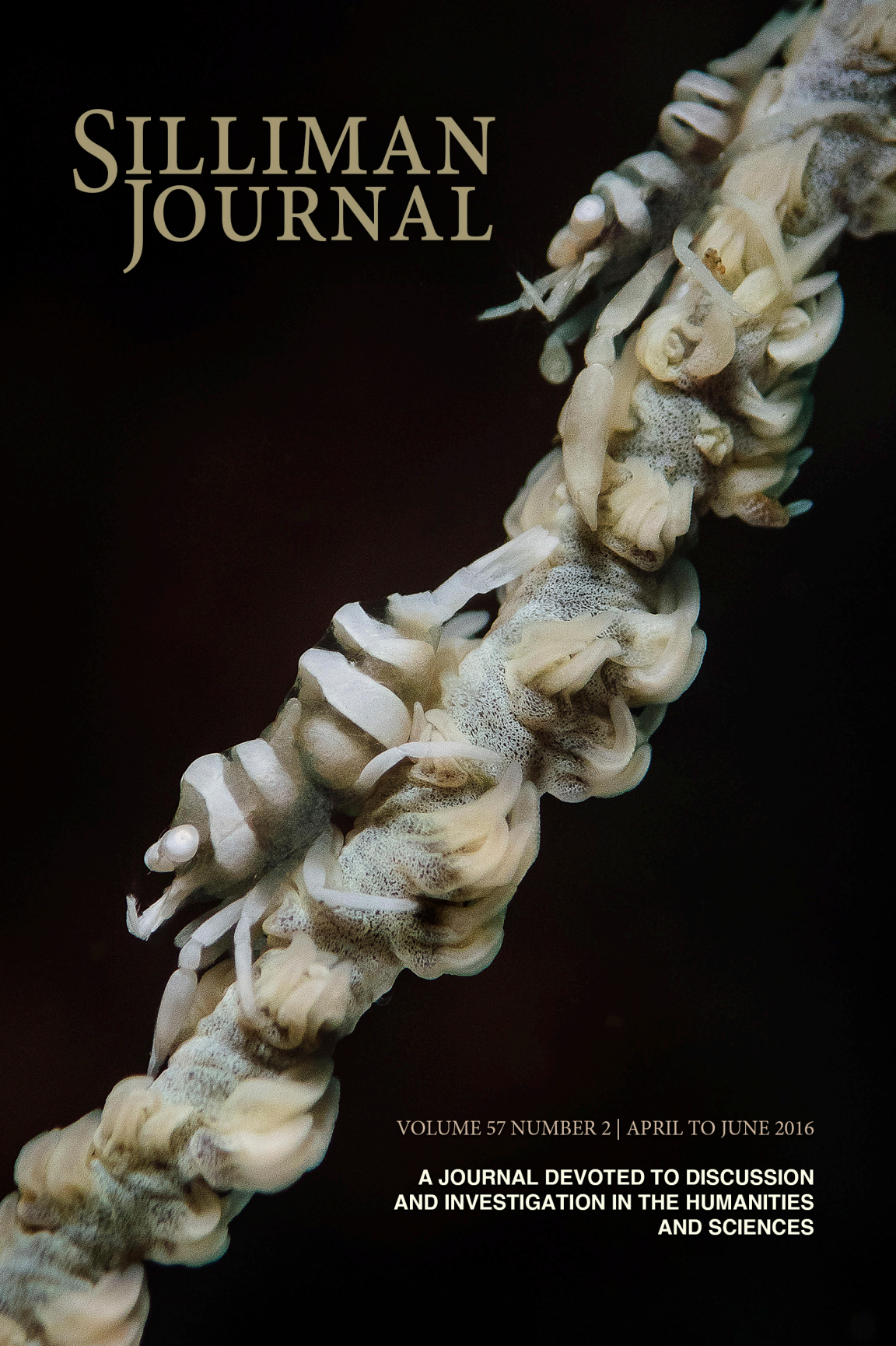
Silliman Journal



VOLUME 57 NUMBER 2 | APRIL TO JUNE 2016

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

SILLIMAN JOURNAL

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

VOLUME 57 NUMBER 2 | APRIL TO JUNE 2016

IN THIS ISSUE

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.

