were determined by inoculation of MIC tubes with no visible growth. It was found out that 62.50 µg/mL was considered the MBC of the *P. betle* for *S. aureus*; 31.25 µg/mL for *S. pyogenes* and 125 µg/mL for *E. coli* and *B. subtilis*. The MFC for *C. albicans* and *T. mentagrophytes* are

250 µg/mL and 1.95 µg/mL, respectively. The MBC and MFC coincided with the MIC obtained.

Anticarcinogenic/Antimutagenic Effect of the *P. betle* Oil

The micronucleus test determines the capability of *P. betle* oil in inducing structural and/or numerical chromosomal damage. The average number of micronucleus formed in the bone marrow after treatment were obtained and compared with the cytotoxic drug cyclophosphamide and 5% Tween 80.

The analysis of variance showed that the effect of treatment on number of micronuclei was significant, $F(2,15)=707.64$, $p<.05$. Post hoc analyses were conducted given the statistically significant F-test. Specifically, Tukey HSD tests were conducted on all possible pairwise contrasts. The following pairs of groups were found to be significantly different ($p<.05$): *P. betle* volatile oil ($M=.517$, $SD=.0753$) and cyclophosphamide ($M=2.150$, $SD=.1225$), and cyclophosphamide and 0.5% Tween 80 ($M=.467$, $SD=.0516$). This showed that the induction of micronuclei by the *P. betle* oil and the negative control were comparable implying that the chemical constituents of the volatile oil have no carcinogenic nor mutagenic activity. This may be due to its antioxidant property or its ability to deactivate carcinogens, or by enhancing the tissue levels of protective enzymes in the body (Betel leaf cure, 2010). In a report by Indian Institute of Chemical Biology, as cited by Widowati, et. al. (2011), chlorogenic acid isolated from leaves of *P. betle* was shown to kill myeloid and lymphoid cancer cells but normal cells are unaffected. It induces apoptosis in human cancer cells transplanted in experimental nude mice but shows no effect on the growth of non-cancerous cells.

CONCLUSION

Piper betle is a twining plant native to Malaysia but found in most parts of the Philippines. The study on this medicinal herb reports the physical properties of the extracted volatile oil obtained from 5 specific places in the Philippines. Its chemical composition revealed 20 components. The antimicrobial activities of the volatile oil was also investigated and revealed a very important antimicrobial activity confirmed by its low

minimum inhibitory concentration (MIC). The volatile oil therefore can be used as a natural antimicrobial agent for the treatment of diseases caused by infectious bacteria and fungi. The volatile oil was also found to be non-mutagenic/carcinogenic as found in the micronucleus test. The mechanism of its antimicrobial activity is not yet well understood. Further studies on the pathway of microbial growth inhibition are recommended and preformulation data obtained in this study should be validated to establish specifications of the oil.

ACKNOWLEDGEMENTS

The researchers would like to thank Saint Louis University and VLIR for making the study possible and the Research and Extension Office for the grant given to the researchers.

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Morphological and Thickness Characterization of Spin Coated Nafion Thin Films on Glass Substrate

Shirley Tiong-Palisoc, Stephen Tadios, and
Michelle Natividad

*De La Salle University,
2401 Taft Avenue, Manila, Philippines*

Nafion thin films ($<2\mu\text{m}$) were fabricated using the spin coating technique. The effects of varying the Nafion concentration (5%, 10%, and 15%) and spin coating angular velocity (1500rpm, 2000rpm, and 2500rpm) on the thickness and morphology of the films were investigated. The deposition of the films onto the substrates was verified using energy dispersive x-ray (EDX) and the surface morphology was characterized by scanning electron microscopy (SEM). Surface morphological results show that the films followed the contour of the substrate onto which they are deposited and nanometer scratch-like features appear at high magnification ($\times 35000$). Thickness measurements were graphed against the different parameters and results show that thickness of Nafion films decrease with increasing angular velocity and increase with increasing concentration.

Keywords: Nafion, spin coating, thin films, elemental analysis, surface morphology

INTRODUCTION

Research in the field of sensors gained momentum in the early years of this century and has grown rapidly since then ^[1]. A sensor is a device designed to respond and detect a physical quantity and convert it to an observable output ^[2]. Sensors that deal with components chemical in nature and that are subjected to an electrical set-up are called electrochemical sensors. This type

of sensor requires for an electrical conductor, and may sometimes be made by producing a thin film electrode ^[3-6]. Electrochemical sensors are currently being used for trace heavy metal detection and as biosensors.

To achieve a quality, fully working thin film electrode, the materials used must be conducting and durable at the very minimum. Mercury is one example and the most commonly used for such, because in addition to being resilient and very conductive, it is also highly sensitive and reproducible to the heavy metal detection method of anodic stripping voltammetry (ASV) ^[6].

Due to the toxic nature of mercury, however, other materials including indium tin oxide (ITO) ^[7] and bismuth films ^[6] are being sought as alternatives. These alternatives are friendlier to the environment, but produce electrodes with films that are more susceptible to fouling under direct ASV measurements ^[6]. To solve this problem, another layer with a permselectivity feature such as Nafion is added to the thin film electrode so that it becomes more robust.

Nafion, a copolymer of tetrafluoroethylene and perfluorosulfonated groups ^[8], is a permselective layer ^[6]. In solution form, coating of this solution using Langmuir Blodgett ^[9], Langmuir Schaeffer ^[10], and spin coating methods ^[11-14] is made possible. Because of its low cost compared to the other deposition techniques mentioned, spin coating was chosen as the method of fabricating Nafion thin films in this study.

EXPERIMENTAL

Material Preparation

Nafion in 5wt%, 10wt%, and 15wt% concentrations in an ethanol solution were obtained from Sigma Aldrich and used without further preparations. Substrates of glass cut into 25 mm x 25 mm were washed with deionized water, soapy water, and again with deionized water, and placed in petri dishes to be washed in isopropanol, methanol, and acetone under a sonicator for 5 min per alcohol. The materials were then heated in a furnace at 80°C for 30 minutes to eliminate any remaining water after the last wash.

Spin coating

To fabricate the thin films, a spin coater of model Spincoat G3P-8 was used. Fabrication consisted of two stages: deposition and thinning. In the deposition stage, a solution of Nafion was sprayed onto the substrate after it has reached

750 rpm. This lasted for 10 seconds until it reached the programmed angular velocity, after which the spinning continues through the thinning stage. In the thinning stage, the solution of Nafion was spread homogeneously along the substrate surface for 30 seconds. Through evaporation, the coated substrates were eliminated of excess ethanol by placing them inside a furnace at 70-79°C for 30 min.

The substrate (silicon, silica, and glass), Nafion concentration (5 wt%, 10 wt%, and 15 wt%), and spin coating angular velocity in the thinning stage (1500rpm, 2000rpm, and 2500rpm) were chosen as parameters. The effects of varying these parameters on the thickness and morphology of the film were investigated.

Characterization

A scanning electron microscope (SEM) of model JEOL 5310 was utilized to conduct elemental, surface morphology and thickness analyses on the fabricated Nafion thin films. The samples were placed inside a coater (JEOL JFC-1200) where each was coated with gold. Coating was done on both sides of the samples (both coated and non-coated in the case of the spin coated thin films). After the gold coating, the samples were held onto a sample holder using a piece of carbon tape and placed inside the SEM (JEOL 5310) chamber. The first to be analyzed were the blank samples. Blank samples were analyzed for comparison purposes. The samples were scanned at x50 (lowest magnification) using EDX. When elements of Nafion were present in the sample, the resulting elemental analysis report was copied to an MS Word file and SEM pictures were captured at x200 and x35000. The platform was then tilted at 75° and an image of the cross section (thickness) was taken at the center of each sample.

RESULTS AND DISCUSSION

Energy-Dispersive X-ray (EDX) Results

A blank substrate was scanned using EDX to provide basis for differentiating Nafion coated and non-coated substrates, followed by the scanning of the samples themselves. The samples were scanned to determine whether they have been coated with Nafion or not. Figure 1 shows the EDX graph

of the blank glass substrate. It can be observed from the graph that the glass substrate is composed of a combination of silicon, oxygen, sodium, magnesium, potassium and calcium.

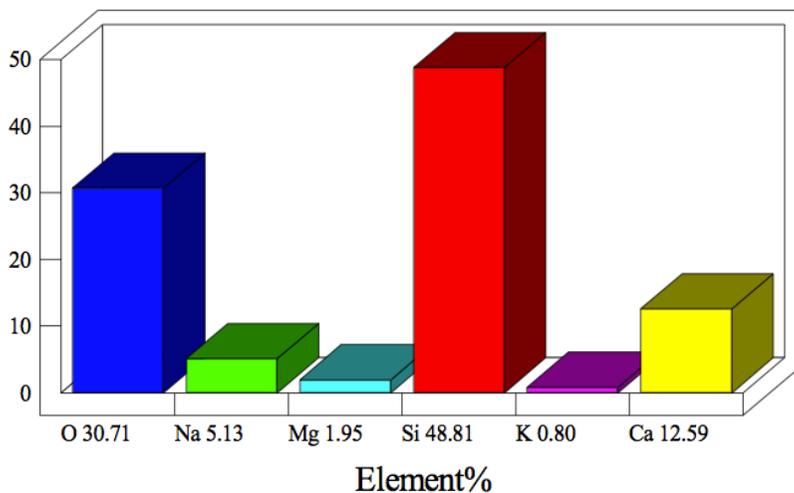


Fig. 1 Detected elements of the blank glass substrate.

Figures 2-4 are the EDX graphs of the sample films. It can be seen that additional elements, which are not in the blank substrate, are found in the samples. These elements, especially fluorine, are taken to be a positive sign that Nafion has been deposited on the substrates. Sulfur in the sample films consistently did not appear by automatic identification at lower concentrations (5 wt% and 10 wt%), and appeared at 15 wt% Nafion concentration (as seen in Figure 4). This absence of sulfur at lower concentrations could be attributed to the small quantity of sulfur in Nafion, which probably was only at trace amounts. It is possible that it might have gone undetected due to its quantity being too small to be quantified. Also shown in the graphs is the near consistent elemental make-up of each Nafion thin film with respect to angular speed, such that angular speed is shown not to have a significant effect on the elemental percentages of the thin films.

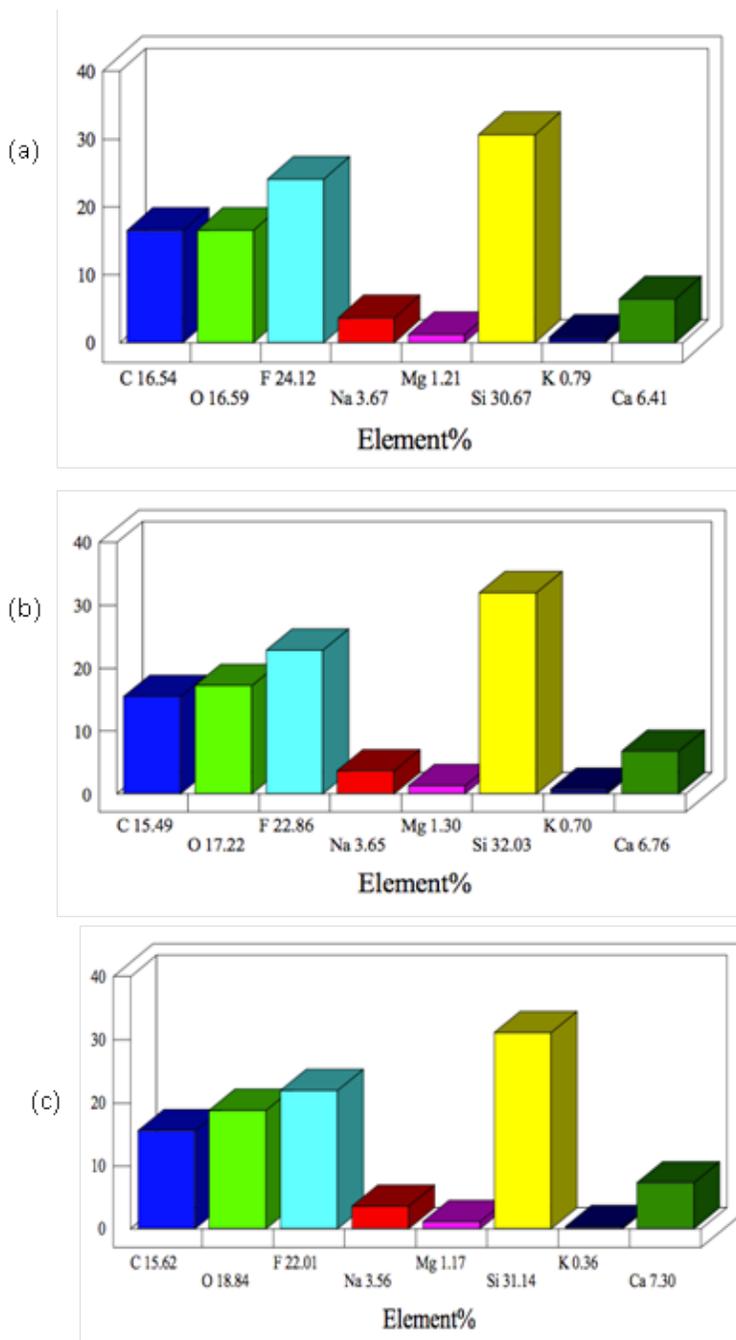


Fig. 2 EDX graphs of Nafion thin films spin coated at (a) 1500 rpm, (b) 2000rpm and (c) 2500rpm using 5 wt% Nafion solution.

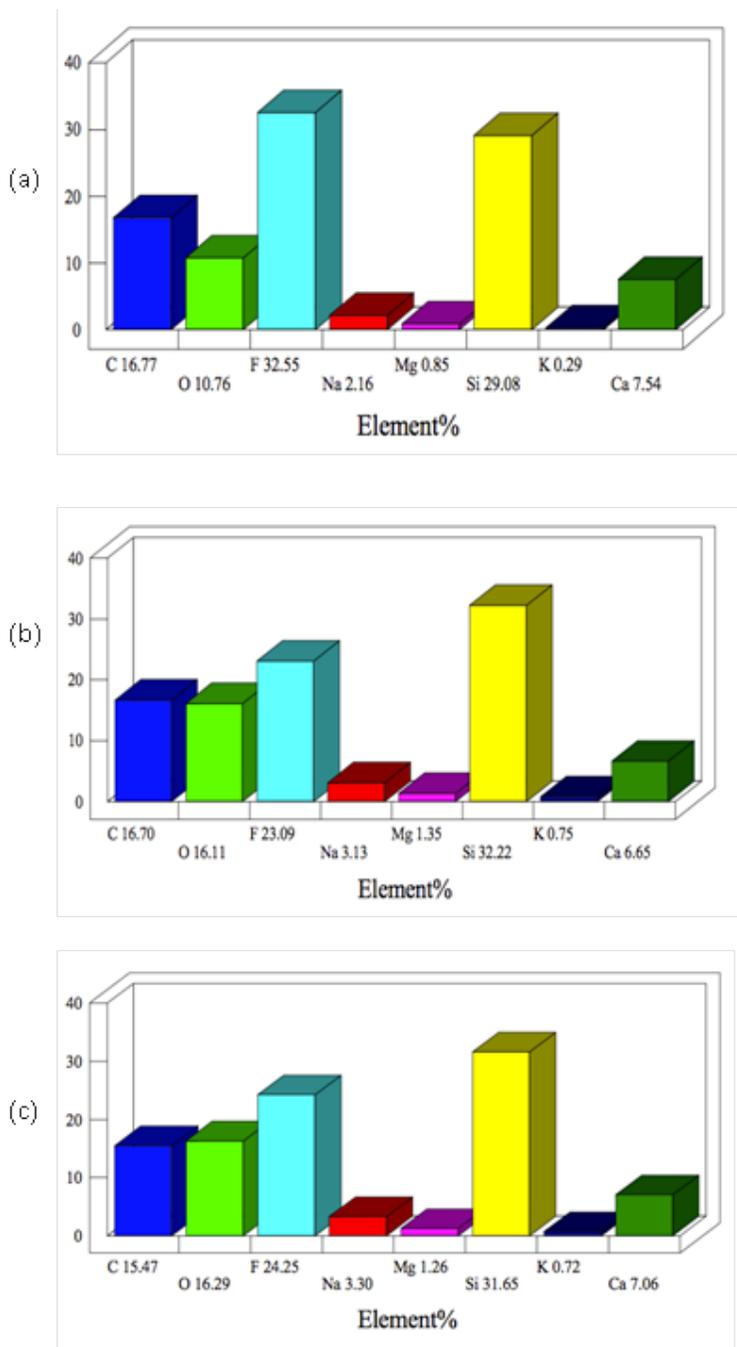


Fig. 3 EDX graphs of Nafion thin films spin coated at (a) 1500 rpm, (b) 2000rpm and (c) 2500rpm using 10 wt% Nafion solution.

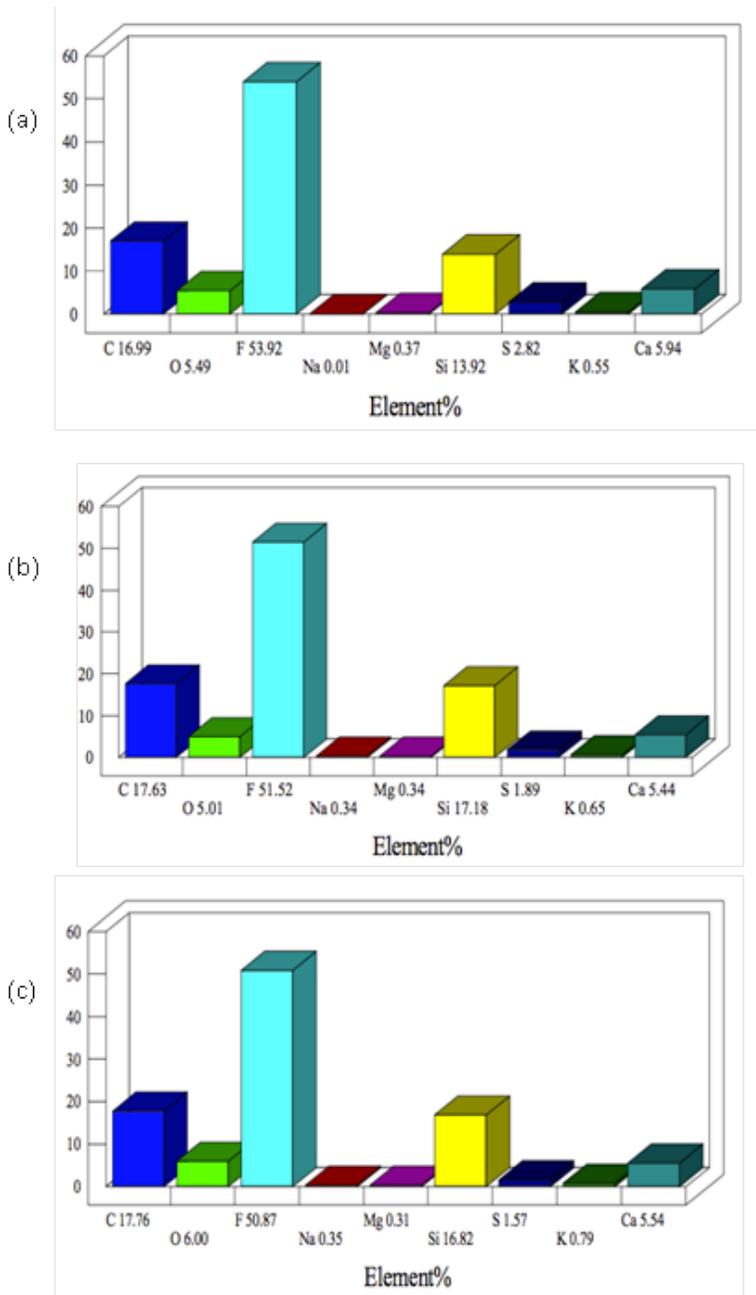


Fig. 4 EDX graphs of Nafion thin films spin coated at (a) 1500 rpm, (b) 2000rpm and (c) 2500rpm using 15wt% Nafion solution.