ISSN 0037-5284

Annual subscription rates are at PhP600 for local subscribers, and $35 for overseas subscribers. Subscription and orders for current and back issues should be addressed to

The Business Manager
Silliman Journal
Silliman University Main Library
6200 Dumaguete City, Negros Oriental
Philippines

Issues are also available in microfilm format from

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

Other inquiries regarding editorial policies and contributions may be addressed to the Silliman Journal Business Manager or the Editor at the following email address: sillimanjournal@su.edu.ph.

Or go to the Silliman Journal website at www.su.edu.ph/sillimanjournal

Book design by Rigel dela Cruz Suarez
Layout by Elaine Pastor
Cover Photo *"Zanzibar Shrimp | Dasycaris Zanzibarica"* by Luigi Borromeo
Printing by SU Printing Press, Dumaguete City

SILLIMAN JOURNAL

VOLUME 57 NUMBER 2
APRIL TO JUNE 2016

Silliman Journal

Board of Reviewers

Contents

REVIEW SECTION

Publication Guidelines

Silliman JournaL welcomes submission of scholarly papers, research studies, brief reports in all fields from both Philippine and foreign scholars, but papers must have some relevance to the Philippines, Asia, or the Pacific. All submissions are refereed.

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.

Silliman Journal does not accept papers which are currently under consideration by other journals or which have been previously published elsewhere. The submission of an article implies that, if accepted, the author agrees that the paper can be published exclusively by the journal concerned.

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.

Manuscripts should be submitted electronically in one Microsoft Word file (including title page, figures, tables, etc. in the file), preferably in RTF (.rtf). Figures and photos must also be attached to the email in .jpeg. Please send one copy of the manuscript as an e-mail attachment, with a covering message addressed to the Editor: sillimanjournal@su.edu.ph

The Editor will endeavor to acknowledge all submissions, consider them promptly, and notify the authors as soon as these have been refereed. Each author is entitled to one complimentary copy of the journal. Additional copies are available by arrangement with the Editor or Business Manager before the issue goes to press.

Other inquiries regarding editorial policies and contributions may be addressed to the Business Manager at nenithpcalibo@yahoo.com, or the Editor at sillimanjournal@su.edu.ph.

SILLIMAN JOURNAL


GILLMAN

"The whole of science is nothing more than a refinement of everyday thinking."
– **Einstein**
(*Out of My Later Years*, 1950)

"It is a curious situation that the sea, from which life first arose, should now be threatened by the activities of one form of that life. But the sea, though changed in a sinister way, will continue to exist; the threat is rather to life itself."
– **Rachel Carson**
(Preface to revised edition of *The Sea Around Us,* 1950)

Editorial Notes

Welcome to the second issue of 2016. You will find on these pages that the research has primarily been in the natural sciences and a theme of marine conservation in a time of changing climate.

The first study is from Silliman University's Institute of Environmental and Marine Sciences where researchers Jean Utzurrum, Clarissa Reboton, and IEMS Director Nida Calumpong investigate fish standing stock and catch from coral reefs in three regions of the Philippines: Region V (Ticao Island, Masbate), VII (Negros Oriental), and XI (Davao Oriental). The authors found strong positive relationships between fish density and biomass with LHC cover but not with reef rugosity, suggesting, however, that these results are still largely preliminary and long-term temporal monitoring of the sites may reveal otherwise. Still, they state, "coral reefs remain to be a significant resource for municipal fisheries and should be monitored vigilantly to ensure food security for future Filipino generations. Sustainable fish stocks are not only reliant on well-regulated fisheries but more so on the effective protection of coral reefs which fishes inhabit."

Second, our colleagues from Nueva Ecija, Philippines look into "Plant Diversity in the Forest Ecosystem of Bataan Natural Park." Annie Paz-Alberto and others wanted to determine the exploitation and

conservation status of the forest ecosystem in Bataan, Philippines and found that the threats in the forest ecosystem included timber poaching, kaingin practices, soil erosion, charcoal making, and wildlife hunting.

Similarly, Bing Brillo and Rhina Bonocan of the University of the Philippines-Los Baños studied ecotourism-based administration and development of Pandin Lake in San Pablo City, Laguna, on the premise that ecotourism benefits the lake in the provision of livelihood to residents and in ensuring the conservation of natural resources and that ecotourism in Pandin Lake, in particular, evolved completely due to a local community initiative. The authors argued, however, for the necessity of government support and commitment as well as research focused on development-governance of small lakes in a field dominated by natural science-based studies (such as in limnology and aquaculture)and overwhelmingly concentrated on big lakes.

The next three articles are by Silliman University biologist-researchers. In particular, Persie Sienes and Nida Calumpong looked into in situ temperature of shallow reef communities in Negros and Apo Island on the rationale that coral reefs provide a wide variety of ecosystem services and goods that benefit humankind, but the survival and health of reefs are threatened by natural and anthropogenic factors such as climate change and pollution. Results for Apo showed temperature peaks in the months of May, June, and July. For Sibulan site, peaks were observed in May, June, and September. Lowest temperature for both sites was observed in February. Between sites, variation may be explained by differences in coastal profiles, depths of reefs and influences of different water current systems. Variation from satellite-derived data may be due to depth differences since the latter are taken only from the surface. The authors recommend continuous in situtemperature monitoring as it provides a more localized profile especially in this period of climate change.

This article is followed by "The Potential of *Psidiumguajava*in Lowering Blood Glucose Levels of Diet-induced Hyperglycemic Female White Sprague Dawley Rats" by Carlo B. Limbaga and Socorro Z. Parco. Given that *Diabetes mellitus* is a chronic metabolic disease that affects a lot of people worldwide, the researchers evaluated aqueous leaf extracts from different varieties of *Psidiumguajava*for their potential in lowering elevated total blood glucose levels (hyperglycemia) by using diet-induced female Sprague Dawley rats finding that Pink Guava (Young Leaves) was found to

be the most effective in treating hyperglycemia in the rats compared with the Hyperglycemic control. There was no significant difference compared with the synthetic drug, Metformin, suggesting that *P. guajava*aqueous extracts are as effective as the established drug for *Diabetes mellitus* in the market.

Sixth, biology department chair Robert Guino-o and colleagues conducted a study entitled "Lowering the Total Coliform of Vermicompost from Solid Waste Materials Produced by African Night Crawler Worm *EudrilusEugeniae*". Highlighting the importance of vermicomposting as an established ecological sanitation program in order to produce low-cost organic fertilizers as an alternative to expensive commercial fertilizers, the authors also said that vermicomposts from biodegradable and human sludge contain high total coliform levels above the limit set by WHO. Hence, their study developed coliform-reducing strategies such as agricultural and hydrated lime, showing that aeration and exposure to the environment did not reduce coliform levels in vermicompost produced by the African Night Crawler earthworm *Eudriluseugeniae* and that post hoc analysis indicated higher total coliform levels in vermicompost applied with lower lime concentration. Their study recommends the use of agricultural lime over hydrated lime as it reduced coliform levels without impairing the NPK levels of the vermicompost.

The final full-length article in this issue is a contribution by researchers from Madras Christian College in Chennai, India—Tilak and colleagues—who investigated traditional knowledge and sustainable local practices for enhancing coastal resource education and management in India. According to the authors, the"variety of coastal ecosystems along the Indian coastline measuring 8,129 km encompassing nine maritime states and four union territories include estuaries, lagoons, mangroves, backwaters, and coral reefs" whose "marine floral and faunal diversity is immense that India stands third in fish production and second in aquaculture in the world." However, such rich coastal resources, has always been under threat for various reasons, contributing to loss in biodiversity and endangeringspecies. The authors suggest that a revival of traditional knowledge on sustainable fishery be synergized with activities of stakeholders (e.g., policy makers, NGOs, and the academe) in order to draft a proposal for an effective and successful coastal resource management.