SEM Results

Figures 5-7 are SEM images of Nafion thin films deposited with 5% Nafion solution. The images at x200 magnification show a relatively smooth surface that is free of lumps or solution accumulation. Magnified at x35000, crack-like features on the thin films appear and become more prominent at a higher concentration. An investigation for the reason behind these was made after Schneider ^[8] reported damage of Nafion membranes via SEM, and results have shown that SEM does create damage to the films. The reason as to why the cracks are relatively more affected has so far not yet been studied, however.

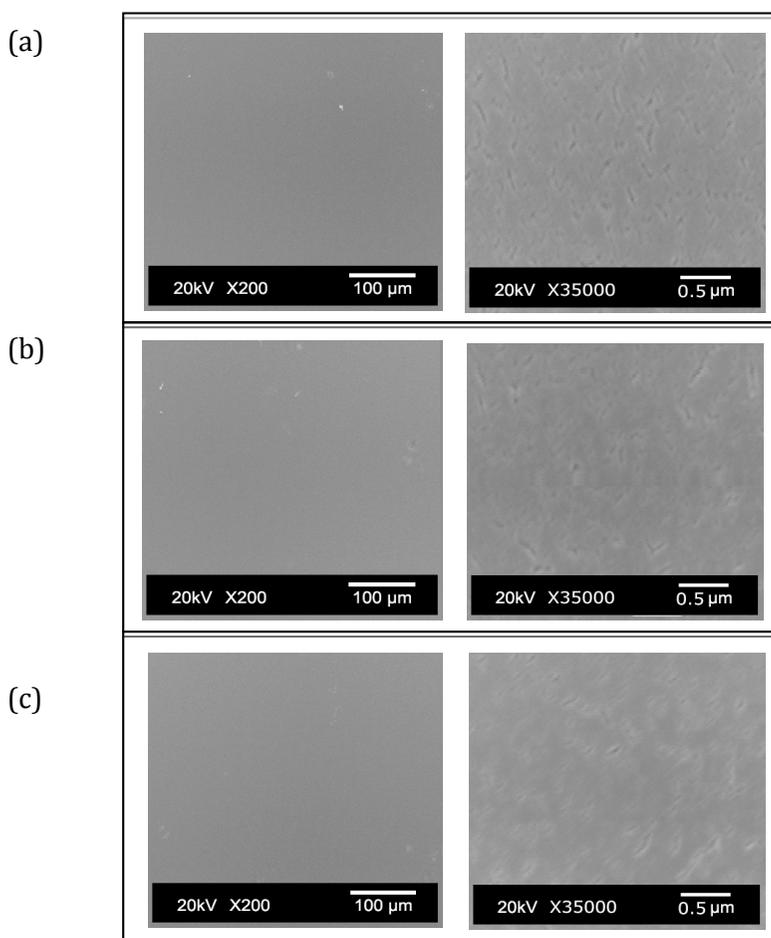


Fig. 5 SEM images of Nafion thin films spin coated at (a) 1500 rpm, (b) 2000 rpm, and (c) 2500 rpm using 5wt% Nafion solution.

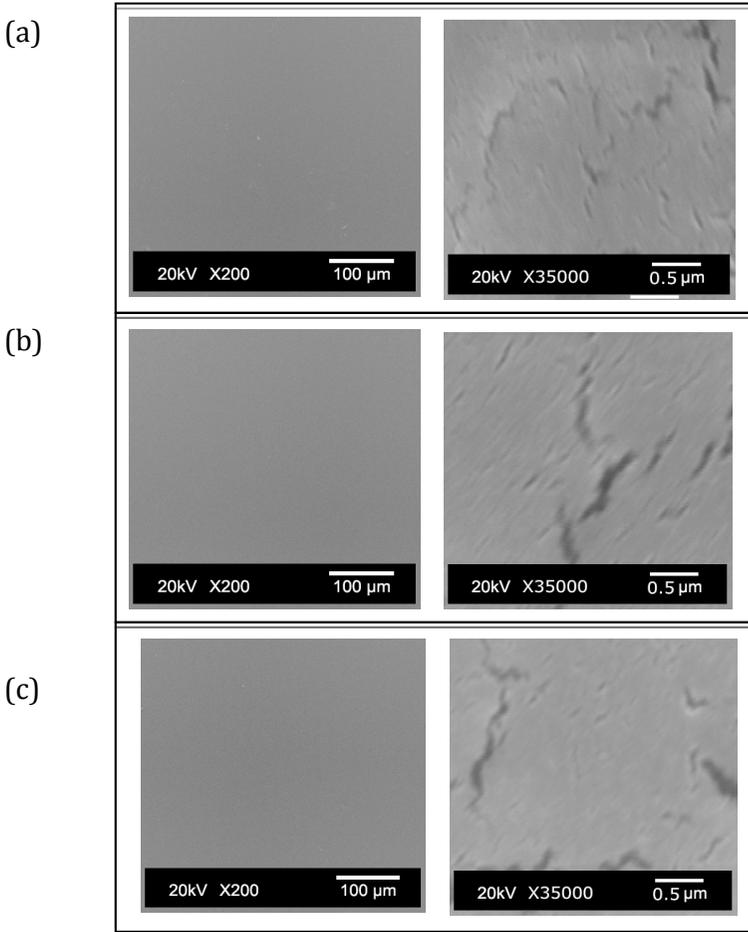
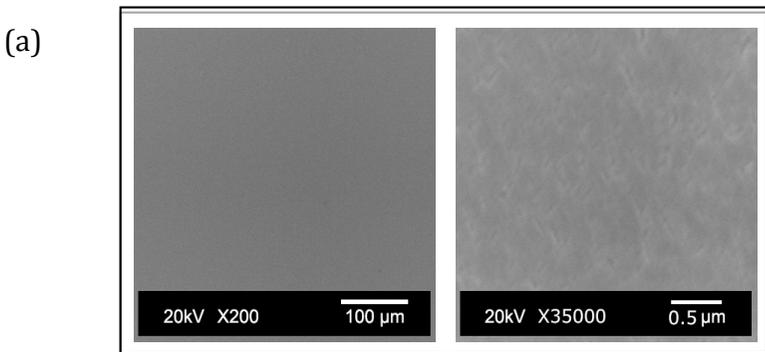


Fig. 6 SEM images of Nafion thin films spin coated at (a) 1500 rpm, (b) 2000 rpm, and (c) 2500 rpm using 10 wt% Nafion solution.



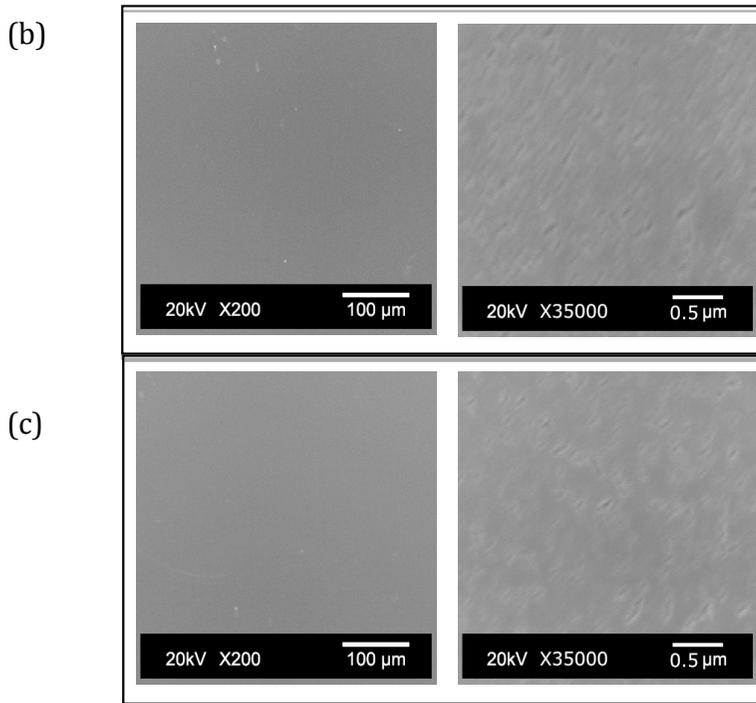


Fig. 7 SEM images of Nafion thin films spin coated at (a) 1500 rpm, (b) 2000 rpm, and (c) 2500 rpm using 15wt% Nafion solution.

Thickness Results

The thicknesses of the thin films were measured using the micrographs obtained from the scanning electron microscope through a program called SemAfore. The lengths of the thin films were measured from the top to the bottom of each layer, taken at an angle perpendicular to the surface of the substrate. One image was taken for each sample and three measurements were done per image (Fig. 8). The three thicknesses per sample were averaged and the approximate thickness was obtained. The data gathered for each were averaged and are listed in Table 1. It can be seen from the data that the relationship of thickness with angular velocity is inverse proportionality and that on the other hand, the relationship of thickness with concentration is direct proportionality. As angular velocity increases, the film thickness decreases; and as the concentration of Nafion increases, the film thickness also increases. Furthermore, it can also be seen that with regard to thickness, the thin films are compatible for sensor applications since they are $\sim 1\mu\text{m}$ [16].

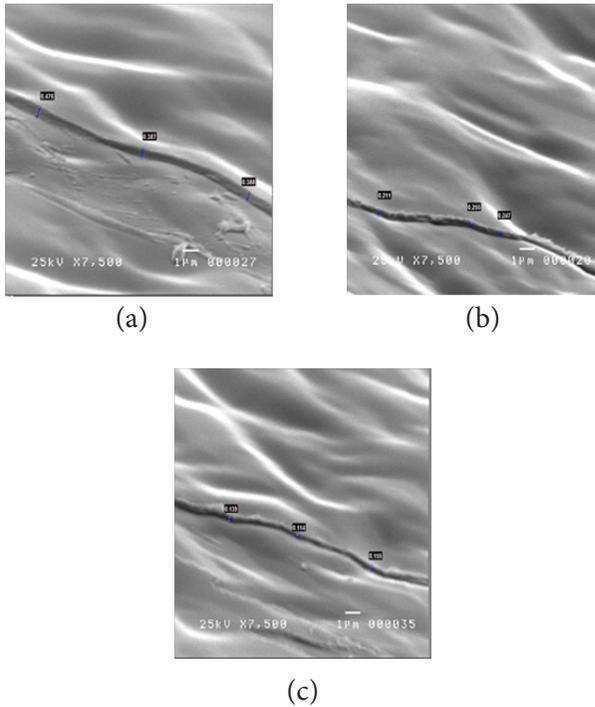


Fig. 8 SEM images showing the three measured thicknesses of film fabricated using 5 wt% Nafion concentration and spun at (a) 1500rpm, (b) 2000rpm, and (c) 2500rpm.

Table 1 Nafion thin film thicknesses.

wt% Nafion	Angular velocity (rpm)	Measured Thickness (μm)			Average thickness (μm)
15	1500	1.94	1.98	1.97	1.97
	2000	1.49	1.47	1.49	1.48
	2500	1.23	1.27	1.25	1.25
10	1500	0.668	0.674	0.676	0.673
	2000	0.363	0.360	0.366	0.363
	2500	0.215	0.215	0.215	0.215
5	1500	0.508	0.495	0.479	0.494
	2000	0.231	0.231	0.231	0.231
	2500	0.140	0.152	0.152	0.148

The graph of thickness with respect to angular velocity is shown in Fig.8, where the data points can be seen in a power function plot. Thickness vs. angular velocity is generally in the form $h \propto \omega^{-b}$ [15]; where h is thickness, ω is angular velocity, and b is a constant. Based on the graph, Nafion thin films are shown to follow this form.

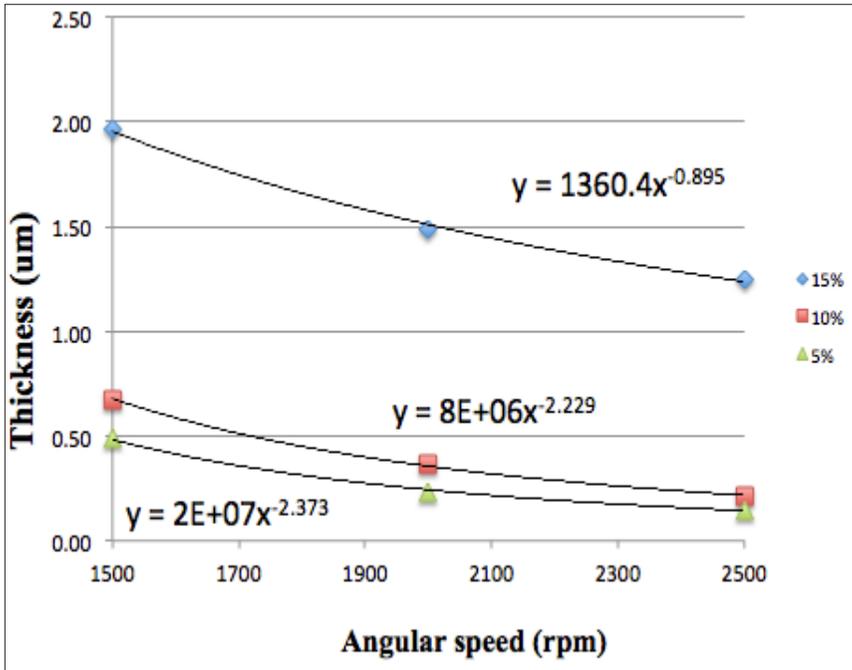


Fig. 8 Thickness vs. angular velocity graph.

The line equations from the graphs are shown below. As the concentration increases, the exponent b decreases.

$$h = 2E+07\omega^{-2.373} \quad (5\%) \quad (\text{Eq. 1})$$

$$h = 8E+06\omega^{-2.229} \quad (10\%) \quad (\text{Eq. 2})$$

$$h = 1360.4\omega^{-0.895} \quad (15\%) \quad (\text{Eq. 3})$$

CONCLUSION

EDX

The EDX graphs of the elemental compositions of the fabricated thin films show spin coating to have successfully deposited Nafion on the substrates.

The expected elements were detected with the exception of sulfur, which only showed up on thin films coated with 15% Nafion concentration. Varying angular velocity did not yield any significant difference.

SEM

Imaging via SEM revealed the Nafion thin films to have a smooth and relatively even surface morphology at low magnification and crack-like deformations at higher magnification.

Thickness Measurements

Thickness measurements show that as angular velocity increases, thickness decreases while as concentration increases, thickness also increases. Furthermore, the thin films are suitable for sensor use since each thickness is more or less around 1 μm [16].

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Life After Rehab: Experiences of Discharged Youth Offenders with Crime Desistance

Pierce S. Docena

*University of the Philippines Visayas
Tacloban College*

This study explored the experiences of former youth offenders regarding crime desistance. Guided by the life story method in research, the researcher interviewed ten male youth offenders who had been discharged from the Regional Rehabilitation Center for Youth (RRCY) in Eastern Visayas. The narratives of the research participants revealed that desistance from crime is a long and difficult process influenced by various factors such as family support, condition of one's community, intervention of significant persons, having a job, getting married, and having children. Implications for crime desistance studies are discussed and the challenges and opportunities for researchers and professionals who deal with youth offenders are likewise examined.

Keywords: youth offenders, juvenile delinquency, crime desistance, children-in-conflict-with-the-law, life story method

INTRODUCTION

How does one live a life after committing a criminal offense? Stories about former offenders often revolve around themes of hope, recovery, and renewal. These stories, especially those by youth offenders, easily become the center of our attention because of their redemptive quality. However, not all youth offenders share the same theme in their post-rehabilitation stories. This paper thus seeks to deepen our understanding of youth offenders' lives after undergoing rehabilitation by presenting and analyzing their life stories.

The extant literature on juvenile delinquency reveals the many issues and concerns surrounding the life of the youth offender. Most of these studies focus on the types of youth offenders (Maki, 1998; Simourd, Hoge, Andrews, & Leschied, 1994), substance-use initiation (Prinz & Kerns, 2003), attributions toward violence (Daley & Onwuegbuzie, 2004), moral reasoning (Chen & Howitt, 2007), and factors affecting recidivism (Carr & Vandiver, 2001; Hanson, 2000; Taylor, Kemper, Loney, & Kistner, 2009; Tinklenberg, Steiner, Huckaby, & Tinklenberg, 1996) among others.

Juvenile delinquency has also become a contentious issue in our society. There is the perennial question of whether youth offenders should be held less accountable for their crimes due to their age (Steinberg & Scott, 2003) and whether the age of culpability for youth offenders should be lowered (Villanueva, 2014) presumably to address the growing number of youth offending cases.

Local Studies on Youth Offenders

In the Philippines, studies on juvenile delinquency are usually conducted among youth offenders who are still inside rehabilitation centers. Examples of such studies explore the youth offender's self-concept (Miguel, 1984), life goals (Vispo, 2006), and level of optimism (Concepcion, 2007); while others evaluate the services in rehabilitation centers (Cabillao, 1998; Pinlac, 1999). Some narrative studies attempt to describe the unique life circumstances, thought processes, feelings, emotions, and perceptions of children-in-conflict-with-the-law (CICL) (Araneta-De Leon, 2002). On the other hand, other researchers use an intersectionality lens to investigate the link between a CICL's sexual orientation and his experiences in a rehabilitation facility (Villafuerte, 2013).

A large-scale study on youth offenders was conducted in 2001, when Save the Children-UK Philippines Programme embarked on research studies that looked into the profile of CICLs and their situation and experiences in the justice administration process. The study was done in three main urban centers in the country—Metro Manila, Cebu, and Davao—representing the country's three main island groupings of Luzon, Visayas, and Mindanao (Bañaga, 2004). This consolidated research deserves mention as it is probably the most comprehensive local study conducted on the subject of juvenile delinquency to date.

While it is clear that a number of researchers have already investigated several aspects of juvenile delinquency in the country, a survey of the local literature exposes the dearth of studies conducted among youth offenders who have been released from detention. This paper therefore seeks to fill this gap in the local literature by focusing on the life experiences of discharged youth offenders.

Life after Rehabilitation

The ultimate goal of rehabilitation centers is to reform youth offenders, thereby preventing recidivism or relapse into criminal behavior. But what really happens when youth offenders eventually get discharged from these facilities? Abrams (2006) noted three notable findings after exploring how youth offenders understand their time in residential care and how the center's programs influence offenders' motivations to desist from crime. First, youth offenders in treatment often feel confused as they grapple with therapeutic or "adult" understandings of their delinquent conduct. Second, secure confinement may not have a significant deterrence effect, particularly for offenders who are accustomed to chaotic lives or institutional living. Finally, youth offenders remain uncertain about their ability to change until they are able to apply their new skills and training to real-world situations. The most significant barrier to lasting behavior change appeared to be the disconnect between lessons learned "inside" the institution and the realities of life "on the outs."