REVIEW SECTION

Graduate students of the Department of English and Literature at Silliman contributed the two reviews for this issue; both are reviews of work done by former professors at Silliman University. Jossaine Galenzoga writes a review of Leoncio Deriada's *People on Guerrero Street* and Ivane R. Mahinay gives us a piece entitled "Making a Shadow Fit a Figure of Which It Is Not the Shadow, Or: The Word Made Sawi".

ACKNOWLEDGMENTS

I wish to thank all contributors to this issue and my associate editor, Warly Caturay, who has been able to combine his editorial responsibilities with graduate studies in Bangkok, Thailand. Indeed, as Bertrand Russell said in *The Conquest of Happiness* (1930), "The mind is a strange machine which can combine the materials offered to it in the most astonishing ways."

Margaret Helen F. Udarbe
Editor

Fish Standing Stock and Catch from Coral Reefs in Three Regions of the Philippines

Jean Asuncion T. Utzurrum,
Clarissa T. Reboton, and
Hilconida P. Calumpong
Silliman University – Institute of Environmental and Marine Sciences (SU-IEMS), Bantayan, 6200 Dumaguete City, Negros Oriental, Philippines

Coral reefs depicting 'fair' and 'poor' coral reef conditions were surveyed at each of three study sites in Regions V (Ticao I., Masbate), VII (Negros Oriental), and XI (Davao Oriental) in 2013 to compare fish standing stock and catch. Reef condition was determined using LIT while fish standing stock was measured using FVC. Fish catches were quantified by random monitoring at selected landing sites done by hired enumerators using Roving Creel Survey from April to December 2013. Results of this study showedpositive linear relationship between live hard coral cover with fish density and biomass but not species richness. No relationship was observed between reef rugosity and fish parameters. Overall, the site Chapel Pt. in Apo I., Negros Oriental was found to have the highest % coral cover (58.93 $\pm$ 7.21) and was the most rugose (1.45 $\pm$ 0.07) of all coral reefs assessed. As expected, this site also ranked the highest in terms of fish species richness (H' = 7.54), fish density (n = 465 $\pm$ 67), fish biomass (3.84 $\pm$ 0.68 kg 500 m^{-2}), and catch per unit effort (CPUE) (3.41 $\pm$ 1.02 kg $manhr^{-1}$). Meanwhile, Bantayan Marine Sanctuary, also in Negros Oriental, had the lowest % coral cover (20 $\pm$ 9.86) and generally low CPUE (0.08 $\pm$ 0.04 to 1.04 $\pm$ 0.14 kg $manhr^{-1}$) but had high species richness (H' = 6.26) and was moderately productive (1.83 $\pm$ 0.36 kg 500 m^{-2}). Baladingan reef in Monreal, Ticao I. was the least rugose and ranked amongst the lowest in terms of overall productivity (1.65 $\pm$ 0.68 kg 500 m^{-2}) despite having high fish diversity (H' = 7.54) and generally high CPUE (0.75 to 1.38 $\pm$ 0.70 kg $manhr^{-1}$). Some of the commonly caught fishes recorded in catch data came from families that were not observed during FVC (e.g., Carangidae, Scombridae, Lutjanidae), making it difficult to infer direct relationships of coral reef condition and

catch. These differences may be due to lack of FVC replicates that might show seasonal patterns and because fishing grounds were not necessarily adjacent to the LIT and FVC sites.