Discharged youth offenders have to cope with a number of changes once they go back to the outside world. For example, Champion and Clare (2006) found that as youth offenders returned to the community, many felt a sense of disconnection from their previous environments and lifestyles, and a consequent felt need to reconnect in some way. These youth offenders also attempted to implement necessary life changes subsequent to release by taking on new roles and lifestyles as well as avoiding old roles and lifestyles.

Sullivan (2004) has observed that there are a number of ways in which problems of reentry have special characteristics for youth returning from secure confinement. Compared to older ex-offenders, youth offenders are especially likely to return to their parents, to be expected to enroll in school, to find criminally active peers more involved in expressive and status-oriented crime, to have little employment experience, and to have less serious

histories of criminal involvement. At the same time, the experience of incarceration itself is likely to hasten the end of adolescence by precipitating school-leaving, separation from parents and prosocial peers, the need for an independent income, and social involvement with older people more deeply involved in criminal lifestyles. The process of reentry for youth offenders is thus intertwined with a whole series of developmental transitions that are more rigidly sequenced than developmental transitions during the adult life course.

The Challenge of Crime Desistance

In an ideal setting, youth offenders who have gone through the process of rehabilitation are expected to desist from crime once they return to their communities. However, results of numerous studies show that the process of desistance is fraught with challenges that the recovering youth has to face every step of the way. What, then, are the factors that influence desistance from crime?

Laub, Nagin, and Sampson (1998) found that childhood and juvenile characteristics are insufficient for predicting the patterns of future offending in a high-rate group of juvenile offenders. This seems to suggest that many of the classic predictors of the onset and frequency of delinquency (e.g., being a difficult child, low IQ, living in poverty, poor parental supervision) may not explain desistance. An interesting finding concerned the timing and quality of marriage by the youth offenders. Early marriages characterized by social cohesiveness led to a growing preventive effect. The data support the investment-quality character of good marriages; that is, the effect of a good marriage takes time to appear, and it grows slowly over time until it inhibits crime. This particular conclusion is a curious one vis-à-vis the sample of participants in the present study, half of whom were married.

Another significant factor in desistance from crime is age. Toch (2010) claimed that the best established fact about criminal recidivism is that the risk of reoffending decreases across the board with age. This is in part because some prisoners experience significant maturation and undergo substantial and relevant personality change.

Maruna (2004) offered a fresh perspective on crime desistance by explaining that active offenders and desisting ex-offenders differ in terms

of explanatory style. Compared to desisting ex-offenders, active offenders tend to interpret negative events in their lives as being the product of internal, stable, and global forces. On the other hand, desisting ex-offenders are more likely to believe that the good events in their lives are the product of external, unstable, and specific causes.

Further studies on the life stories of discharged youth offenders and ex-convicts focus on overcoming adversity and attempts at reform (Mallon, 1998; Maruna, 1997; Todis, Bullis, Waintrup, Schultz, & D'Ambrosio, 2001). To a large extent, these studies point to themes of resiliency in adolescents who have been through a difficult life event and are now living their life back in the so-called straight world. Todis and colleagues (2001) examined the life stories of formerly incarcerated adolescents and reported that postcorrection supports were insufficient to allow many of the youth offenders to transition smoothly back to their communities. For example, most of the respondents had to return to the same homes that they lived in when they were breaking the law. Unfortunately, the structure provided by their families was inadequate to keep them from reoffending, just as it had been inadequate to keep them from getting into trouble in the first place.

Some discharged youth offenders do transition away from delinquent behavior, a phenomenon labeled colloquially as "going straight." In a related study on the published autobiographies of 20 ex-convicts, Maruna (1997) identified a prototypical reform narrative that was shared by virtually all of the accounts he examined. This reform narrative starts with early scenes of passive victimization leading to a delinquent quest and repeated scenes of "bottoming out." The negative cycle is not broken until the protagonist experiences a "second chance" for agency and/or communion, often through the intervention of a good friend or a potential lover. The final life story chapters consolidate reform through the protagonist's generative efforts to "give something back" to the world as he attempts to help other actual or would-be criminals develop their own reform stories.

These aforementioned studies attempt to illuminate the construct of resiliency in people who have experienced difficult life situations. However, not all discharged youth offenders end up going and remaining straight. Thus, it is important to explore other life paths taken by youth offenders after being discharged from the rehabilitation center and as they face the challenge of reintegration into their families and communities.

The Present Study

This paper explores the significant life experiences of youth offenders after being discharged from a rehabilitation center. Specifically, it seeks to answer the following questions:

1. How would discharged youth offenders describe the process of reintegration with their families and communities?
2. What factors enable and impede crime desistance among discharged youth offenders?

METHOD

Participants

Ten discharged male youth offenders from the Regional Rehabilitation Center for Youth (RRCY) in Eastern Visayas were purposively selected to participate in this study. Their ages ranged from 19-27 years ($M = 23$, $SD = 3$) at the time of the interview. As for their educational attainment, seven out of ten had some elementary education; two were able to finish elementary level while one reached secondary school. Most of them held low-income jobs such as being a pedicab driver or a construction worker. Exactly half of the participants were single; four were married while one was separated. Of those who had been married, only three had children; one of the single participants, however, had a child with a former classmate.

Table 1 shows that the most common offense that had been committed by the discharged youth offenders was theft while the rest had been apprehended either for substance abuse, robbery/holdup, or frustrated murder. With regard to their incarceration history, all but one of the ten participants spent time—ranging from 18 days to 4 years with an average of 10 months—either in lock-up or the city jail before they were transferred to RRCY. Their length of stay in RRCY ranged from 2 to 24 months (median = 9.5 months) while their length of period since being discharged from RRCY at the time of the interview ranged from two-and-a-half to eight years, with an average of about five years. Interestingly, only three out of 10 had no history of incarceration prior to RRCY, but they were nevertheless previously involved in delinquent behaviors and criminal acts.

The Life Story Method

The life story was used both as subject matter and method in this study. As a subject matter in research, life stories are said to reside at the third level or standpoint in terms of studying the person (McAdams, 2001). At this level, individuals make sense of themselves by constructing evolving life stories that organize their reconstructed past, perceived present, and anticipated future into a coherent whole. McAdams (2001) also believes that it is through life stories that individuals make sense of events in their lives and, ultimately, of themselves.

As a method in research, life stories of the ten participants were collected through a semi-structured interview guide in *Waray*. The life story method is particularly relevant to the participants who, given their low educational background, might not have been able to express their sentiments had they been asked to complete self-report inventories or other quantitative measures. By being asked to tell stories instead, they were able to share the meaning of their various experiences, reconstruct their past, anticipate future events, make sense of who they are, and elaborate on their answers to the interview questions.

Procedure

Data were gathered by first asking for permission from the Department of Social Welfare and Development (DSWD) to track those who have already been discharged from RRCY. The participants were located with the help of barangay officials and community members; in some instances, the participants themselves referred the author to other discharged youth offenders they knew. Among the ten participants, half required just one initial visit before the actual interview; the rest were visited a number of times before the interview was conducted. The recorded interviews lasted from about one to two hours. After transcribing the interviews, a matrix was created for the participants' responses to the major questions.

The content coding system used in data analysis was frequency coding, which involved developing criteria for meaningful units of the response and recording the number of instances of these units in the data (Woike, 2007). Themes were then developed out of the codes generated and were validated by rereading the matrix of responses, ensuring that they captured the

narratives of the participants. The study followed basic ethical considerations such as informed consent and assuring the participants anonymity and confidentiality. Pseudonyms were also used in the presentation of their narratives.

RESULTS

Reintegration with the Family

All ten participants were discharged into the care of their families. Practically everyone said that they experienced positive treatment from their families upon coming back from RRCY. For example, Matt and Josh felt happy because their families were once again complete. Josh recounted asking for his parents' forgiveness on his first day back home; his parents in turn told him to just forget about the past and to try not to repeat his negative behaviors.

Tommy, Ariel, and Rick reported that their relationship with their families significantly improved compared to their pre-RRCY lives. Tommy explained that his family treated him well because he made it a point to show them that he had changed for the better. Rick mentioned that he now got along well with his mother and attributed this to the fact that his mother now had a new partner (his second stepfather) who was not violent like his previous stepfather.

Reintegration with the Community

Majority of the discharged youth offenders did not experience negative treatment from their neighbors upon going back to their communities. Matt felt welcomed in their barangay while Tommy and Dolph noted that their neighbors treated them better than they did before. According to Tommy, he was no longer the center of gossip in their barangay. Similarly, Dolph noticed that his neighbors now seemed to trust him more than they did in the past.

The most common reaction of their neighbors upon their return to their community was to ask them whether they would now change or go back to their old ways. This was usually said in jest as a form of welcoming back the discharged youth offender. Matt said that he definitely no longer

wanted to slip back into his past behaviors, let alone return to jail, but he also expressed uncertainty since nobody could predict the future. He added, “... *it tukso kun kaya likayan, likayan.*” (We should resist temptations while we can.)

Notably, only one respondent shared experiencing stigma after his release. Ariel disclosed that people still see him the same way even today. Some of his neighbors would talk behind his back and call him “*kawatan*” (thief); sometimes he would answer back and admit that he was indeed once a thief but he has already changed. He also felt uncomfortable going to public places he used to frequent: “*Makuri pag nakadto ak ha merkado damo nakilala ha ak, natamod nala ako, makaarawod labi na kun upod ko tak uyab, danay ginpapa-una ko nala, nasunod nala ako.*” (It’s hard when I have to go to the market where a lot of people know me. I just bow my head down. It’s embarrassing especially if I’m with my girlfriend. Sometimes I tell her to go ahead of me, then I just follow her.)

Going Straight vs. Going Back to Old Ways

With regard to their experiences with crime desistance, six participants claimed that they no longer went back to their past antisocial behaviors after leaving RRCY. Many of them were kept busy by their jobs. Ethan joined his father in construction projects; Josh helped his older sister finish high school out of his earnings; and Todd assisted his parents in selling fish at the market.

Tim was very careful about staying away from trouble; he no longer joined his friends whenever they would engage in petty theft such as stealing chickens from their neighbors. According to him, “*Nadiri na ako nga bisan guti mahugawan tak ngaran.*” (I no longer want to besmirch my name even just one bit.) Some of the participants still joined their friends in drinking sessions but they said they no longer abused alcohol and other drugs like they did before. Ariel said his friends influenced him to smoke and drink (the latter he learned only after his stay in RRCY) but he no longer went back to stealing.

Only three participants admitted to going back to their old ways immediately after being discharged from RRCY. This is true in the case of Matt who shared, “*Pagkuhaa ha akon, nag-promise na ako nga di nak mauro. Pag-gawas ko, dinhi amo manla gihap masamok; damo man an nagtitinda hin shabu dinhi. Nadara na liwat ako; paspasay ak shabu dinhi.*” (When

they [parents] fetched me from RRCY, I promised them that I would no longer go back to my old ways. But when I went back to our community, I found that it was still the same—many were still selling shabu. I got hooked on drugs again. I became a heavy user of shabu.) Rick also went back to sniffing rugby, although he asserted that he no longer used it as much as he did before and that he now hides from people whenever he uses it.

Ion probably had the worst case of relapse into criminal behavior. He went back to shoplifting after being discharged and would usually come back to their barangay when he finally had enough money to sustain his gambling habit. Aside from this, Ion and some of his friends got involved in large-scale shoplifting in Metro Manila. They would usually leave Tacloban in groups of ten and stay in a city in Metro Manila for a couple of months going around malls and large drugstores to steal expensive infant formula which they sold to a buyer who bought them for a significantly lesser price. He was arrested thrice but he was always freed after his friends negotiated with the police and paid for his release. About three years after leaving RRCY, he was again jailed in Tacloban for stealing a cellphone. Ion claimed that he was forced to steal due to his financial difficulties. He already had a wife and three children during that time.

Tommy seemed to have gone straight for the first two years after being discharged from RRCY. He concentrated his energies on working either in construction projects or driving their pedicab but was eventually jailed for frustrated murder. He stabbed his Japanese employer because he was not compensated for his work at a construction project. He spent 11 months behind bars and was out on probation at the time of the interview with the help of their barangay chairman who applied for his custody.

DISCUSSION

This study sought to examine the life stories of discharged youth offenders, particularly their experiences of reintegration with their families and communities, in order to understand the factors that enable and impede the process of crime desistance. A critical examination of these factors is important in two ways: first, it can help concerned parties improve their efforts at assisting ex-offenders in their desistance process, and second, it can make us appreciate the oft-neglected fact that the path to the straight world is not that straight at all.

Factors in Crime Desistance

The narratives of the participants revealed several factors that influenced their process of desistance from, or relapse into, crime. These factors are discussed in the following subsections.

Family support. The support extended by one's family plays a critical role in the desistance process because discharged youth offenders usually have no one to turn to except their families. Although the participants' narratives do not give the impression that the positive treatment of their families was strongly related to their desistance from crime, it was still a significant improvement from their relationship with their families during their pre-RRCY days.

Community condition. Majority of the participants also reported being treated positively by their neighbors upon their return. However, their stories revealed that the communities they went back to still had the same problems as when they left them. This is consistent with some studies that report various challenges for the youth offender in terms of transitioning into their communities (Todis et al., 2001). For some participants, the community played a role in their relapse into crime. Such is true in the case of Matt who went back to his barangay and found that it was still full of drug pushers; he eventually got hooked on shabu not long after being discharged from RRCY.

Unfortunately, the problem of going back to the proverbial "same old community with the same old problems" could not be dealt with that easily because relocating to a better community was not a viable option for the participants. In fact, not one of them mentioned the possibility of moving to a different place because it was assumed that they would all go back to their families in their original communities, which still had the same conditions that predisposed them into offending in the first place.

It also did not help that some participants experienced being looked down on or talked about by their neighbors who knew of their past behaviors. This was indeed a challenge for those who said that they were still viewed by their neighbors as the delinquent youth that they once were despite their current efforts at reform.

Intervention of significant others. Another factor found to have facilitated crime desistance for some participants was the intervention of significant persons, which is consistent with Maruna's (1997) prototypical reform narrative in which the youth offender gets a second chance at life with

the help of someone else. This usually took the form of being adopted by a concerned neighbor in an attempt to help the youth desist from his old ways. Matt, Ariel, and Rick all experienced being adopted by a couple from their neighborhood who knew about their past antisocial behavior and wanted to help them reform their lives. These interventions benefited the participants because their new guardians proved to be better providers than their biological families and afforded them opportunities to stay away from getting into trouble with the law.

Employment. One of the stronger factors that facilitated the desistance process for most of the discharged youth offenders was having a job. Working for a living consumed most of the participants' time, which meant that they had less time to spend in antisocial activities. Despite their meager income, earning money through their respective jobs made the discharged youth offenders feel productive because they were able to support their families. This, in turn, made them feel good about themselves and encouraged them to do better in their work so they could fulfill their family obligations.

Marriage and children. Getting married and having children was yet another significant factor that influenced the participants' desistance process. Now that many of them had to support their families through their work, being involved in criminal activities became much less rewarding presumably because of the associated possibility of incarceration. Going back to jail meant that the married participants would have to endure being separated from their families; worse still, it also meant that their wives and children would have to suffer the consequence of losing their sole source of support. Having children seemed to be an additional reason not to go back to one's old ways as reflected in some of the participants' desire to do the best that they can so their children could live comfortable lives.

In relation to this, Sampson and Laub (1993; cited in Laub, Nagin, & Sampson, 1998) found that individuals who desist from crime are significantly more likely to have entered into stable marriages and steady employment. They claimed that marriage and work act as "turning points" in the life course and are crucial in understanding the processes of change. Although the participants in this study currently hold jobs that are far from being steady, the experience of working to support their families nevertheless acts as a potent factor that restrains them from re-offending.

Moreover, Laub, Nagin, and Sampson (1998) emphasized that the preventive effect of marriage emanates from the quality of the marriage

bond and not from the existence of marriage itself. This argument becomes more relevant if we compare the experiences of Matt and Josh with their respective marriages. Between the two, Josh is arguably at an advantage in terms of family support and quality of marriage and is thus at lesser risk of reoffending. In fact, Josh had never had any trouble with the law since he was discharged from RRCY years ago.

On the other hand, Matt went through two unsuccessful marriages already—he left his first wife after forcing her to abort their baby, whereas he was separated from his second wife on account of her infidelity. Matt almost relapsed into criminal behavior because he attempted to kill his wife and her lover. Whether Matt is in danger of reoffending at present is still uncertain; after all, he still has two children who motivate him to work harder to support their needs. What is clear, however, is that Josh seems to be at lesser risk of reoffending than Matt because the former has more positive experiences with his marriage.

Interestingly, the case of Ion offers what seems to be a paradoxical effect of marriage and family life on his desistance process. Ion admitted that he still engages in occasional shoplifting, especially when he is out of work, in order to support his wife and three children. Then again, he also claimed that marriage was a great help in his efforts to reform his life. Upon closer analysis, however, it becomes apparent that Ion's occasional forays into unlawful activities is really the effect of poverty and not of having a family per se. His reoffending should therefore be viewed as a desperate response to difficult times, made even more difficult by the pressure to support his family.

The Not-so-Straight Path to the Straight World

The experiences shared by the discharged youth offenders regarding life in the outside world reveal that desistance from crime is not just a simple matter of no longer having a criminal record after incarceration and/or rehabilitation. Indeed, the path to the straight world is not so straight at all—crime desistance is a long and difficult journey filled with roadblocks and U-turns, and the ex-offender needs more than just sheer determination to succeed in his efforts at maintaining a straight life in the outside world.

This difficult process is evident in the stories of those who went back to their old ways immediately after their release. Despite their resolve to

change their lives once they left RRCY, Matt, Rick, and Ion found that the communities they went back to were still the same disruptive places that they had left, and that the lure of their old ways was too hard to resist given that they had no other preoccupations and received very weak social support. Tommy was also determined to make good in the outside world and was actually enjoying a life free from trouble during the first two years after being discharged; however, he nearly killed his employer for a work-related disagreement and was thus incarcerated again.

The complicated process of crime desistance becomes even more apparent if we compare the experiences of the ten discharged youth offenders in terms of the nature of their offending and the length of their stay in RRCY. A closer examination of the participants' incarceration histories and offending trajectories (see Table 1) reveal that all ten participants are long-term, habitual offenders. This is evidenced by the fact that all but three of them had previous histories of incarceration, while the three individuals who were not previously incarcerated still had past involvement in delinquent behaviors and criminal activities. In spite of this, only four participants—Matt, Tommy, Rick, and Ion—relapsed into antisocial behavior after being discharged from RRCY. Similarly, seven participants were once chronic drug users (Matt, Tommy, Josh, Rick, Todd, Dolph, and Ion), but only Matt and Rick went back to using drugs after leaving the Center.

The participants' length of stay in the RRCY may be classified into long term (11 months and above), medium term (five to 10 months), and short term (below five months). Following this scheme, half of the participants were long-term residents (Tommy, Josh, Rick, Tim, and Dolph), three were medium-term (Matt, Ariel, and Ion), and the other two were short-term (Ethan and Todd). If we assume that the length of stay in the RRCY is a factor in crime desistance, it is intriguing to note that the four individuals who relapsed into delinquency and criminal behavior actually came from both the long- and medium-term groups. The picture gets even more complicated if we factor in the participants' stay in lock-up or in the city jail prior to being committed to RRCY.

The point in the foregoing discussion is that the process of crime desistance is a complex process influenced by various factors. Therefore, these factors should not be examined separately but should instead be viewed as interacting with each other to direct the course of the youth offender's post-rehabilitation life.

Furthermore, the real-life examples of the ten discharged youth offenders should make us rethink our notion of crime desistance. For Maruna (2004), desistance does not refer to a simple termination event that takes place at the time of a last offense. Instead, desistance is the process of refraining or abstaining from illegal behavior. He therefore prefers to categorize some ex-offenders as actively desisting if they are strongly engaged in this ongoing process of self-restraint and self-definition. Operationally defined, these actively desisting individuals were once long-term, habitual offenders, but who at the time of the interview had been crime-free and drug-free for more than a year apart from having no plans of future involvement in criminal behavior. On the other hand, another group might be more appropriately called as persisting ex-offenders because they are still active in their criminal careers and admit to explicit plans of maintaining their illegal behaviors.

Following Maruna (2004), only Ion falls under the category of persisting ex-offender because he still engages in occasional shoplifting when he is out of money and he sees himself doing it again because of his financial difficulties. The rest of the participants may be classified as actively desisting, including the three who relapsed into crime, because just like the others, Matt, Tommy, and Rick had been free from drugs and criminal activities for at least a year at the time of the interview, apart from having expressed their desire to no longer go back to their old ways.

Based on Maruna's (2004) classification scheme and the experiences of the ten discharged youth offenders, it seems misleading to simply categorize discharged youth offenders into those who have either desisted from or relapsed into crime. After all, there is no assurance that those who maintained a clean record post-RRCY will continue to live straight lives; these individuals are faced with daily struggles (e.g. poverty and criminal activity in the community) that could still put them at risk of reoffending. Correspondingly, some of the participants who experienced relapse are now back on track, while some still continue to engage in antisocial behaviors every once in a while.

For these reasons, it is more appropriate to classify discharged youth offenders using a continuum for risk of reoffending. Based on significant factors that influence the desistance process, they could be assigned to different points in the continuum ranging from being less- to more-at-risk of reoffending; such a classification scheme more accurately reflects their status vis-à-vis crime desistance and could thus help us identify who is in greater need for intervention. Admittedly, we have yet to come up with a good model

that is capable of both evaluating the discharged youth offender's status based on the factors discussed earlier and placing him at a point in the hypothesized "risk of reoffending continuum" to predict the probability of either desistance from, or relapse into, crime.

IMPLICATIONS FOR FUTURE RESEARCH

This study showed how multifaceted the process of crime desistance is. To be sure, there are other factors that play a role in whether a discharged youth offender goes straight in the outside world or relapses back into criminal activity. Future studies may examine possible internal or dispositional factors in delinquency (e.g., self-control, susceptibility to influence, attributional style, moral reasoning, cognitive ability, emotional maturity, etc.) to complement the external factors discussed in this study. The role of the community may also be elaborated by taking on an ecological systems perspective, specifically focusing on the social dynamics of the community and how this predisposes the youth to delinquency.

Future researchers may also be interested in sketching a prototypical life narrative of the Filipino discharged youth offender such as the one proposed by Maruna (1997). Collecting life stories will prove to be of value in this kind of research as it will highlight the similarities in the trajectories of post-rehabilitation life by discharged youth offenders.

Beyond narrative studies of former youth offenders, it is likewise important to come up with quantitative investigations such as coming up with a model that would predict the youth offender's risk of reoffending given certain factors. This kind of research will have important implications both for research and policy on juvenile delinquency.

Implications for Practice

The RRCY no longer has responsibility over the former youth offenders once they get discharged because the provision of aftercare services now rests upon the concerned local Social Welfare Development Office (DSWD, 2007). Unfortunately, aftercare services for discharged youth offenders are either weak or nonexistent. It is alarming to note that only one out of the ten participants in this study mentioned receiving some form of aftercare support from the DSWD after leaving RRCY.

In light of this sad reality, the DSWD is encouraged to strengthen its aftercare program and closely supervise its implementation. The discharged youth offenders who express interest in pursuing their education outside the RRCY should be assisted in securing enrolment, especially because of the possibility that they might lack certain school requirements. Perhaps the DSWD could assign at least one individual to monitor the progress of the discharged youth offenders' education, and see to it that they get all the possible assistance they need in order to graduate.

The families and communities also need to be educated in terms of dealing with the reintegration process of former youth offenders. Because both family and community support are deemed to be significant factors that could either facilitate or hamper crime desistance, these two institutions need to be aware of their important role in the reintegration process and should thus be duly trained and assisted in dealing with youth offenders who are ready to return to their homes and communities to start new lives.

Drawing on the stories of the participants, the DSWD should likewise focus on assisting the discharged youth offenders in securing employment that not only fits their capabilities but also pays them well enough to support their families. For example, the DSWD can link with other government agencies such as the Technical Education and Skills Development Authority (TESDA) in training and endorsing the discharged youth offenders for suitable employment. The discharged youth offenders' need for employment cannot be overemphasized because most of them now have families to support.

SUMMARY

This study sought to fill a gap in the local literature on youth offenders, who have always been studied while they are still inside rehabilitation facilities. Cognizant of the fact that these facilities serve as temporary shelters for youth offenders, the author focused on those who have already been discharged from a local rehabilitation center and investigated their experiences with reintegration into the outside world and the challenges of crime desistance. The participants' narratives revealed the complex and multifaceted nature of life after rehabilitation. Results highlight the need for more systematic and holistic approaches to dealing with the issue on youth offenders to ensure that the resources allotted for rehabilitation facilities do serve their intended purposes.

AUTHOR NOTE

Pierce S. Docena, Division of Social Sciences, University of the Philippines Visayas Tacloban College.

Portions of this paper were presented at the 49th Annual Convention of the Psychological Association of the Philippines held in Cebu City.

Correspondence concerning this article should be addressed to Pierce S. Docena, Division of Social Sciences, University of the Philippines Visayas Tacloban College, Tacloban City, 6500 Leyte. Fax: (053) 325 5108. Telephone: (053) 325 9291. Email: pierceecology@gmail.com

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Table 1 Incarceration History of Research Participants

Name	Age upon entry to RRCY (in years)	Offense	Length of stay in City Jail/Lock-up prior to RRCY	Length of stay in RRCY	No. of years since discharge from RRCY (as of interview)	Previous experience with incarceration
Ethan	16	Theft	4 months	2 months	4	Theft (29 days); mother applied for custody/probation
Matt	19	Frustrated murder & 3 counts robbery	48 months	7 months	6	Twice incarcerated for theft (3 months) and rugby use (6 months)
Tommy	20	Robbery/Holdup	18 days	24 months	3	Possession of deadly weapon (7 months)
Ariel	14	Theft	6 months	6 months	4	Incarcerated about 6 times in lock-up ranging from 2 days to 1 week for various cases
Josh	16	Substance abuse (rugby use)	4 months	11 months	8	No history of incarceration, but with past history of criminal activity
Rick	15	Substance abuse (rugby use) & illegal gambling	12 months	24 months	5	Had been in and out of lock-up about 20 times for rugby use; detention ranging from 1 day to 1 week

Name	Age upon entry to RRCY (in years)	Offense	Length of stay in City Jail/Lock-up prior to RRCY	Length of stay in RRCY	No. of years since discharge from RRCY (as of interview)	Previous experience with incarceration
Todd	16	Theft	1 month	2 months	5	No history of incarceration, but with past history of delinquent behavior
Tim	17	Qualified theft	NA	14 months	2.5	No history of incarceration, but with past history of delinquent behavior
Dolph	17	Theft	3 months	12 months	7	Had been in and out of DSWD detention about 7 times; had been detained at lock-up 3 times for shoplifting
Ion	20	Theft	8 months	8 months	6	Incarcerated at least 10 times at lock-up for shoplifting

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Job Demands, Working Postures, Workstations, and Prevalence of Work-related Musculoskeletal Disorders Among Teachers in Silliman University

Reynaldo D. Ramos

Department of Undeclared Majors, Daegu University, Daegu City, South Korea

Cyflor E. Putong

Institute of Rehabilitative Sciences, Silliman University, Dumaguete City, Philippines

This paper aims to establish the magnitude of work-related musculoskeletal disorders (WMSDs) among 119 randomly selected teachers in Silliman University and to point out the associated risk factors by examining the job demands, workstation and the working postures assumed by teachers as they performed their assigned tasks. The results of the study showed that the conduct of lectures, test preparation, and computer work consumed majority of the teacher's time. The three-month prevalence of musculoskeletal disorders was 82% and majority experienced shoulder pain, lower back pain, upper back pain, and neck pain. The posture analysis showed that neutral postures were observed in the back, arms, and legs except in the neck where combined non-neutral posture is about 59%. Major ergonomic deficiencies were found in the backrest, seat pan, arm rests, seat and work surface heights. Worth noting to both seated and standing workstations is that none of these were adjustable to accommodate the varied tasks of teaching. Therefore, the teachers in the study were at risk to work-related musculoskeletal disorder because the nature of their work demanded them to assume a variety of postures and activities that may be perpetuated by an improperly designed workstation.

Keywords: working postures, work-related musculoskeletal disorders, risk factors, teachers, job demands, non-neutral postures, workstation

INTRODUCTION

Teaching is a challenging and stressful occupation. In a 2005 study, it was identified as one of the most stressful out of the 26 occupations that were examined (Johnson et al., 2005); teachers had attributed this condition to work (Kyriacou, 2001), experienced this stress at work for at least 50% of the time (Blix, et al., 1994), and often or almost always at work (Chalmers, 2004). It's not surprising that for the past decade work-related musculoskeletal disorders (WMSDs) have become increasingly common among teachers worldwide and across all teaching groups. With a prevalence rate of between 12% and 84% affecting predominantly the back, neck and the upper limbs (Erick & Smith, 2014) concurrent with the increasing pressures, technological, curricular changes and demands of teaching, WMSD can become a major cause of many health- and productivity-related problems similarly affecting many occupations worldwide if left unattended. This is alarming since these disorders are chronically painful, incapacitating, career-ending, life-changing, and costly to employers, workers, and society in terms of time lost from work, absenteeism, direct and indirect health expenditures, and productivity losses (Nordin et al., 2011; Cardoso et al., 2009; Maguire & O'Connell, 2007). This is even worse in developing countries where substandard working conditions are prevalent and awareness of ergonomics issues, education and training programs are limited (Sealetsa & Thatcher, 2011).

In Asia, a prevalence rate of 30 - 65% was reported by teachers in Hong Kong, Japan, Malaysia, and China affecting primarily the shoulders, arms, neck, and low back (Masaru & Misako, 2001; Tsuboi et al., 2002; Jin et al, 2004; Chiu & Lam, 2007; Chong & Chan, 2010; Samad et al., 2010). In Europe, teachers had problems in the same body regions (Wiklund & Sundelin, 2003; Nordin et al., 2007) as well as in the Middle East where the prevalence among Saudi Arabian teachers was at 79.17% (Darwish & Al-Zuhair, 2013). The reported figures are conservative and represent only reported cases. Research studies have been dedicated to address the problem ranging from injury prevention to identification of a wide range of risk factors creating musculoskeletal stress. However, risk exposure still continues and is far from being solved. Possible reasons could be the differing work content and methods, workplace characteristics, teaching style and culture, and work organization practices within the teaching profession

making research results inadequate if not ineffective for universal use. This is because interventions of this nature require attention to the individual, organization, and job characteristics (Williams & Westmorland, 1994). Thus, to ensure a continued provision of quality education, suitable intervention programs have to be pursued if these causes of waste of human and financial resources are to be prevented. These however demand evidence to tailor-fit such programs and set priorities for intervention.

In the Philippines, WMSD studies and respondents remain low and limited to high school and college teachers. At the national level, the limited social security coverage and the defective reporting system make it difficult to establish its magnitude and risk factors. Workplace risk factors have not been thoroughly examined particularly the job demands and their associated physical activities, working postures and the impact of workstations on these postures. Although ergonomic interventions have been shown to help improve WMSD symptoms, they are usually non-existent and do not oftentimes form part of any traditional medical or rehabilitative interventions in the academe, let alone in the country. Therefore, this research was undertaken to establish the prevalence of WMSDs among teachers in Silliman University (SU), and the existence of its associated risk factors by examining the job demands, physical activities, working postures, and the workstation of teachers. The information and insights generated are vital in improving the working environment for teachers with similar working conditions, job and demographic characteristics and in building initial ergonomic database for the teaching profession.

THEORETICAL CONSIDERATIONS

The United Nation has declared that education is central in meeting its Millennium Develop Goals (MDG) for it equips learners the necessary core values, behavior, knowledge, and skills in understanding and addressing the prevailing problems of this century (UNESCO, 2010; UNESCO, 2015). Unfortunately, there are work conditions surrounding this sector that continuously expose and predispose its workers to varying amount of musculoskeletal stress that may lead to WMSDs (Erick & Smith, 2011). These disorders are inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, bones, peripheral nerves and a localized blood vessel. They are caused by either a single or cumulative injury leading to

persistent pain, discomfort and disability (Punnet & Wegman, 2004). Several literatures have revealed that WMSDs are the result of various interacting work conditions that a good understanding of each is necessary to provide appropriate and prioritized intervention programs (Boyling, 1994).

One of the work conditions is the job demand of teaching itself. Teachers perform varied tasks ranging from classroom teaching and supervision, administrative, to extension work that imposes static, in some cases dynamic load on the musculoskeletal system. In the classroom, they stand for long hours performing monotonous to repeated activities like overhead board writing with one or two upper limbs elevated, and may stoop, kneel, squat, bend over or twist their trunks and neck while attending to students' questions or needs. In their offices, they bend or twist their trunk and neck, extend their arms outward as they prepare for tests and lessons, mark, type using a computer, and read while seated. If these demands are done for several hours without rest, they become risky because they can cause muscle tendon strain and encourage static muscle contraction which can potentially constrict blood vessels thereby compromising circulation and removal of waste products in the area, eventually causing muscle fatigue, pain and joint soreness and in some cases acute tendonitis (Occupational Safety and Health Agency [OSHA], 2000). A study in China showed that prolonged standing and sitting, static posture and uncomfortable back have been associated to neck, shoulder, and low back pain among teachers (Yue et al., 2012.). Incidentally, these demands and activities have also been known sources of body pains among teachers.

Second condition is the sedentary nature of teaching. Due to lack of physical activity, work problems such as poor posture, poor breathing pattern, sluggish circulation, and diminished physical activity can emerge (Bullock, 2000). Thus, tasks that require minimum muscular effort like teaching can be considerable and potentially risky when they are voluminous, monotonous, and repetitive since they have the potential of overwhelming the body's tolerance and repair capabilities. With computer use, they are not only more exposed to repetitive and monotonous motions of the wrist and hands but also to awkward and sustained postures like "poking chin" during computer operation which have been associated to WMSD development (Fabrizio, 2009; Ayanniyi et al., 2011; Andersen et al., 2008).

Third and last condition is the absence of an ergonomic standard in the academe. School workstations particularly the furniture used may

not be designed to accommodate teacher's physical characteristics and technology (e.g. computers). This creates mismatch that prevents the use of human body efficiently and effectively. As a result, risk exposure increases for it encourages the assumption of unhealthy postures that overload the weight-bearing structures of the musculoskeletal system (Bullock, 2000). This scenario happens when working tables are too low forcing teachers to stoop in order to perform work and when too high they may extend their back and abduct their arms resulting to a greater effort in maintaining the position. Such posture can cause fatigue, strain, discomfort, and eventually lead to WMSDs by increasing the workload and the muscle requirements of the tasks (Khalil et al., 1993; Vedder, 1998). When these postures become habitual, reduced lung capacity, muscular contracture, structural deformity, with a corresponding limitation of motion may also ensue, and WMSD may develop (Khalil et al., 1993; Bullock, 2000). A study among employees who used office tables for computers and adopted a bent and unsupported back postures reported trouble in the shoulder, back, arm, wrist, and the neck (Shikdar & Al-Kindi, 2007). Several studies also showed that the furniture used and the job demands that require prolonged standing and sitting with head down posture during reading, computer use, marking, and writing, have been associated to WMSD development (Chiu & Lam, 2007; Lemoyne et al., 2007; Tissot et al., 2009; Ayanniyi et al., 2011). In our effort to become globally competitive and relevant, studies focusing on the teaching profession must be undertaken to secure the health and productivity of teachers as part of the nation's security and sustainability. Thus, WMSD prevalence and its predisposing factors have to be established so that working conditions, physical workloads, and working postures can be modified and optimized to promote efficiency, safety, and comfort at work (Ong & Kogi, 1992; Richardson, 1994; O'Callaghan & McIntyre, 1995).

METHODS

Observational technique, particularly the work sampling technique, was done to assess participants' risk exposure to WMSDs since it is more appropriate in studying non-repetitive tasks, and in estimating the percentage of time workers spend in certain postures as they perform various tasks (Buchholtz et al. as cited in Capio, 2001). In this study, the participants included teachers of SU from all levels, who are regular employees, have

academic, administrative, extra-curricular, or clinical assignments, have no history of trauma or surgery, no physical deformities and defects, congenital or acquired, or ailment prior to employment. Teachers who were on sick, study, maternity or vacation leave were excluded. A stratified sampling design was used to ensure adequate representation since they were selected from various academic units of SU — a non-stock, non-profit and non-sectarian institution of higher learning that provides early childhood, elementary, high school, and college education located in Dumaguete City, Negros Oriental, Philippines. A sample of 119 teachers was randomly selected from a list distributed as follows: 91 college (76.5%), 28 School of Basic Education (SBE) which is further distributed as 11 high school [HS] (9.2%), and 17 elementary school [ES] and early childhood school [ECS] (14.3%).

The data were collected via direct observation, on-site visitation, and self-administered standardized questionnaire that could be answered in less than ten minutes. The data collection was done in the field covering two semesters. This was done to ensure that working postures and exposures to risk of teachers, and their overall condition at work could be directly observed. The respondents were assured of the confidentiality of their responses and their participation could not affect their current job status. The following were the three data collection tools:

1. A Pilot-tested *Task Analysis Self-administered Questionnaire* was used to gather the demographic profile such as age, marital status, educational attainment, medical and accident history, years of teaching, and the job demands of the respondents. They were asked to indicate the number of hours they spent per week, the frequency performing the various tasks as reflected in their academic load, and specify the dominant task, the essential time element, the workstation, and the physical activities or requirements of each task. The data obtained were used to identify the dominant workstation for the on-site visit using two workstation checklists, and the job demand for Ovako Working Posture Analyzing System (OWAS).
2. A *Modified Nordic Musculoskeletal Questionnaire* was used to establish the prevalence of WMSD and the body parts affected. This self-administered questionnaire was purposely designed to record

work-related musculoskeletal symptoms in working populations (Kuorinka et al., 1997). To determine the prevalence of symptoms defined as “job-related ache, pain, etc.,” the respondents were asked whether they had ever experienced work-related pain or discomfort in the past three months in nine different anatomical areas. It had three general questions that deliberately probed on the nature of the complaints, their duration and prevalence in nine areas of the body. Also, had a body picture showing areas of concern to guide respondents. These were the same anatomical areas as those reported by Bork et al. (1998) and Cromie et al. (2000). In addition to questions regarding the prevalence of work-related musculoskeletal symptoms, teachers were asked to indicate whether symptoms in each anatomical area had interfered with work at home or away from home, and whether symptoms had been bothering them during the last seven days. The last three questions were used to determine the perceived relationship of the complaints to work. To get the prevalence, the number of “yes” was divided by the total number of respondents and multiplied by 100%.