Keywords: coral reef fish; coral reef ecosystem goods and services; fish standing stock; fish catch; Ticao Island; Apo Island; Pujada Bay; Philippines

INTRODUCTION

The Philippines is considered to be a megadiverse country. Situated in the Coral Triangle, it has rich seascapes filled with diverse marine organisms that make up complex ecosystems. Coral reefs are perhaps the most productive of these ecosystems, providing critical habitat for spawning, breeding, nursery, and feeding areas of keystone species, *i.e.* herbivorous fishes and invertebrates (Moberg & Folke, 1999) and economic opportunities for fishing, tourism, and recreational activities. Reef-related fisheries have been estimated to contribute 15 to 30% of total fisheries production in the Philippines (Licuanan & Gomez, 2002; Aliño et. al., 2002) . However, the booming population growth of Filipinos has resulted to a rising demand in fish products, placing intense pressure on coastal resources with fishers sometimes resorting to destructive fishing methods, *i.e.* blast fishing and cyanide fishing. White, Vogt, and Arin (2000) have suggested that most coral reefs in the Philippines can no longer sustain fish catches although many papers will argue that fish yields can be increased with the establishment and proper management of marine reserves (Alcala, 1997; Alcala, Russ, & Maypa, 2002; Babcock *et al.*, 2010).

The benefits of marine reserves are best exemplified by the "spillover effect" or the net export of adults, and "recruitment effect," which is the net export of juveniles. Recruitment patterns have been explored in species of anchovies and mackerels (Pauly & Navaluna, 1983) and groupers (Mamauag, Penolio, & Aliño, 2007) and are likely to be influenced by changes in monsoons and seasons. Spillover effect has been studied more extensively, especially in the world famous Apo I. Protected Landscape and Seascape (AIPLS) in Negros Oriental, Philippines, in researches on predatory fishes by Russ and Alcala (1996; 2010); Alcala *et al.* (2002); Russ, Alcala, and Maypa (2003); Russ, Alcala, Maypa, Calumpong, and White(2004); and Abesamis, Alcala, and Russ(2006a). The magnitude and scales of these fishery benefits may differ among various species (Gell & Roberts, 2003) and rely on several factors, *i.e.* effectiveness of

protection (Alcala, Russ, Maypa, & Calumpong, 2005; Samoilys *et al.*, 2007), spatial gradients (Dorenbosch, Grol, Nagelkerken, & Van der Velde, 2005; Abesamis *et al.*, 2006b), and habitat complexity (Russ, Stockwell, & Alcala, 2005).

Fisheries in the Philippines provide major socio-economic benefits. However, declines have been reported in recent decades. Green *et al.* (2004) found that fish catches of hook-and-line gear in six provinces were <5% than catches in the 1940s and 1960s. In the early 1990s, a decline in catch landings by municipal fishers was recorded by Barut, Santos, and Garces (2004), suggesting increased resource depletion and stiff competition from commercial fishers. Hilborn *et al.* (2003) outlines other factors that can cause stock depletions, including climate, pollution, and the introduction of non-native species. Pollution has been linked with sedimentation which may inhibit coral growth and inconsequentially, degrade coral reef condition. This is because reef-building corals will not be able to perform their ecological function and the entire reef framework will likely collapse (Rogers, 1990), resulting in reduced habitat complexity or rugosity of the reef and downtrends in overall fish productivity.

This paper examines the relationships of coral reef condition with the services and goods it provides as inferred from fish biomass estimates and fish catch data collected from six coral reefs in three regions of the Philippines:Region V (Ticao I., Masbate), VII (Negros Oriental), and XI (Davao Oriental). Coral reefs assessed as 'fair' were expected to provide better services (*e.g.*fish production expressed as fish density and biomass) and goods (*e.g.* fish catch) compared to those assessed as 'poor'.

STUDY SITES

Transect Sites for Coral Condition and Fish Standing Stock

Two sites in each region were selected based on coral reef condition (e.g. 'fair' and 'poor') inferred from baseline data (Fig. 1). Baseline information used were from Reboton and Candido (2014) for Region V sites, Calumpong, Estacion, Lepiten, and Acedo (1997) for Region VII, and Alcala, Bucol, Maypa, Luchavez, and Padin (2012) for Region XI.