3. The *OVAKO Working posture Analyzing System (OWAS)* was used to identify and classify work postures of the back, arms, and legs, and their musculoskeletal loads during various phases of work. It was modified to include the neck for this study. With this fourth tool, a video recording of teachers’ working postures in their actual work setting was done after 10 minutes into every work shift (one class period) to make them comfortable until the participant would take a break. The video recorder was positioned strategically and discreetly to reduce obtrusiveness and Hawthorne effect. Videotape frames in the form of posture combinations were recorded at 30-second interval using a five-digit code describing various postures and force combinations, and then compiled in a standardized form. The neck had five postures (straight, bent forward, bent on one side, bent backward, twisted on one side), the arm had three (both arms below shoulder level, one above the shoulder, and both above the shoulder); the trunk had four (straight, bent forward, straight and twisted, bent and twisted); and the leg had seven (standing on both legs, standing

on one leg straight, standing on both legs bent, standing on one leg bent, kneeling on one or both legs, walking, and sitting). Non-neutral postures were described in this study to include postures that were bent, straight but twisted, bent and twisted, one or two arms above shoulder level, standing on one or two legs bent, one or two knees touching the ground.

4. The *Seated and Standing Workstation Checklists* were used to assess the respondents' workstations. The Checklists were used to assess the workstation design of the University of the Philippines teachers in Manila (Gonzaga et al., 2002). The Seated Workstation Checklist contained 34 questions covering basic components like backrest (7), armrest (5), seat pan (11), seat height (4), work surface (7). The Standing Workstation Checklist included 31 questions on work posture (9), work surface (13) and work area (9). Both checklists highlighted orientation of body parts while at work, surface heights, location and accessibility of controls, quality of materials and equipment, and space requirements. Both were answerable by "yes" or "no" where the "no" answer might signify a problem that needed attention. An on-site workstation visit was done using these tools to determine presence of any workstation deficiency and mismatch between the workstation and the teacher.

Meanwhile, descriptive statistics were used to describe the personal variables and essential features of the work condition of the respondents.

RESULTS

Profile of the study participants. Of the 119 respondents, majority of respondents were females (74.8%), married (70.6%) with children (64.7%) and were more than 30 years old (86.6%) where majority belonged to the age group of 31 to 40 years and 41 to 50 years. Among teaching groups, ES and ECS had the most number of married teachers with children (76.5%), who were more than 30 years old (94.1%) and along with HS, had the most number of females (over 80%). Table 1 also shows that majority had more than 10 years teaching experience (66%) and taught in college (66.7%), in

HS (63.6%), and in ES and ECS (64.7%). They worked for 6-8 hours (65.0%), 5-6 days (58.8%) a week where over 70% were from SBE.

Furthermore, most respondents spent more than 50% of their daily working time teaching or doing teaching-related task (90.8%) and working exclusively for SU (96%) in which majority were college teachers. More than 50% of teachers had master's degree (52.1%) and less than 10% had doctoral degree in which majority were also from college. A little over 80% considered their symptoms to be work-related, where 24.4% of these were absolutely work-related. In contrast in HS, teachers in ES and ECS reported the highest work-relatedness of symptoms. The other details of the demographic and work profiles are reflected in Table 1.

Table 1. Demographic and Work Profile of Respondents (in percent)

Variables	College (n=91)	SBE		Total (n=119)
		HS (n=11)	ES & ECS (n=17)	
Gender				
Male	27.5	18.2	17.6	25.2
Female	72.5	81.8	82.4	74.8
Age				
20 – 30 years old	15.4	9.1	5.9	13.4
31 – 40 years old	32.9	45.4	41.2	35.3
41 – 50 years old	27.5	18.2	17.6	25.2
51 – 60 years old	19.8	27.3	35.3	22.7
61 – 70 years old	4.4	0.0	0.0	3.4
Marital Status				
Married	70.3	63.6	76.5	70.6
Single	29.7	27.3	23.5	28.6
Widow	0.0	9.1	0.0	0.8
Number of Children				
0	37.4	36.4	23.5	35.3
1 – 2	42.9	18.2	41.2	40.3
3 – 4	17.5	45.4	37.3	22.7
5 or more	2.2	0.0	0.0	1.7
Educational Attainment				
Bachelors	29.7	72.7	82.4	41.2
Masters	61.5	27.3	17.6	52.1

Doctoral	8.8	0.0	0.0	6.7
Length of Service in years				
0 – 5	21.2	18.2	23.5	21.9
6 – 10	12.1	18.2	11.8	12.6
More than 10	66.7	63.6	64.7	65.5
Working Hours per Day				
Less than 5	17.5	18.2	11.8	16.8
6 – 7	22.0	18.2	23.5	22.7
7 – 8	38.5	63.6	52.9	42.0
more than 8	22.0	0.0	11.8	18.5
Number of Times a Task is done Per week				
1 – 2	2.2	0.0	11.8	3.4
3 – 4	40.7	27.3	29.4	37.8
5 – 6	57.4	72.7	58.8	58.8
Perform Task > 50% of Daily Work Hours				
Yes	92.3	81.8	88.2	90.8
No	7.7	18.2	11.8	9.2
Working Exclusively for SU				
Yes	97.8	90.9	88.2	95.8
No	2.2	9.1	11.8	4.2
Perceptions of work-relatedness of WMSDs				
Absolutely work-related	25.3	9.1	29.4	24.4
Partially work-related	56.0	54.5	64.7	57.1
Absolutely not work-related	18.7	36.4	5.9	18.5

Experienced symptoms of WMSDs

Eighty-two percent (82%) of teachers had experienced work-related pain, trouble, ache or discomfort at sometime in their working life in the last three months. Table 2 shows the greatest proportion of this in the shoulder (61.3%), followed by the lower back (54.6%), upper back (51.3%), neck (49.6%), and wrist & hands (44.5%). These are the same body parts commonly reported by college, ES and ECS teachers, while HS teachers had the shoulder, lower back, neck, knees, ankle and foot. The prevalence rates, however, vary across groups with ES and ECS reporting the highest in the neck (70.6%), shoulder (70.6%), upper back (64.7%), wrist and hands (52.3%), hips and

thighs (47.1%). Table 2 also shows symptoms in the upper back (12.6%), lower back (10.9%), ankle and foot (9.2%), hips (8.4%) and shoulders (8.4%) that prevented respondents from doing work. Across groups, the top body parts that prevented college teachers from doing work were: upper back (11%), shoulder, ankle and foot (8.8%); lower back (27.3%) and ankle & foot (27.3%) for HS teachers; and upper and lower back (17.6%) for ES and ECS teachers. In the last seven days, teachers generally had problems in the upper back (34%), lower back (30.2%), shoulders (26.8%), and neck (18.5%). Across teaching groups, the prevalence rate variation in these body parts are considerable except in the lower back. The other details are reflected in Table 2.

Risk factors related to work

Job demands. As shown in Table 3, majority reported conduct of lectures (78.2%), test construction and evaluation of students (68.1%), and computer work (54.6%) as their top three demands that consumed most of their working time per week. By teaching group, college teachers reported the same top three demands (lectures at 83.5%, test construction and evaluation of students at 65.9%, and computer work at 61.5%). Whereas, HS teachers reported test construction and evaluation of students (72.7%), lectures (63.6%), and observe and assist students (45.5%) as their third demand. Likewise, ES and ECS teachers reported test construction and evaluation of students (76.5%), lectures (58.8%), except that paperwork (58.8%) is their third demand.

Job-related physical activities. Table 4 shows that teachers reported standing (94.9%), sitting (89.9%), and walking (89.1%) as dominant physical activities related to do teaching work. By teaching group, over 90% of college and HS teachers reported standing as the prevailing job-related physical activity followed by sitting (90.1% and 81.8%, respectively) and walking (87.9% and 81.8%, respectively). While ES and ECS reported sitting (94.1%) as their dominant physical activity followed by standing (88.2%), walking (82.4%) carrying (76.5%) and trunk bending (64.7%).

Meanwhile, over 80% of teachers in each group ranked the classroom as their dominant workstation. College and HS ranked the laboratory, ES and ECS ranked home as their second workstation, respectively. Home ranked third in workstation where College and HS teachers spent doing their teaching-related work.

Table 2. Reports of WMSD Symptoms Across Groups of Teachers (in percent)

WMSD's symptoms in the last 3 months				
Body Parts	College (n=91)	SBE		Total (n=119)
		HS (n=11)	ES & ECS (n=17)	
Shoulder	59.3	63.5	70.6	61.3
Lower back	54.9	54.6	52.3	54.6
Upper back	51.7	27.3	64.7	51.3
Neck	47.2	36.4	70.6	49.6
Wrists & Hands	46.2	18.2	52.3	44.5
Ankle & Foot	34.1	36.4	29.4	33.6
Knees	29.7	36.4	35.3	31.1
Hips & Thighs	26.4	27.3	47.1	29.4
Elbows	18.7	9.1	23.5	18.5
WMSD's symptoms preventing Respondents from Doing Work				
Body Parts	College (n=91)	SBE		Total (n=119)
		HS (n=11)	ES & ECS (n=17)	
Shoulder	8.8	18.2	-	8.4
Lower back	7.7	27.3	17.6	10.9
Upper back	11.0	18.2	17.6	12.6
Neck	5.5	18.2	-	5.9
Wrists & Hands	6.7	9.1	-	5.9
Ankle & Foot	8.8	27.3	-	9.2
Knees	6.6	9.1	5.9	6.7
Hips & Thighs	7.7	18.2	5.9	8.4
Elbows	3.3	-	-	2.5
WMSD's symptoms in the last 7 days				
Body Parts	College (n=91)	SBE		Total (n=119)
		HS (n=11)	ES & ECS (n=17)	
Shoulder	30.8	9.1	17.6	26.9
Lower back	30.8	27.3	29.4	30.2
Upper back	35.2	9.1	47.1	34.4
Neck	16.5	9.1	35.5	18.5
Wrists & Hands	26.4	9.1	17.6	23.5
Ankle & Foot	12.1	9.1	17.6	12.6
Knees	12.1	9.1	11.8	11.8
Hips & Thighs	11.0	9.1	17.6	11.8
Elbows	7.7	-	5.9	6.7

Table 3. Job Demands Across Groups of Teachers (in percent)

Job Demands	College (n=91)	SBE		Total (n=119)
		HS (n=11)	ES & ECS (n=17)	
Lecture	83.5	63.6	58.8	78.2
Test & evaluation of students	65.9	72.7	76.5	68.1
Computer work	61.5	36.4	29.4	54.6
Lecture and laboratory preparation	56.0	36.4	23.5	49.6
Observe and assist students	35.2	45.5	29.4	35.3
Laboratory activities	39.6	27.3	-	32.8
Paperwork	26.4	36.4	58.8	31.9
Related learning experience	31.9	-	-	26.1
Fieldwork	26.4	18.2	29.4	26.1
Supervisory work	27.5	18.2	11.8	24.4
Debriefing	13.2	9.1	-	10.9
Administrative work	13.2	-	5.88	10.9
Research work	3.3	-	-	2.52

Table 4. Job-Related Physical Activities Across Groups of Teachers (in percent)

Physical Activities	College (n=91)	SBE		Total (n=119)
		HS (n=11)	ES & ECS (n=17)	
Standing	96.7	90.9	88.2	94.9
Sitting	90.1	81.8	94.1	89.9
Walking	87.9	81.8	82.4	89.1
Carrying	42.9	45.5	76.5	47.9
Handling	41.8	36.4	41.2	41.2
Reaching above head	30.1	27.3	47.1	32.8
Trunk bending	25.3	27.3	64.0	31.1
Lifting	23.1	27.3	47.1	26.9
Reaching below head	20.9	36.4	47.1	26.1
Gripping	20.9	45.5	35.3	25.2
Trunk twisting	20.1	9.1	29.4	21.0
Squatting	20.1	9.1	23.5	20.2
Carrying	16.5	27.3	29.4	19.3
Pulling	16.5	27.3	29.4	19.3
Kneeling	8.8	9.1	11.8	9.2
Half kneeling	4.4	9.1	17.7	6.7
Crawling	3.3	-	11.8	4.2

Working posture. Respondents conducting lecture, the job demand commonly performed by all were videotaped for a modified OWAS. From the 24 participants, a total of 3,636 video frames were generated and table 5 shows that college teachers had the most non-neutral posture of the neck (59.4%) while the other body parts were mostly neutral. Teachers in ES and ECS dominated non-neutral postures of the neck at 60.6%.

In the arms, majority of the working time (89.0%) was generally spent with the arms neutral (i.e. arms below the shoulder level). Teachers in HS spent most of their teaching time in this posture at 95.3%. Meanwhile, ES and ECS teachers dominated non-neutral arm postures at 13.7%. As for the back, majority of the working time (85.6%) was generally spent with the back neutral (i.e. straight) and over 85% were assumed by college and HS teachers. Teachers in ES and ECS had the most non-neutral back postures at 25%. In the legs, over 90% was spent in neutral posture across teaching groups.

Table 5. Neutral and Non-neutral Postures Assumed by Teachers Across Groups (in percent)

Body Parts	College (n=17)		SBE				All Teachers (n=24)	
			HS (n=3)		ES & ECS (n=4)			
	Neutral	Non-Neutral	Neutral	Non-Neutral	Neutral	Non-Neutral	Neutral	Non-Neutral
Neck	40.2	59.8	47.5	52.5	39.4	60.6	40.6	59.4
Arms	88.9	11.1	95.3	4.7	86.3	13.7	89.0	11.0
Back	87.4	12.6	86.0	14.0	75.0	25.0	85.6	14.4
Legs	99.7	0.3	98.7	1.3	94.8	5.2	98.9	1.1

Work station quality. The Seated and Standing Work Station Checklists were used to assess the workstations where respondents performed work.

Seated Work Station

Workstations where teaching and teaching-related job demands of sitting were subjected to seated workstation assessment. Sixty (60) seated workstations as representative samples were assessed covering the basic workstation components such as the backrest, armrest, seat pan, seat height, and work surface. Of the 60 workstations that were visited, 83.3% of backrest did not have a porous breathable, rough textured material and none (0.0%)

can be adjusted to any angle, 83.3% cannot be tilted forward and backward, cannot support the upper back, and the lower back. Thirty percent (30%) had armrests and only 1.7% with armrests was fully padded, about 28.3% provided enough support and only 15% provided a comfortable support to the upper limb. None of the armrests was easily adjustable. More than 80% workstations provided adequate support to the buttocks and to body contours. However, only 16.7% were upholstered with ergonomically desired material, 21.7% allowed some degree of backward tilt, only 26.7% had well-rounded edge, 1.7% were adjustable (controls were easy to reach), 33.3% were designed to distribute pressure evenly on the buttocks and thighs. The seat heights of chairs were not adjustable to allow the feet to rest on the floor, 47.7% were found to be 3cm to 5cm below the fold of the knee when a person is standing suggesting that more than 50% of the seat height was set either too high or moderately high relative to the knee fold. Finally, 35.0% of work surface height was designed to provide comfort to the shoulder and none were adjustable.

Standing Work Station

Workstations, where teaching and teaching-related job demands of standing were subjected to standing workstation assessment. Twenty-five (25) standing workstations as representative samples were assessed highlighting the working posture, working surface, and working area. In the 25 standing workstations, working posture category showed head and neck bent down, sideward or backward at 72.2% and twisted at 65.5% along with the trunk. Meanwhile, trunk leaned forward or backward at 69.7%, arms and elbows were extended outward at 41.5% while the forearm, wrists and hands were 23.1% straight and parallel to the floor. Only 35.0% of work surface were at correct height for the type of task and only 38.7% surface height allowed for the performance of tasks with shoulder relaxed. None of the working surface height was adjustable and only 3.8% were designed to reduce reaching above the shoulder. Merely 34.5% of the standing workstations prevented static muscle holding and only 31.5% eliminated full extension of arms. Teachers had enough working area to move about and able to stand naturally with weight on both feet and perform close to and in front of the body. They can easily do alternate sitting and standing during work and all the work areas visited were well lit.

DISCUSSION

In this study, we investigated the existence of WMSDs among teachers in all levels, their work-relatedness, and examined the job demands, physical activities, workstations and working postures that may predispose teachers to these disorders.

Prevalence and perceived work-relatedness of WMSD symptoms

Using a modified Nordic Musculoskeletal Questionnaire, this study established the existence of WMSDs among SU teachers and the 82% prevalence rate was within the range of several international researches. Likewise, the body parts affected and reported specifically the shoulder (61.3%), upper (51.3%) and lower back (54.6%), and neck (49.6%) were generally consistent except that the prevalence rates in this study are either relatively higher or lower than others. Possible reasons include subject selection and composition, social economics and customs, administrative and individual teaching practices, the limited inclusion of body parts in the investigation, and the non-use of standardized case definition among studies being varied across countries making comparison of prevalence rates in particular impossible in musculoskeletal epidemiology (Campo et al., 2008); nonetheless, it appears that pain in these body regions is common among teachers. It has been observed that nature or type of work determines location and prevalence of these musculoskeletal injuries (Cardoso et al., 2009; Shuai et al., 2014; Bork et al., 1998) suggesting that proper identification of the potential sources of risk exposure is needed for an effective intervention.

In terms of work-relatedness of symptoms, about one-fourth perceived their symptoms to be absolutely work-related and over 50% indicated it to be partially related. Household chores and family/parenting responsibilities such as childcare duties among female teachers may have influenced this perception considering that majority of the respondents were females and married with children (Table 1). A study showed a strong relationship between number of children and musculoskeletal pain at value 0.006 (Darwish & Al-Zuhair, 2013) and it was attributed to more time needed to childcare, higher probability of psychological stress, and demand for more teaching load to augment earnings (de Zwart et al., 1997). There are also

consistent evidences showing greater predisposition of females to WMSDs than males (Erick & Smith, 2014; Yue et al., 2012; Treaster & Burr, 2004; Wu et al., 2011). Possible reasons can range from higher emotional exhaustion (Chang-Jiang et al., 2004), workload, and family pressure (Ihlebaek et al., 2002), lower pain threshold and physical strength among females than males to household tasks and body mass index differentials (Punnet & Herbert, 2000). It seems that their domestic or household duties can potentially limit the chance to rest their body after work thus exposing them to additional stress. Hence, it may help if female teachers are given adequate rest periods in between classes and before going home, priority and consideration when assigning teaching loads to accommodate parenting duties, and early and easy access to treatment and prevention programs.

Nonetheless, those who indicated it to be absolutely related to work perceived it to be exclusively caused by work suggesting that the current symptoms were likely obtained from within their present workstation. This perception is similar to a survey conducted in Great Britain where a total of 40% adults claimed that the onset of their back pain was related to the type of work they did (Dodd, 1997). Meanwhile, those who perceived it to be partially work-related may have recognized the role of work conditions and the length of time they spent as teachers in school in their WMSD development. It was reported that the increasing number of teaching years had been found to have a significant correlation with musculoskeletal pain disorders (Chiu et al., 2006; Darwish & Al-Zuhair, 2013). In this study, over 60% taught for more than 10 years and over 90% are exclusively teaching in SU (Table 1) making it plausible that the cumulative impact of teaching could have taken a toll on their musculoskeletal system and as a result, WMSDs obtained were perceived to be confined too within their present workstation.