The sites in Region V are located on the eastern seaboard of Ticao I., which is one of three major islands in the province of Masbate. Site V-1 is the coral reef in Sitio Baladingan situated in Brgy. Famosa, Monreal

(12.62996°N - 12.6308°N, 123.70267°E – 123.70165°E). Site V-2 is located in Brgy. Tacdugan, San Jacinto located to the south across the opening of a shallow bay (12.61577° N – 12.61529°N, 123.71575°E – 123.71714°E). Site V-1 was assessed 'poor' while site V-2 was assessed as 'fair'in 2009 (Reboton & Candido, 2014). Both reefs were generally characterized by patchy coral communities in sandy areas(Calumpong *et al.*, 2014). According to accounts from locals, illegal fishing activities (e.g. blast fishing, compressor diving) also occur in the area. At the time of this study, no protective measures were in place for both sites. However, public consultation and demarcation of a proposed sanctuary in Sitio Baladingan was conducted by Silliman University – Institute of Environmental and Marine Sciences in early 2014 through a project funded by the United Board for Christian Higher Education in Asia. There are fishing communities on the island and this study appears to be the first to monitor fish catches landed in Famosa. No benchmark data and fisheries data were available for Tacdugan.

In Region VII, the two sites surveyed are located in Negros Oriental. These are the Bantayan Marine Sanctuary (BMS) in Dumaguete City (Site VII-3) and Chapel Pt. at Apo I. in the municipality of Dauin (Site VII-4). Site VII-3 is a 1.2-ha patchy reef flat interspersed with seagrass and sandy areas, located on the east coast of this province (9.33006° N – 9.33049° N, 123.31294° E – 123.31206° E). It lies close to the mouth of Tañon Strait, where a bottleneck effect tends to create a strong north to south current that exits into the Bohol Sea during the period of November to January and in the opposite direction from June to August (Han *et al.*; 2009). It was established in June 2012 and has since been actively managed by the local and city government through the Bantay Dagat, which consists of deputized fish/sea wardens. However, the areas outside the BMS are subjected to an array of activities, including swimming, water sports (*e.g.* jet skiing, skim boarding), gleaning, and fishing. Additionally, the coastline in Bantayan is generally exposed to pollution from picnickers, coastal households, and from a nearby creek. The reefs in Bantayan were assessed as 'poor' by Calumpong *et al.* (1997). On the other hand, Site VII-4 (9.07717° N - 9.07622° N, 123.26641° E – 123.26623° E) is located in the Apo I. Protected Landscape and Seascape (AIPLS)which has been protected since 1994 under a Protected Area Management Board (PAMB). Chapel Pt. is a dive site with extensive reef flat (≥ 50 m) found on the western front of the island, directly facing the community area and is subject to disturbances caused by snorkelers, SCUBA

divers, and boat traffic. The AIPLS was strongly influenced by mainstream currents from the north (Abesamis *et al.*, 2006a) and fishing activities are limited by monsoonal changes (Russ *et al.*, 2004). The reefs in AIPLS were assessed as 'good' by Calumpong *et al.* (1997) and have remained as such despite having been exposed to extreme natural phenomena, which included three El Niño events (in 1997, 1998, 2010) and typhoons Sendong (in 2011) and Pablo (in 2012).

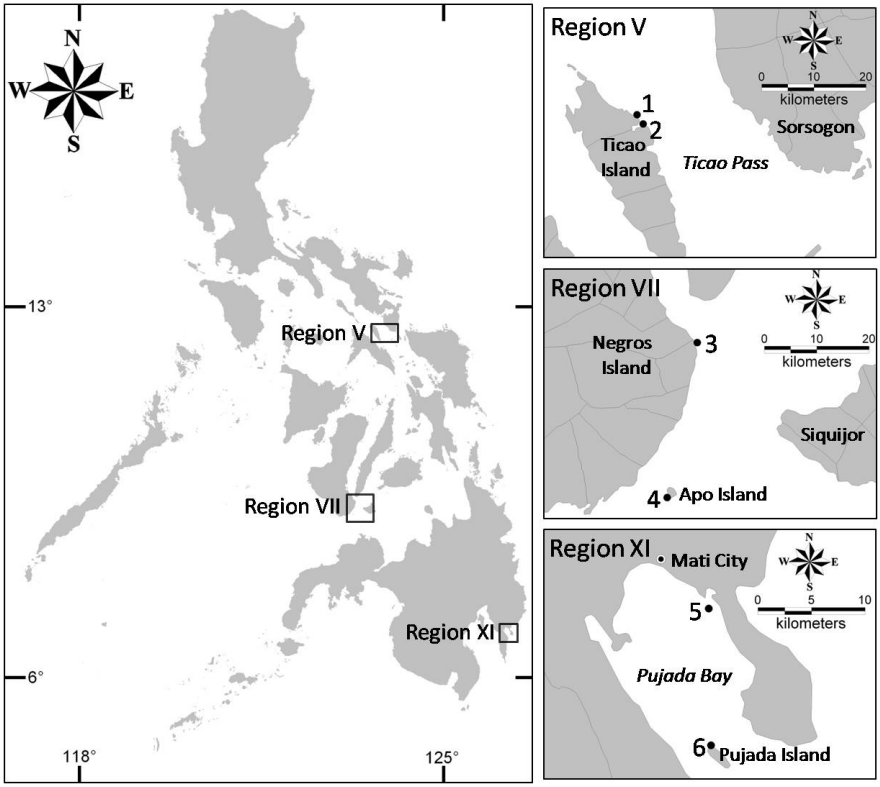


Fig. 1. Maps showing survey sites in Region V (Masbate): 1 - Baladingan, 2 - Tacdugan; Region VII (Negros Oriental): 3 – Bantayan Marine Sanctuary, 4 - Chapel Pt., Apo I.; Region XI (Davao Oriental): 5 - Guang-guang, and 6 - Pujada I.

Sites in Region XI are within the Pujada Bay Protected Seascape (PBPS) (6.80111° N – 6.90694° N, 126.15222° E – 126.32583° E), which is nestled in the southeastern portion of Mindanao, approximately 157 km from east-southeast of Davao City (Jimenez & Eballe, 2002). The bay

encompasses an area of 21,200 ha and was declared as a protected seascape in 1994 under Presidential Proclamation No. 431, thereby placing it under the muti-sectoral management of its own PAMB. Site XI-5 is part of Sitio Guang-guang in Brgy. Dahican (6.91408° N – 6.91279° N, 126.25706° E – 126.25694° E) which made 'poor' coral reef condition (Alcala *et al*., 2012). It is located in the inner portion of the PBPS whileSite XI-6, Pujada I. (6.79690° N – 6.79641° N, 126.25823° E – 126.26016° E) with 'fair' coral reef condition (Alcala *et al*., 2012) is found near the mouth of the PBPS. Both survey sites are characterized by fringing coral reefs. In Guang-guang, the reef area begins after a seagrass bed at ~3 m depth and gradually slopes to ~13 m depth whereas the reef area in Pujada I. reached ~20 m depth, with corals most abundant at 3-7 m and slopes occurring at 6-10 m. Although both sites are within a protected area only Site XI-6 is a designated no-take marine reserve.

Sites for Fish Catch Monitoring

Fish catch monitoring was conducted in Brgy. Famosa for site V-1, Brgy. Bantayan for Site VII-3, Apo I. for Site VII-4, Brgy. Dahican for Site XI-5, and Brgy. Tamisan for Site XI-6 since it has local jurisdiction over Pujada I.

MATERIALS AND METHODS

Characterization and selection of sites were ascertained using manta tow technique. For measuring coral reef parameters, five 20-m transects were set parallel to the shoreline at 7-10 m depth at each site. Benthic cover was obtained using the line-intercept transect (LIT) method described in English, Wilkinson, and Baker (1997). Identification of coral species was done following Veron and Pichon (1976; 1980; 1982); Veron, Pichon, and Wijsman-Best (1977); Veron and Wallace (1984); Wallace (1999); Veron (2000); and Fabricius and Alderslade (2001). Coral reef condition was determined using the four categories of hard coral cover (Gomez, 1991), quality reef indices (Gomez, Alino, Yap, & Licuanan, 1994; Manthachitra, 1994), and indices of dominance and diversity (Odum, 1971). To determine rugosity, the Chain Method of Hill and Wilkinson (2004) was modified such that the chain was laid on the upper contour of the reef within the 20 m transect used for LIT. Rugosity was calculated as the length of chain

used per 20 m transect and rugosity index was used to signify architectural complexity of the reef (Alvarez-Filip,Dulvy, Gill, Cote, & Watkinson, 2009). Thus, a perfectly flat surface would have a rugosity index of 1 while more complex surfaces would show larger values.