Apart from teaching experience, age has been considered a factor to WMSD development and possibly had played a role, too. It is a common knowledge that the body's nutrition and metabolism, physical condition, body tissue composition and integrity, and healing and repair systems change over time making it difficult to withstand the daily musculoskeletal stresses. Studies in Brazil and Turkey revealed that teachers who were above 40 years had a higher chance to develop WMSDs (Cardoso et al., 2009; Korkmaz et al., 2011) and in Botswana, teachers who were 41–50 years were 1.56 times more likely to experience LBP than those who were less than 31 years old (Erick & Smith, 2014). Whereas two Chinese studies reported a higher percentage

of neck and low back pain among 31 – 35 and 30 – 39 years old teachers, respectively (Chiu & Lam, 2007; Jin, et al., 2004). In this study, more than 50% of teachers were more than 40 years old and possibly at the peak of their productivity while over 85% were more than 30 years old (Table 1). They were presumably predisposed due to the aforementioned demographic risk factors. When multiple risk factors are present, it increases risk to WMSDs (Bullock, 2000). Hence, despite respondents' low absolute perception on work-relatedness of symptoms especially from HS, comprehensive measures must be put in place to minimize progression because these disorders, whether exclusively work-related or not, can be possibly aggravated by work and by the effects of the immediate working environment.

Furthermore, teachers have also reported trouble in the back, shoulder, wrist and hand, and neck in the last seven days (Table 2) suggesting presence of acute conditions that may indicate the existence of workplace risk factors. The back, the ankle and foot on one hand were the common body parts preventing the respondents from doing work in the last 3 months. This was expected since standing and repetitive overhead board writing, prolonged sitting resulting from test preparation and marking, lesson preparation and reading, computer and desk work, and walking which are commonly reported in this study are vital teaching postures and activities that are known to cause stress to these structures (Shuai et al., 2014; Chong & Chan, 2010; Ariens et al., 2000; Lemoyne et al., 2007). Therefore, protection of this population is important to allow them to continue working effectively and remain productive given that more than half of the respondents may have already developed the best and time-tested teaching strategies and practices in the performance of their tasks with their long teaching experience.

Prevalence variation and teaching

The study showed varied prevalence rates across teaching groups suggesting that there might be certain factors and aspects in the academe that predispose teachers more to WMSDs than others. In the current study, ES and ECS teachers reported the highest prevalence rate in the neck, shoulder, upper back, and lower limbs compared to college and high school teachers, except the low back which is fairly consistent across groups (Table 2). Parallels can be seen in the study of Chong and Chan (2010) where primary teachers reported higher neck and shoulder pain than secondary teachers at 68.2 vs.

62.0%; $p < .01$ and at 72.8 vs. 65.1%; $p < .001$, respectively. One possible explanation could be that this teaching group had the most number of married teachers with children, females and aging more than 31 years old (Table 1). These profiles have been known to predispose teachers more than the others to WMSDs (Erick & Smith, 2014; Yue, et al., 2012; Chiu & Lam, 2007; Darwish & Al-Zuhair, 2013). It is probable too that higher prevalence rates in this teaching group could be explained by the nature or type of work they perform. Teachers in this group were more pre-occupied with test and evaluation of students, marking, and paperwork than college and HS teachers (Table 3). Almost 90% of them performed these dominant tasks 3-6 times per week, more than 5 hours per day consuming more than 50% of their daily working hours (Table 1). These demands are characterized by sustained activities of sitting resulting from frequent reading, marking and computer work which are known causes of neck, shoulder, and back pain among teachers (Samad et al., 2010; Chiu & Lam, 2007; Ayanniyi et al., 2011; Andersen et al., 2008).

Another possible explanation could be the demographic and physical attributes of students in ES and ECS. Teachers in this group handled 4-12 year old students and were generally smaller than college and HS. The difference merits different postural and classroom managerial demands from teachers where movement combinations had to be employed to keep students engaged, focused, and safe. In the process, this may predisposed them to reach above and below head, carry, bend and twist their trunk, squat, and lift more frequently during class and perhaps even after class. It is not surprising that these physical activities are higher in this teaching group (Table 4). During the conduct of this study, students were seen standing and moving around inside the classroom prompting teachers to stoop and squat to get hold of them. Prior researches among teachers have attributed these activities to musculoskeletal injury to these body regions (Yamamoto et al., 2003; Kumagai et al., 1995; Grant et al., 1995; Punnett & Wegman, 2004). Conversely in college and HS, their top activities were confined to standing, sitting and walking suggesting that their symptoms may be more on these activities than lifting, bending, squatting, or twisting (Table 4). In addition, the behavioral and emotional issues common among young students may have contributed too. Issues like these may not only create physical stress but also psychological stress. A study revealed that those who were under stress had 4.15 and 2.18 susceptibility to LBP than those who were not

experiencing stress (Atlas et al., 2007; Beyen et al., 2013). In a separate study, educating and managing young students are themselves sources of stress among teachers (Mariammal et al., 2012).

Whereas in college, apart from having the most number of single and male teachers, the low prevalence rates reported were probably due to greater academic freedom enjoyed by teachers allowing them to have control over the demands of their teaching load. It has been postulated that high work demands and low authority over decisions may cause WMSDs while feelings of being in command inhibit stress (Eriksson, 1996). Likewise, the number of childless teachers was relatively higher than HS, ES and ECS too, thus they were free from childcare duties and had more rest time, and only a few had 3-4 children (17.5%). A study in Salvador observed that teachers with three or more children were more likely to report MSDs than those with one or two children (Cardoso et al., 2009). Their workload was also relatively lower (Table 1) and it is possible that those teachers with doctoral degrees had graduate school teaching load where students were few and highly independent and motivated. However, the low prevalence rates among HS teachers is surprising when factoring in workload, gender composition, and the number of teachers with 3 – 4 children (Table 1), and the amount of stress they had when dealing with adolescent's behavioral, mental, and emotional issues. It was probable that older HS teachers with longer experience may have already developed mechanisms to cope with these demands and challenges. This may include employing of family members doing the marking or typing, recycling of old test questions on computer, availing of the therapeutic effects of massage and enrolling themselves in health and wellness programs. Overall, the study findings revealed that teachers are exposed to WMSDs, which may pose a serious threat to the quality of teachers and teaching in the years to come if left unattended.

Job demands and job-related physical activities

Another purpose of this study was to determine teaching demands and physical activities predisposing teachers to assume non-neutral postures. Majority of the respondents ranked conducting lectures, test and evaluation of students, and computer work as the top three most common job demands that they performed 3-5 times in a given week and consumed 6-7 hours of their working hours (Table 1), of which majority was spent in standing

followed by sitting, walking, carrying, handling, reaching above head, and trunk bending (Tables 3 and 4). This is expected given the nature of their academic assignment. These demands and physical activities have been known to cause neck, shoulder and back problems among teachers as reported in several studies (Erick & Smith, 2014; Darwish & Al-Zuhair, 2013; Grant et al., 1995; Yue et al., 2012). Incidentally, these were the same body parts affected in this study.

Meanwhile, just as prevalence rates variation existed in this study, so did the job demands suggesting the variability of risk exposure across groups. In contrast to college, SBE teachers ranked test and evaluation of students first while observing and assisting students, and paperwork as additional demands for HS, ES and ECS, respectively. These demands are sedentary, and may involve non-neutral postures such as neck bending and twisting resulting from frequent reading, writing or typing and possibly even trunk bending with arms extended outward for reaching while seated for long periods of time. Prior researches have attributed these demands, activities and postures to musculoskeletal injury to these body regions among teachers. In this study, one possible reason to this variation could be the varying levels of academic freedom in SU as a school of higher learning that allows college teachers more especially a greater degree of autonomy and flexibility. Given their academic expertise in their field of specialization and the nature of their learners, this autonomy provides them with greater professional input and control in designing their syllabus as they work within the limits permitted by their respective departments pursuant to existing academic standards and government regulations. For instance, they can choose oral over written examination including the number of examinations or quizzes in a semester; individual or group graded reporting over pen and paper examinations which would mean less after class marking.

Another reason could be that education in the primary, secondary and tertiary levels is totally different in terms of curricular content, purpose, orientation. The same goes for student composition and characteristics. Just as the needs of students in each group differ, so do the kind of education, assistance, and demands required. Given students' age and level of knowledge and maturity, SBE teachers had to closely supervise and provide assessment-based academic guidance to students to determine if they met the required level of mastery. Given the sequential nature of their curriculum, they had to periodically monitor progress and direction through worksheets and

frequent formative assessments/quizzes. In this study, more than 70% of SBE teachers had test and evaluation of students suggesting they had more assessments in their syllabus or lesson plan than in college which may result to higher observing and assisting of students, and paperwork. They do this for 7-8 hours and more frequently than college teachers (Table 1). In this case, it is possible that SBE had to deal with a higher workload, frequent and longer sitting and neck bending postures, and pressure thus exposing them more to musculoskeletal stress than others and possibly to psychological stress too especially when responding to feedback and complying with grade deadlines. If a task creates more psychological demands, the body is more susceptible to any kind of musculoskeletal disorder affecting body regions (Hestbaek et al., 2004). A study in China mentioned workload, number of examinations, and pressure to graduate students as factors causing higher prevalence rates among senior HS teachers (Yue et al., 2012).

One possible reason for a higher workload in college though is teaching overload, which can be limited administratively or by choice. Another reason is the frequent use of computers, which is the highest in this group at 61.5%. Computer use has been suggested to expose users to shoulder, neck and back injury (Ayanniyi et al., 2011; Andersen et al., 2008). For both SBE and college teachers, the amount of load and number of overloads and students (i.e. oversized class) per class may add up to the load and time they need to spend in their office or at home sitting thereby increasing the likelihood of working beyond the regular office hours compromising the body's ability to repair itself adequately. Previous study in Britain had linked overtime work done after returning home as the most frequently identified risk factors due to work (Dodd, 1997) because workers deprive their bodies of rest and recovery increasing risk of developing WMSDs (Eltayeb et al., 2007; Tornqvist et al., 2009). Overall, the results demonstrate differences in the experience of WMSDs among teaching groups suggesting that risk exposure is varied within the profession and the conditions surrounding them as well as the possibility of demographics dictating their susceptibility to these disorders.

Moreover, the extent of influence of academic policy and culture while taking into account student differences in developmental levels, and the degree of administrative control on work which all translate to varying levels of flexibility and freedom across teaching groups "make and break" teaching demands and WMSD predisposition. With the new K-12 curriculum due for implementation, this scenario may impact college teachers moving to

senior HS who are now faced with the certainty of adapting SBE's academic curriculum, policies and culture; and SBE teachers who are now faced with the possibility of a much higher workload despite of no additional teaching load or hours. With K-12, new teaching aids or materials have to be prepared for the new subjects and several assessments (e.g. self-assessment, formative assessment, summative assessment) have to be done to determine students' interest, strengths, knowledge and mastery of the subject as they move towards a spiral curriculum. Assessment also includes aptitude test, a career assessment examination, and an occupational interest inventory. Senior HS students are also expected to take national and competency certifications (Official Gazette, n.d.), which may add stress to teachers. In total, the results highlight the other stressful side of teaching reinforcing the observation that the differing nature and multiple demands of teaching work, school's academic policies and culture, level of administrative controls, and student characteristics may play an important role in exposing teachers to musculoskeletal injury and thus should be considered in designing appropriate intervention strategies.

Working postures and teaching

The other purpose of this study was to determine if classroom work have predisposed teachers to assume unhealthy working postures. Based on the results, the classroom working posture was generally similar across teaching groups. The neck was in non-neutral posture (i.e. bent forward, backward or sideward and twisted) while the arms (i.e. arms below shoulder level), legs (i.e. standing on one or both legs straight, walking, and sitting) and back (i.e. straight) generally were in neutral posture. The assumption of this posture was obviously influenced by workplace and teaching job characteristics where teachers were expected to bend and rotate their neck to either side, move one or two arms to get their point across, stand, walk, and occasionally sit to address a large group of students in the classroom. Teachers assume this posture to gain and hold students' attention inside the class (Grouws & Cebulla, 2000).

The result also showed postural variation across groups in the neck, back, arms, and legs. Teachers in ES and ECS assumed majority of the non-neutral postures of the neck, arms, back, and legs in comparison to those in HS and college. This suggests that non-neutral postures such as neck

bending and twisting, one arm or both arms above shoulder level, trunk bending/twisting, standing on one or both legs bent and kneeling were more commonly adopted by teachers in ES and ECS than in HS and college. Most of these non-neutral postures were reported as physical activities in Table 4, which is consistently higher in this teaching group. A similar case was observed among pre-school teachers where they were seen kneeling, sitting on the floor, lifting, squatting, and bending at the waist while working with smaller children (Grant et al., 1995). There was also a positive association between furniture and adoption of inappropriate body posture among teachers (Cardoso et al., 2009). Thus, it is possible that classroom furniture, age and physical attributes of students have contributed to the variation. Chairs and desk, more especially in ECS, the size of students in both ECS and ES are generally smaller prompting them to adopt non-neutral postures during teaching. Meanwhile, one or both arms raising could be due to differing nature of learners, and availability of resources where class demonstration activities were perceived to be more appropriate and effective over plain lecture-discussion to improve understanding, where using traditional teaching materials (e.g. visuals or flash cards via the board) was preferred over power point, and where arm movement combination was more effective and readily available to help young students learn class activities easily or stay focus and connected over other teaching media (e.g. YouTube). Non-neutral postures in HS and college particularly trunk and neck bending and twisting, and knee bending are probably more on individual teaching style (e.g. board writing while talking), class content (e.g. laboratory class with psychomotor components), and classroom workstation (e.g. textbooks and other teaching materials/aids, overhead projectors or computer placed on low surface height tables during teaching).

Meanwhile, neutral postures are generally high in the legs. This means teachers either stand or walk most of the time inside the class. This is expected in a classroom environment where such postures project teachers as experts and providing facts to students. Despite being neutral, these working postures place loads on the weight-bearing structures of the musculoskeletal system (Ostrom, 1993) and are tiring for they require several muscles to contract in maintaining an upright position. If postural change is infrequent they may lead to WMSDs especially in the ankle and foot – body parts that prevented them from doing work (Table 2). Since prolonged standing without the ability to sit down has been shown to be the

most significant predictive factor for the development of low back pain at work (Tissot et al., 2009), occasional sitting on saddle chair while teaching may help. A saddle chair lowers fatigue by reducing muscular contraction and promotes good spinal alignment (Canadian Centre for Occupational Health and Safety [CCOHS], 2015). As for the non-neutral postures in the legs, majority was assumed by ES and ECS teachers. This is likewise expected since knee bending, squatting, or kneeling allow them to engage and listen to young students at eye level, get their attention while eliminating the intimidating posture of standing in class, and in the process, create a warm and caring environment. It appears that ES and ECS teachers have more body movements that may help reduce sedentary behavior and improve learning, but if they would go beyond tolerance or repair levels, they might be more prone to physical exhaustion and eventually to WMSDs. Also, prolonged and frequent arm-raising posture is unhealthy for it causes static neck and shoulder contraction leading to muscle fatigue, pain, numbness, and soreness (Bullock, 2000; US Department of Labor, 2011). College and HS teachers possibly see these movements unnecessary, even disrupting at times so they minimize them considering that their students are quite grown-up, more mature, focused, responsible and mindful of their behaviors.

Since these postures and physical activities (e.g. body movements) are indispensable and inevitable components of teaching, they can be minimized in order to protect teachers. For instance, during lesson planning or syllabus-making phase, it may help to include teaching and learning strategies that break up the lecture and for students to engage more in class and incorporate class activities that minimize assumption of a single posture or reduce the time spent in each posture. Postural variation allows overwork body parts to rest and recuperate. This is feasible in teaching because it's not restrictive unlike other professions and so teachers can always change posture anytime. In addition, long duration and large classes with or without heavy board writing should have adequate rest periods in between. Depending on the purpose, a 5-10 minute break is beneficial especially for back discomfort (Van Dieen & OudeVrielink, 1998). To minimize neck twisting, teachers may face and talk to students only after board writing and to help minimize neck and trunk bending, they may use a podium, computer-generated visuals (e.g. power point) and a laser pointer. Teacher's height may be a factor too, so the use of elevated platforms inside classrooms may be considered or reviewed if they encourage non-neutral postures. To

minimize arm raising above shoulder level, teachers can maximize available multimedia resources of the university (e.g. YouTube educational videos that meet intended learning objectives or outcomes) or vary their class activities and if board writing is unavoidable, reach within the point of comfort. If discomfort or soreness persists, then medical or rehabilitative intervention is recommended and should incorporate preventive controls that include but not limited to physical conditioning, proper posture training, and symptoms detection so that rest and posture modification can be done at once. This is especially important in the sciences like Nursing where they have 3-hour classes. Unfortunately, OWAS observation was limited to the conduct of lecture, thus a thorough postural study covering all aspects of teaching is warranted to identify other aspects of tasks and subtasks that may force them to adopt non-neutral postures.

Workstation Quality

Using the guidelines designed by ergonomic experts, the result of the workstation assessment revealed several inadequacies in the present workstation that may have influenced teachers to adopt inappropriate postures. The checklist revealed that more than 50% of workstations were not designed to accommodate the varied tasks of teaching. First, more than 50% of the chairs do not have an armrest. This deficiency exposes the cervical and shoulder muscles to contract continuously causing static muscle contraction, fatigue, and pain in these regions, and even injury in the lower back (Khalil et al., 1993). Likewise, non-adjustable or improperly adjusted armrests may fail to provide adequate support to the upper limbs, and some parts of the upper back and head, and may expose teachers to awkward postures. For instance, armrests that are too low may cause teachers to adopt uneven and awkward postures when leaning over on one side. A too high armrest on the other hand may cause them to raise shoulders. Both can result in muscle tension and fatigue in the neck, shoulders and back. For low armrest, a small pillow may be placed in between the armrest and forearm to comfortably position the upper limb on the armrests with elbow at 90 degrees and shoulders relaxed. A high armrest may be removed if it prevents proper positioning of the chair to allow comfortable reading and typing distance; or restricts sit to stand and turning movements (WorkSafeBC, 2009).

Second, office chairs lacked lumbar support and appropriate material and design. A proper backrest should support the entire back including the lower region and provide a comfortable posture that permits frequent variation in a sitting position (WorkSafeBC, 2009). Majority (83.33%) of the chair had a backrest but the shape provided inadequate support to the back. Hence, teachers may not have sufficient support to their spine while seated doing deskwork or computer work leading to a continuous trunk muscle contraction to maintain it in the upright position. To address this, teachers may place a comfortable pillow between the back and backrest and a rolled-up towel or small pillow to the curve of the lower back as lumbar support and position them until they feel comfortable and relaxed without impeding upper limb and trunk movements. There is also no porous breathable, rough texture material cover to facilitate good heat dissipation and adequate circulation to the area distal to it (Khalil et al., 1993; Hermenau, 1995). This may compromise nutrient delivery to the muscles and possibly create discomfort.

Third, though the seat pan provided secured support to teachers and were mostly adequate to the body's contour, majority were not upholstered with slightly porous and rough material that helps prevent direct contact between pressure points and soft tissues, and ensures proper heat dissipation and adequate circulation in the area (Environmental & Occupational Health & Safety Services [EOHSS], 2008). More than 50% of these were not designed to distribute pressure evenly exposing them to contact stress and less than one-third was found to have well-rounded edge (waterfall design). This means that a greater percentage of teachers were exposed to an increased pressure to the underside of their thigh and leg that may compromise blood circulation to the lower legs (US Department of Labor, 2011), and possibly compress the sciatic nerve (Hermenau, 1995). A soft flat, well-upholstered cushion may be placed in between the buttocks and seat pan. Teachers may also stand and walk whenever they feel uncomfortable.

Finally, seat height should be adjustable to accommodate the desk height requirements consistent with office tasks. The seat height in this study was not adjustable and more than 50% was set either too high or moderately high relative to the knee fold. A seat that is set too high can cause teachers to lean forward to place the feet on the floor thereby depriving them of the backrest for support. This is risky since it increases static muscle work to the back muscles and makes it more difficult to maintain the S-shape

of the spine (Hermenau, 1995). In this unsupported position, mechanical stress on the lumbar spine increases by 35% that when exceeding the body's tolerance and repair capabilities, the effects manifest in the form of neck, and shoulder pain, upper and lower back discomfort, muscle fatigue, restricted circulation, and even headache (Khalil et al., 1993; Leggat & Smith, 2006). A desirable seat height in a seated workstation is when the upper extremities rest comfortably on the desk, the forearms are angled between horizontal to 20 degrees up, elbows are between 90 and 120 degrees, and the trunk within 30 degrees of upright position (Canadian Center for Occupational Safety and Health [CCOHS], 2015). This allows teachers to load their musculoskeletal system properly and position themselves comfortably and favorably in relation to the working table/desk as they sit for several hours in their offices reading or preparing examinations/quizzes or lectures, doing word processing, marking, researching in front of computers. Unfortunately, the present workstation has poorly designed chairs, which can lead instead to poor sitting habits, and place undue stress to the musculoskeletal system (Khalil et al., 1993). To help address these deficiencies, a good ergonomic chair in all academic offices is beneficial for it securely supports the weight of the body, provides comfort and is adjustable (Keyserling, 1986). It can provide varied, but appropriate body postures that ensure adequate blood circulation, reduce load on the back, and allow freedom of movement (Khalil et al., 1993; Keyserling, 1986). A study conducted by Rempel et al., in 2007 demonstrated that an adjustable height task chair with a curved seat pan can reduce neck and shoulder pain severity among sewing machine operators.

Meanwhile, in a standing workstation, the work surface (i.e. table) should be designed to keep it optimally compatible with the physical characteristics of the user and requirements of the tasks (Hermenau, 1995; Khalil et al., 1993; Ostrom, 1993). Adjustability is important because when tasks are executed in work surfaces that were designed either excessively high or low over time without adequate rest, they can create discomfort, fatigue, and stress to the neck, shoulders, and back musculoskeletal structures (Richardson, 1994; Ong & Kogi, 1992; Hermenau, 1995; Ostrom, 1993). In the present study, working tables were too low for a standing posture during lecture and sometimes were used for computers, books, and overhead projectors. This forces teachers to bend their trunk, and possibly their knees too and twist their neck every time they glance or read a line

from a book or to operate a projector or change slides. This is not only unhealthy but also disrupting to students. For a standing workstation, surface heights should be 5 cm above elbow height to keep trunk upright (CCOHS, 2015). A podium and use of a laser pointer may help. If it is too high, a platform to step on is needed to help maintain a good posture.

CONCLUSION AND RECOMMENDATION

The results showed that an overwhelming number of teachers reported pain or trouble in the last three months and the most prevalent body part affected was situated in the shoulder followed by the back and neck. Majority of the respondents perceived their symptoms to be partially and absolutely work-related suggesting their awareness of the role of work situations in WMSD development. Incidentally, the matter must have not been seriously looked into or was not considerably alarming to cause personal or institutional attention. Although the present study had inherent limitations because both exposures and outcomes were based on self-report, which may be influenced by participants' biases, certain procedures were however adopted to minimize these. All respondents were informed that their privacy was assured and reports were treated with utmost confidentiality. Nevertheless, this study was an important initial step in minimizing WMSD prevalence for it provided a picture into the kind of risk teachers are exposed to in the academe. Particularly, the job demands and the workstation deficiencies which had predisposed them to assume working postures, that if maintained over time without rest and postural change, are unhealthy to their musculoskeletal system. Under these circumstances, it is reasonable to suspect that teachers with similar working conditions are at risk of developing the disorder and may pose a serious threat to their health, economic stability, educational quality and productivity if left unattended. The results also demonstrated differences in the experience of WMSDs among teachers, where SBE teachers appeared to be more susceptible suggesting that risk factors and exposure were varied within the profession and across teaching levels. In this light, the present prevalence of symptoms and demographic profile of teachers stress the importance of having a range of strategies or opportunities at their disposal to reduce risks posed by their work and avoid injury. Therefore, all stakeholders need to be mindful when making administrative and personal decisions and initiate plans to improve

teacher's physical working conditions and help promote a safe workplace and a healthy workforce based on the following recommendations:

1) There should be ergonomics education and training programs for all stakeholders especially on WMSD risk factors, signs and symptoms. These programs should highlight the role of risk factor awareness and identification in early detection or recognition of WMSDs so that symptoms experienced can be immediately addressed either or both medically and ergonomically before they become disabling injuries. It should also include instructions on proper body mechanics, healthy working postures, and timely postural or activity change/breaks to avoid monotonous, repetitive activities. It should be long-term and integrated into the daily work tasks in and out of campus, and thus should be institutionalized;

2) There should be health and wellness programs that promote healthy lifestyle and active living through regular fitness and strength conditioning activities. A free gym membership or gym for employees may be considered in the campus. Educational flyers or posters showing simple office exercises and proper body mechanics should be posted in strategic places on campus;

3) There should be a multidisciplinary occupational health and safety unit (OHSU) that is tasked to investigate high-risk workstations or situations associated with WMSDs, and implement controls to prevent its development. For this to be successful, teachers are encouraged to report unhealthy practices or harmful workplaces and to recommend practical solutions. Absences or hospitalizations due to work or related to WMSDs should be reported too and all reports/investigations should be kept and maintained as ergonomic database for research, surveillance, and other purposes;

4) The administration should invest in modifying existing risky workstations to accommodate the varied tasks of teaching in both standing and seating by providing height-adjustable work

surface in the classroom and functional ergonomic chairs in faculty offices to allow proper body positioning and placement of computers, books, and other teaching aid/materials. It should also invest on new technologies that can aid teaching and install them in classrooms and faculty offices;

5) The administration should prioritize the needs of female teachers especially those with children by consulting them during teaching load preparation and assignment. This will allow them to have control over their tasks as they balance teaching activities and parenting responsibilities over each working day. Meanwhile, to minimize mental and physical exhaustion, the use of break times in order to regain vigor or unload stressed structures must be ensured by institutionalizing breaks and stretching or short exercise as a class activity; and

6) Since this study cannot provide information in predicting injuries, longitudinal and cohort study should be done in future researches. Studies exploring the statistical interaction and precise relationship between other factors like psychosocial demands and other aspects of the physical, socio- demographic, organizational environment, and WMSD occurrence have to be done as well.

ACKNOWLEDGEMENT

The authors are grateful to the faculty of Silliman University who participated in the study, SU staff, to the research mentoring of Dr. Enrique G. Oracion, and to the financial support from Silliman University through the Faculty Development Grant for Research managed by the Research and Development Center. We are thankful to our parents, families, friends, to Dr. Lynn Larena-Olegario for the support and encouragement, and to Dr. Teresa L. Manabat for sharing her expertise.

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Impact of the 2011 Typhoon “Sendong” (Washi) on the Coral Reef of Apo Island Marine Reserve, Dauin, Negros Oriental, Philippines

Kathryn Rosell-Jadloc

*Biology Department, Silliman University,
Dumaguete City, Philippines*

Clarissa Reboton

*Silliman University – Institute of Environmental and Marine
Sciences (IEMS), Bantayan, Dumaguete City*

Claro Renato Jadloc

*Silliman University – Angelo King Center for Research and
Environmental Management (SUAKCREM), Bantayan,
Dumaguete City*

Oliver Paderanga

*Silliman University – Institute of Environmental and Marine
Sciences (IEMS), Bantayan, Dumaguete City*

On December 16, 2011, a severe Tropical Storm ‘Sendong’ (International name: Washi) hit Negros Oriental. The typhoon caused strong wave surges in Apo Island and the coastline of Negros. The typhoon damaged the eastern section of the island where the marine reserve is located. Survey of the protected area showed live hard coral to be $0.53 \pm 0.68\%$.

INTRODUCTION

On December 16, 2011 super typhoon “Sendong” (International name: ‘Washi’) hit Negros Oriental resulting in great damage to life and properties. The typhoon also hit the eastern section of Apo Island where the 22-ha marine reserve is situated.

The marine reserve was established in 1984 and in 1994, the whole island was declared a protected landscape and seascape by Pres. Proc. No. 438

pursuant to R.A. 7586 (NIPAS act of 1992).

METHOD

The benthic data used in this paper was obtained from a one-year survey on coral diseases inside Apo Is. Reserve (Rosell-Jadloc et al 2012). The initial data gathered in February 2011, 10 months before the typhoon, was used to compare with the survey conducted two months after the typhoon on February 2012.

To assess the benthic cover of the reef, the line intercept transect method modified from English et al (1997) was used. Three permanent 20-m belt transects at 10-m intervals were established 3-5m deep, parallel to the shoreline. Within each transect, data on benthic life-forms (Table 1) were collected.

A 2 x 20 m belt transect was also set along each transect wherein coral colonies were counted. Colonies were identified to the genus level following Veron (2000).

Table 1. Benthic life-form codes (modified from English et al 1997).

Life Form Category	Description	Life Form Category	Description
AA	Algae	SC	Soft Coral
DCA	Dead coral with algae	RCK	Rock
LHC	Live Hard Coral	RU	Rubble
S	Sand	OT	Other organisms

RESULTS

Benthic life-form composition

Before the super typhoon, live hard coral (LHC) cover within the reserve was 21% ± 3.83%. Rubble (R) and dead coral with algae (DCA) both covered 17% ± 9%, while rock (RCK), soft coral (SC) and sand (S) contributed 14.17% ± 11.02%, 13.95% ± 9.94, and 13.22% ± 9.81% , respectively.

After Sendong live hard coral dropped to 0.53% ± 0.68% while rubble and rock increased greatly (34.15% ± 9.66% and 35.80% ± 8.01% respectively), double its pre-typhoon level (Figures 1-2).

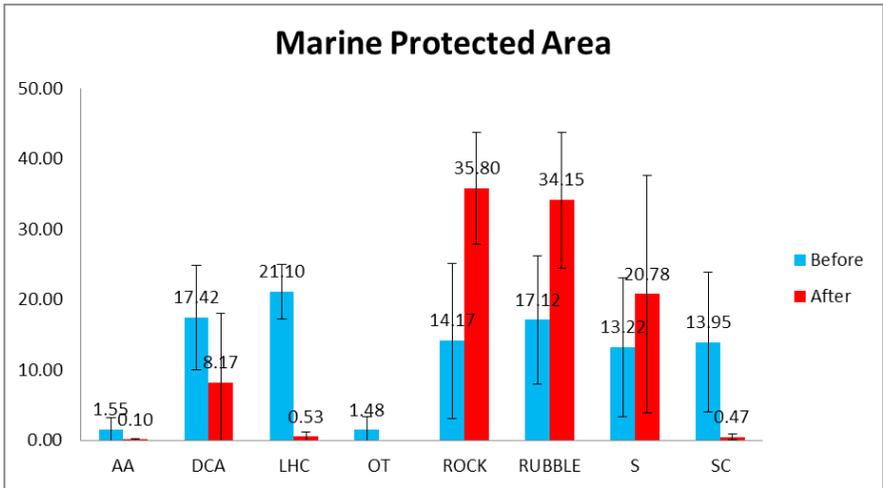


Figure 1. Benthic life-form composition of Apo Island reserve Before and After Typhoon “Sendong”. (Legend: AA - algae; DCA - dead coral with algae; LHC - live hard coral; OT - others; ROCK - rock; RUBBLE - broken dead corals; S - sand; SC - soft coral)



Figure 2. Apo Island Reserve. A: before the typhoon; B: 2 months after the typhoon. (Photo: A/K.Rosell-Jadloc; B/C.Reboton)

Colony Count

The typhoon also changed the composition of corals in the sanctuary. Prior to the typhoon, branching *Porites* and massive *Galaxea* colonies were abundant (Figure 3A).

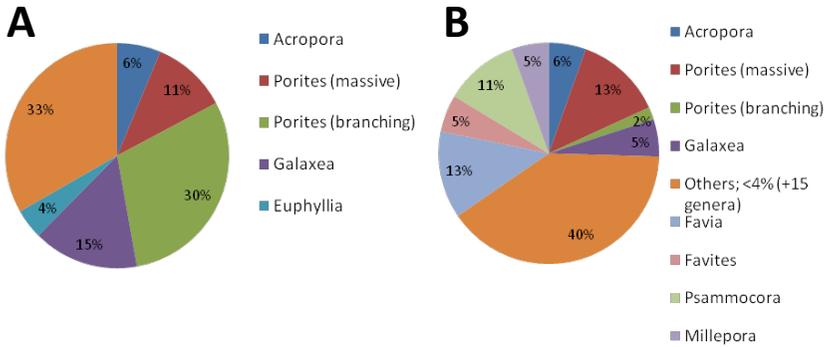


Figure 3. Coral colony composition. A: before the typhoon; B: 2 months after the typhoon

After Sendong, branching *Porites* colonies that accounted for 30% of the live hard coral composition were reduced to only 2%. Robust colonies with massive growth forms now dominate the coral population (e.g. *Favia*, *Porites*, *Psammocora*) (Figure 3B). These colonies are known to withstand strong waves. However, most of them were also uprooted or damaged by scouring. What remained were only live patches of these damaged colonies. “Weedy” species that have fast growth rates (e.g. *Acropora*, *Millepora*) were found to re-establish rapidly.

DISCUSSION

Super typhoons create large-scale damage not only on land but also on shallow-water marine ecosystems, such as coral reefs. Typhoon “Sendong” resulted in a drastic change in the benthic and species composition in the marine reserve of Apo Island. Live hard coral colonies were destroyed, and abiotic components such as sand and rubble has become the dominant substrate types. Colonies that were previously dominant, such as massive *Galaxea* and branching *Porites*, were destroyed and their numbers greatly diminished. Different groups of coral species, those that are fast growing and those with robust and massive growth forms, now characterize the reef. A review by Harmelin-Vivien (1994) on the destructive nature of typhoons showed that recovery of damaged areas can vary in space and time and that typhoons have long-lasting consequences on reef structure and function. Typhoons can also result in changes in coral species composition (Foster et al 2011).

On December 2012, a year later, the reserve was hit by another typhoon (“Pablo”). Although typhoons are short-term disturbances, frequent occurrences can hamper the recovery and establishment of corals. A monitoring protocol in Apo, one of the most studied and successful community-based marine reserve in the country, has been ongoing to gain insight and evaluate reef recovery and resilience in a changing climate.

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A Note on a Small Collection of Leptocephali from the Bohol Sea, central Philippines

Adonis Floren

*Silliman University- Institute for Environmental
Management and Marine Sciences, Dumaguete City;*

Abner Bucol

*Silliman University-Angelo King Center for Research and
Environmental Management, Dumaguete City*

Geraldine Quiñones

*College of Arts and Sciences, Foundation University,
Dumaguete City*

This paper describes the leptocephali collected by cruises made in the Bohol Seain 2009.Specimens are presently housed at the Fish Larvae Collection in the A.C. Alcala Environment and Marine Science Laboratories (ACA-MSL) in Silliman University under the care of the first author. A brief account on each taxon is provided.

Keywords: ichthyoplankton, leptocephalic larvae, Bohol Sea

INTRODUCTION

Historically, there has long been a peculiar lack of interest in larvae by Ichthyologists (Smith 1989, 2005). In fact, fish larvae are generally missing in museum collections primarily because traditional fish systematists viewed larvae as undeveloped, imperfect entities that lack the morphological features that characterize their species (Smith 2005).

Attempts have been made in the past in order to address this problem. For example, Moser et al. (1984) published *Ontogeny and Systematics of Fishes*, encouraging ichthyologists to use early-life-history (ELH) stages in

working out the systematic relationships of fishes. However, as Smith (2005) emphasized, the goal was not able to get off the ground.

This paper presents the preliminary results of the identification, description and characteristics of leptocephali collected from the Bohol Sea (with emphasis in the Dipolog Strait) and in the shallow coastal waters in Negros Oriental, Bohol and Siquijor. It is hoped that this work may be continued in the near future and that additional leptocephali may be revealed, examined, and properly catalogued at Silliman University's A.C. Alcala Environment and Marine Science Laboratories (ACA-MSL).

METHODS & MATERIALS

Sampling of leptocephali

Our samples of leptocephali were collected from the Bohol Sea (with emphasis in the Dipolog Strait; Fig. 1) and were sampled using modified Bongo plankton net. Depth ranged from ca. 100 to 150m. Samples were immediately preserved in 10% formalin and later deposited in the Fish Larvae Collection at the A.C. Alcala Environment and Marine Science Laboratories (ACAMSL-FLC).

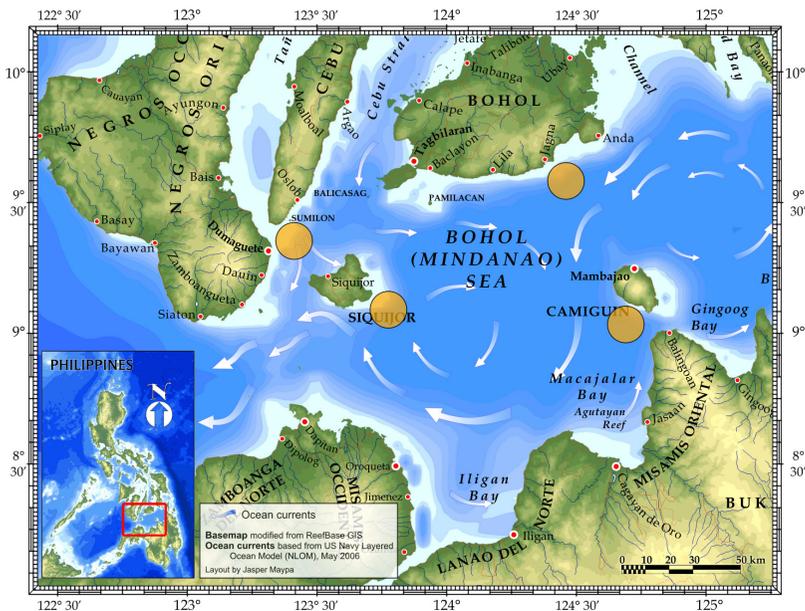


Figure 1. Map of the Bohol Sea in the central Philippines showing the collecting sites.

Larval rearing

Rearing of leptocephali were thus far limited to elopiform larvae collected from the shallow coastal waters off Bohol, Siquijor, and Negros islands using push net with the mouth size of 1.6m and the mesh size of 1mm. Sampling started at sunrise and completed in mid-morning. After the collection, the larvae were maintained in the laboratory until adult morphological characters were observed. Attempts have been made earlier to collect larvae in the open ocean using Bongo net but mortality was very high. A refinement of this method in the coming field surveys is necessary in order to collect larvae even in the open seas.

The other types of leptocephali were immediately preserved while onboard a chartered fishing vessel. Those of *Elops* and *Megalops* were maintained in separate aquaria and fed twice a day with rotifers (*Brachionus plicatis*) and brine shrimps (*Artemiasalinae*) at concentrations of about 2000 and 120 individuals per liter of water, respectively. Polyunsaturated fatty acids (PUFA) from shark or cod liver oil (capsule form) at concentrations of 0.5-1.0 ml per liter of seawater was also given as enrichment. *Nanochloropsis* sp., *Tetraselmis* sp and *Isochrysis* sp. were cultured in the laboratory as food for the rotifers and brine shrimps.

Rotifers were fed with boiled egg yolk at concentrations of approximately 100 grams/liter of seawater prior to feeding them to the larvae. This was done to fortify the nutritional value of rotifers.

Identification of leptocephali

We identified leptocephali samples up to the lowest taxon possible based on Miller and Tsukamoto (2004) and Smith (1979).

RESULTS AND DISCUSSION

The present leptocephali collection comprised of seven families, comparably lower than what is known in the Indo-Pacific (see Miller & Tsukamoto, 2004). Details on these samples are presented in the accounts below.

Taxonomic Accounts

Order Elopiformes

Family Elopidae (Ladyfishes, Tenpounders)

Elops machnata Forsskål, 1775

Description: Larvae leptocephalic, becoming less compressed with age; dorsal in advance of anal; in metamorphic specimens HL 10.9% in BL; SnL 3.2% in BL; ED 14.7% in HL; BD 6.4% in BL; myomere counts about 63; head small about 10% of the body length; caudal fin forked with fin ray count 24-33; dorsal and anal fin rays 21-25 and 10-14, respectively.

Remarks: *Elops* differ from *Megalops* in having a relatively long dorsal fin positioned just in front of, but not overlapping much with the anal fin. It has depressed head and more dorsal rays than anal rays (Smith, 1979; Miller and Tsukamoto, 2004). The bodies of metamorphosed individuals are elongate with relatively small head and eyes. The tail is forked and melanophores can be seen along the ventral side of the body after 6 days of rearing. The fin is more advanced in development from the anal fin. Fin rays on caudal fin number 24-33. Dorsal fin rays count is 21-25 and anal fin rays count is 10-14. In about 2 weeks of rearing the body became elongate with moderate head and small eyes. Yellow color appeared on the transparent body after 3 weeks.

It should be noted that the taxonomy of *Elops* is still poorly known and authors differ in the number of species (McBride et al. 2010). In the Indo-Pacific, Smith (1999) provisionally recognized a single species *E. hawaiiensis* Regan, 1909 which may consist of several species while others recognized two species, *E. hawaiiensis* and *E. machnata* (Miller and Tsukamoto 2004; McBride et al. 2010).

McBride et al. (2010) noted that *E. machnata* has lower vertebrae counts ranging from 63-64 compared to *E. hawaiiensis* (68-70). Counts in our samples showed 63 myomeres, which corresponds to its vertebral numbers, suggesting that the specimens examined in this study are *E. machnata* (see also Sato & Yasuda, 1980).



Figure 2. *Elopidae (Elops machnata)*

A. Leptocephalus of *Elops machnata*; BL 32.5mm, BD 3.7mm, HL 2.7mm, ED 1.8 mm, SnL 0.7mm, PDL 24.8mm, PAL 22.1mm. Not flattened head and the dorsal fin positioned just in front of but not overlapping much with the anal fin (see also Smith, 1979; Miller & Tsukamoto, 2004).

B. Late-metamorphic *Elops machnata*. BL: 29mm, BD: 2mm, HL: 5.5mm, ED: 1.2mm, C: 21, D: 23, A: 12.

C. Juvenile *Elops machnata*. BL: 20mm, BD: 4.0 mm, HL: 5.5 mm, ED: 1.8 mm. C: 28, D: 16, A: 27

Family Megalopidae (Oxeye, Tarpons)

Megalops cyprinoides (Broussonet, 1782)

Description: Larvae leptocephalic like Elopidae; HL 6% in BL; ED 36% in HL; BD 24% in BL; dorsal and anal fins overlapped distinguishing them from Elopidae; dorsal rays (9-16) lower than anal rays (16-25).

Remarks: The leptocephali of *Megalops* differ from *Elops* in having the origin of anal fin under middle of dorsal fin, not depressed head and fewer dorsal rays than anal rays (Smith, 1979; Miller and Tsukamoto, 2004). The body of *Megalops* is elongate with small head and eyes. No yellow coloration is apparent on the body after 3 weeks. Tail is forked and melanophores are found on the ventral side of the body. The mouth is protruding. Feeding and swimming behaviour is similar to *Elops*.

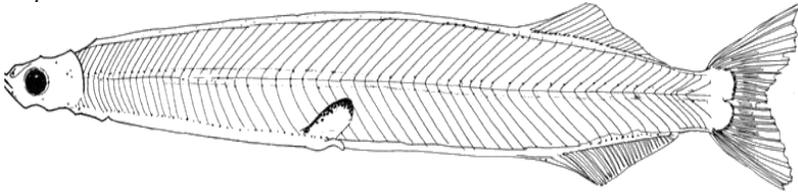


Figure 3. Leptocephalus of *Megalops cyprinoides*. Measurements in mm: BL 32.9 BD 2.95 HL 2.2 ED 0.6 SnL 1.2 PDL 22.4 PAL 31.9. Samples collected from Negros Oriental, Camiguin, Bohol and Siquijor. Note the overlapping dorsal and anal fins.

Order Anguilliformes (Eels and their allies)

Family Congridae (Conger Eels)

Specimens: ACAMSL-FLC 02706, 1917, 01424, 01268, 4828, 02603, 2012, 03195

Remarks: Smith (1979) described congrid leptocephalus as having moderate to elongate body, variable tail, simple gut, ventral pigments present. Identification to species difficult and can be done by elimination approach due to variability of characters. Larvae of subfamily Congrinae (including the widespread genus *Conger*, which our specimen probably belongs) usually lack lateral pigment.



Figure 4. Head region of a conger (Congridae) leptocephalus.

Family Muraenesocidae

Specimens: ACAMSL-FLC 002400

Remarks: Samples were collected in the Dipolog Strait.

Family Muraenidae (Moray Eels)

Specimens: ACAMSL-FLC 1745

Remarks: Our samples of muraenid leptocephali were obtained by one of us (A. Floren) from the vicinity of Spratlys Islands in the South China Sea during the Philippines-Vietnam JOMSRE Expeditions in 2005 and 2007 (Floren, 2008). Armada (1997) reported several samples in the Sibuyan Sea (part of Visayan Sea) and Sulu Sea areas.

This family can be readily distinguished by their deeper bodies with dorsal fin origin originating either before the vent (Subfamily Muraeninae) or near the tip of the tail (Subfamily Uropterygiinae).



Figure 5. Head region of an unidentified muraenid leptocephalus.

Family Chlopsidae (False Morays)

Specimens: ACAMSL-FLC: DSC03218

Remarks: Distinguished by their deep bodies, pointed tails, short gut (>50% of body length) and pigments in gut and in lateral line (Miller & Tsukamoto, 2004).

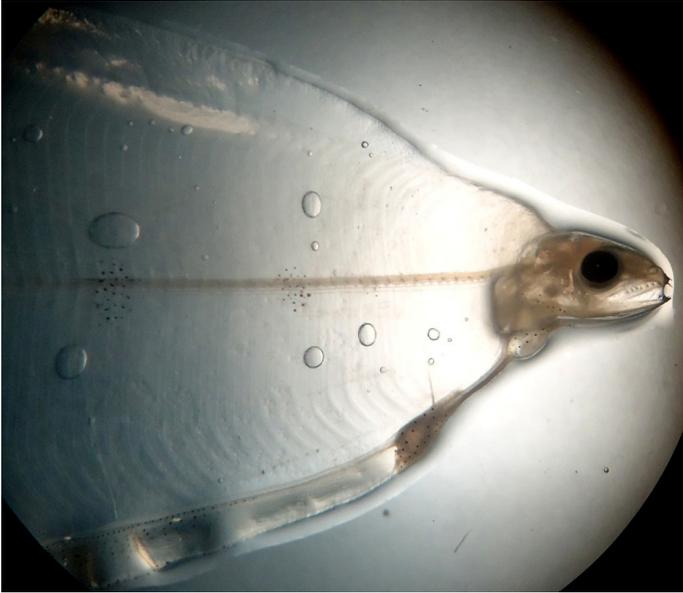


Figure 6. Head region of a chlopsid leptocephalus.

Family Nemichthyidae

Specimens: ACAMSL-FLC 00660

Remarks: Body long and slender, with pigment on top of notochord, pointed tails with small pigments on top of gut (Miller & Tsukamoto, 2004).



Figure 7. Head region of a nemichtyid leptocephalus,
probably *Avocettina* species.

CONCLUSION AND RECOMMENDATIONS

The taxonomic information presented herein represents only a fraction of the work needed to fully assess the taxonomic status of leptocephalic larvae in the Bohol Sea and its adjoining waters. We recommend that a follow-up but a more thorough study be conducted to document other leptocephalic larvae in the Bohol Sea.

ACKNOWLEDGEMENTS

We acknowledge the Commission on Higher Education (CHED) for funding the research on ichthyoplankton assemblages in Dipolog Strait. Dr. David G. Smith of USNM and Dr. Michael J. Miller of the Ocean Research Institute are also thanked for providing relevant references used in this study.

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Returning Home through Imago: A Review of Joseph Legaspi's Imago, a Collection of Poems

Lady Flor Partosa

In *Imago*, Joseph Legaspi's poetry collection takes the readers to a landscape of the memory that appears startlingly vibrant, evoking the past with tenderness that even those events of death, pain, and violence become lovingly remembered. In this poetry, the family—mother, father, brother, and sisters—are portrayed with an intensity that brings them to life: they are at times sensual, brutal, and gentle. The poet's growing awareness of his sexuality, too, which can appear confusing and jarring, is rendered with straightforward innocence.

The poetry collection is first published by Cavan Kerry Press in 2007 and much recently by the University of Santo Tomas Publishing House in 2015. As the book makes its way to the Philippines, perhaps it is timely to ask these questions: Why does the persona remember his childhood past in the Philippines? What value does such recollection hold for the persona and the reader?

"Poem for My Navel," the poem that follows "Imago," is the first entry in Part I of the book, which aptly commences the journey of inward thought and introspection. Although traditionally navel-gazing is associated with meditation, recently the term has gained notoriety to describe writing that is self-indulgent and narcissistic. But in Legaspi's poem, the navel becomes so much more: a symbol for "attachment" and "detachment" to his home. For

the persona, the “navel” is a “hollowed reminder” and then “my oyster pearl purse” which he describes as follows:

you burn along
an equator, my homeland,
my Philippines I
never conceived
of leaving, mother, dear
sustenance, my senses
in the obsidian darkness,
cross-wires of my existence
and non-existence.”

The juxtaposition of “existence” and “non-existence” indicates the ambivalence the persona feels as he gazes at his navel, which reveals the ambiguous frames of identity of the dispersed, those who are uprooted from their homelands. In describing the Filipino diaspora, San Juan, Jr. (2000) explains that since the Filipino nation is not entirely autonomous, diasporic subjects do not think of a nation to return to; rather, the home is associated with local towns, villages, and childhood memories. For poems particularly in sections I, II, and III of the book, the persona surrenders to the village of his childhood and describes it with extraordinary clarity—the family life with the mother and father, the ritual of circumcision, the killing of goats and chickens, the mating of pigs, fights between siblings, games with other children— not as much as to escape from the present but to grapple with the metamorphosis that has taken place.

In “Two Elegies,” the scenes of his grandfather’s funeral as a “lush three day affair” and the slaughtering of the goat (“the *bolo* knife plunged smoothly, penetrating/the fur caressing the skin and throat into bloodletting”) are interspersed with a more current meditation of death: “I traveled here among the acacia trees to mourn the deaths:/...the hushed deaths of my misbegotten grandfathers,/and with them, charred pieces of my mother, dead,/petrified pieces of my father, adrift.” Such is the case of “Blood Thirst,” with the persona describing the violent and aggressiveness that mark the intimacy of brothers: “Throughout the years, my brother and I/participated in the bloodletting...Fought other boys cheating us at cards./Fell down roofs and flights of stairs, hurling our bodies/to their toughening.” However, the

last stanza brings the readers to the “now” and how time has altered the two brothers: the persona in New York who writes poetry and the other who “tips cows/with his fraternity brothers in San Jose.”

Indeed, the family figures prominently in the persona’s metamorphosis specifically in his own understanding of pain, sacrifice, and sexuality as a boy who is entering adolescence. For instance, the persona’s initiation rite of circumcision becomes a collective affair for the whole family. “Imago” starts with a seemingly ironic line (“As soon as we became men/my brother and I wore skirts) and then later contemplates on the role of women in the young boys’ lives as they become men: “I then thought of the others at the verge of their manhood:/...boys wearing the skirts of their sisters/and grandmothers, touched/by the hands of their mothers/baptized by green waters,/and how by week’s end/we will shed our billowy skirts,/like monarchs, and enter/the garden of our lives.” In the “Eye of the Wound” the persona recalls the saving mercy of his sister and mother who treated his wound, and in spite of the pain remarks: “...I will be healed and saved by women, again and again,/ but despite this,/the body will seek its lost passion, evade the sex that seared its flesh,/the body never forgets.” In “Killing a Chicken,” the very act of killing the white hen becomes a metaphor for a mother’s sacrifice: “The razor smiled smoothly,/with sincere grace./The hen quivered, but it was not her life/I was thinking of, but my mother’s:/the life she had given up for her children,/the many deaths she had performed, the hearts/and gizzards she had eaten...” The father, on the other hand, is a paragon of beauty and masculinity that towers over the persona. “You were more handsome than I,” he observes in the “Scheme of Beauty” while comparing himself with his father as they stood side by side the mirror. In the poem “The Circumcision, he remarks: “I want my penis to be/like my father’s, the union of beauty and purpose”.

“Departure: July 30, 1984” aptly begins the last part of the book, with the complete date signifying a landmark of the great change in their lives—the family starting a new life overseas. Now relocated to America, the once mermaid-like mother and the virile, handsome father have become fast-food and hospital workers in the new country in “The Red Sweater” and “My Father in the Night.” However, in the poem “This Face,” the child that once looked into the mirror and ate pomade in the poem “Scheme of Beauty” has grown up and recognized the Asian ancestry in the reflection: “it is my father’s face.” Despite the strangeness and foreignness associated with his Asian identity in America with stereotypes as “sterile,” “almost female,” “the

gook, nips, and flips,” he asserts his heritage as he looks at his reflection: “it is the face of someone/who is the source of my conceit, my Asian-nes,/my maleness. It is my father’s and I love it.”

Indeed, the persona not only makes this connection to his heritage consciously, but his search for a link towards his past follows him in his subconscious. In “California Beaches,” a peculiar case of two dead infants found on the seaside leads the persona to a recurrent dream of carrying a stillborn child in his arms and singing to it a lullaby. Through the dream, the past comes back to haunt him through the memory of his twin cousins who were born dead: “They were so tiny they fit in a pickled egg jar/and were buried under our house/in a country surrounded by water, which I left years ago./They have come searching for me.”

The persona carries another child in “The Little Blackbird” but this time it his niece he holds in his arms. And through the baby, the persona renews the connection to his memories: “but the sweetness of the first words/and raven sounds which roll from your tongue/has made me remember what I left behind.” And, from here, recalls:

somewhere in a timeless place
 a boy rides a horse through rice puddles
 a boy feeds on the ivory meat of coconuts
 a boy suckles on the udders of a carabao
 and under a tropical twilight dome fireflies scatter like stars
 onto a field where that same boy falls into a deep, silent slumber.
 Now , you sleep, little blackbird.
 I will chase away the cat, the destroyer
 of the moth of dreams,
 and when you awaken
 you will again restore my sight to the threads that bind.

Noting how the poet has synthesized both Philippine and American experiences, Philip Levine in the foreword claimed that the poetry collection belongs to the “multicolored kaleidoscope we call American literature.” However, he acknowledged that some readers may describe the poems as “exotic”; although if it were so, he continues, then most of the recent poems in America are “exotic.” When one describes the works as exotic (strange, mysterious, etc.) as if it is only what the work will ever be, then such

categories imprison a myriad of experiences by pushing it to the periphery. Such dichotomy and mythologizing of the 'Other', reveals the undercurrent of Orientalism—a “Western style for dominating, restructuring, and having authority over the Orient” (Said, 2001/1978). This system of thought plants the seeds of imperialism—the dichotomy of East and West—further continuing to subjugate the East by casting it as mystifying and enchanting with no other insights to offer. In the introduction to the book *Diaspora, Memory, and Identity*, a collection of essays from different disciplines that explore diasporic experiences in Canada, Agnew (2005) cited Shirley Geok Lim (as quoted by Kain) who wrote about the ambiguity experienced by the contemporary immigrant writer: ‘This knowledge of my other origin allows you to deny me entry into your society on your own terms, brands me as an exotic, freezes me into a geographical entity.’ However such recognition of the writer’s identity is important as well: ‘Should you proceed to treat me as if I were not different... , I would also accuse you of provincialism, of inability to distinguish between cultures.’ Acknowledging the history and identity of the writer is necessary; such identification, however, should not be the reason to push the writers and their work into the margins by exoticizing them and rendering them static, as if they are beautiful, charming trinkets on display.

In *Imago*, for instance, the memories of the persona’s childhood, his village, and his family are not idealized to become static images that represent a whole nor are they sentimentalized to become alluring and captivating. But he recalls them out of necessity as if life depended on it. We have a voice changed and enriched by the past through which he returns home: the journey to the bakery with his brother at the break of dawn in “The Bringers of Bread,” the kites at “war in the sky” in “Kite Season,” sisters tangled in flowery blanket on the next bed in “Sleeping Together,” the faith-healer with a green bandanna in a “nipa-hut temple” in “Faith Healer,” the box of insects from a playmate in “Shoebox”; and even those events of terror and fright: the fear of the vengeful bat in “Bat Hunting,” the huddling children in a shaking house during a storm in “Typhoon”, and the squealing pig being mated to a boar in “The Sow.”

Indeed, most scholars have explored the idea of home among diasporic identities. Agnew (2005) speaks of the same recurrent inquiries about home in the essays compiled in the book *Diaspora, Memory, and Identity*. Although home is a physical space, it is also as much a realm in the imagination, a

longing to a point of origin or a place of belongingness. In this context, she mentioned Kain (as cited by Agnew, 2005) who argued that the “diasporic individual lives in a home, but is torn by the need to make it authentic and real.” In *Imago*, memories in themselves have become a lifeline to home. In the “Little Black Bird,” for instance, the persona finds concreteness through the baby in his arms and through her makes home more real through the memories he brings back to life.

Truly we have a voice that is kaleidoscopic: one that is brightly colored not out of style but simply because that it is the only way to speak. Diasporic identities which lie in the “beyond” have challenged people to look at otherwise static and homogenous concepts such as national identity with a more critical eye (Bhabha, 1994). What does this mean for readers in the homeland where the poet wishes to belong? A work can be both part of American literature and tread Philippine terrain, allowing readers to inhabit in this imagined homeland. Borders can be dismantled so we (readers in the Philippines) can see our own villages as remembered by those who have now situated in a different country. Through these poems by Joseph Legaspi, readers such as myself who are from the archipelago across the ocean—the landscape the poet has left and returns to in his poetry—can recognize a place so familiar that I can say we certainly share the same home. Reading most of the poems in *Imago*, I remember the stories my parents told me about growing up in villages in the countryside. The poems are surprisingly closer to me and more intimate than I could imagine. Through *Imago*—both winged, metamorphosed creature and ideal mental image—the poet has found his way home.

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