Reef productivity was determined from three 50-m transects that were laid along the LIT transects at each site. All fish encountered within 5 m on both the left and right sides of the transect line were identified and counted. Their total length was estimated following fish visual census (FVC) method modified from English *et al*. (1997). Identification of fishes was done using the field guide by Allen, Steene, Humann, and Deloach (2003) and Fishbase (Froese& Pauly, 2014).

Fish catch at landing sites was monitored using the Roving Creel Method as described in Maypa, Russ, Alcala, & Calumpong (2002). Local enumerators were trained to monitor fish catch for eight fishing days (two days per lunar cycle). Catch per unit effort (CPUE) and income per unit effort (IPUE) values were derived from the catch data. Identification of commercially important fishes was based on fish families reported as targeted in the baseline reports used.

RESULTS

Fish Standing Stock

Species Richness. Statistical Sites VII-4 and V-1 exhibited the highest indices of diversity (H' = 7.54), followed by VII-3 (H' = 6.26) and XI-6 (H' = 5.34) while V-2 and XI-5 ranked lowest with H' values of 4.42 and 3.65, respectively (Table 1). Herbivorous damselfishes (Pomacentridae) were the most diverse in all sites. Wrasses (Labridae) were also highly diverse at all sites except XI-5. Overall, commercially important fishes were more diverse at VII-4 (n = 38), BMS (n = 34), and XI-6 (n = 26).

Fish Density. Fish densities were highest at VII-4 and V-1 (Fig. 2A). Pomacentrids were the most dominant fish in all sites. Surgeonfishes (Acanthuridae) and butterflyfishes (Chaetodontidae) were the next two most abundant fishes at VII-4 while in V-1, wrasses and schooling cardinalfishes (Apogonidae) ranked second and third in abundance. Labrids also consistently ranked among the most abundant fish families observed except at VII-4 and XI-5. Site XI-5, which ranked low in species richness, ranked third in mean

total density; however, this site had the lowest density of target fishes, with pomacentrids dominating fish abundance. Conversely, mean total density was lowest at XI-6 but 27% of this were target fishes, having the highest concentration of target fishes across all sites.Overall, there were remarkable downtrends in mean total densities of fishes observed in this study when compared to benchmark data from 2009 (Region V sites), 1997 (Region VII sites), and 2011 (Region XI sites). The most drastic of these declines appeared to be those at VII-3 and VII-4 while XI-6 showed less radical reductions (Fig. 2B). On a positive note, sites V1 and XI-5 were both reported as having low fish densities (Alcala *et al.*, 2012; Reboton & Candido, 2014) but were found to show uptrends in this study. No benchmark data were available for site V-2.

Fish Biomass. Biomass estimates for both total fish and target fishes were highest at VII-4 (Fig. 2C). Site VII-3 ranked second in overall productivity although biomass of target fishes ranked third after XI-6, which recorded the highest percentage of target fish biomass (52%). V-1 ranked third in overall biomass but was among the sites with low productivity of target fishes whileV-2 and XI-5 both ranked poorly in total productivity and biomass of target fishes. When compared to the above-mentioned benchmark data, downtrends were clearly visible for all sites except V-1 which showed slight improvement (Fig. 2D). Although total density of fishes at XI-5 had increased, this study found that density and biomass of target fishes at that site were reduced.

Fish Catch

A total of five landing sites were monitored during this study: Brgy. Famosa in Region V, Brgy. Bantayan and Apo I. in Region VII, and Brgys. Dahican and Tamisan in Region XI. Data collection was heavily reliant on the availability of catch enumerators; thus, the number of survey days were not the same across the sites. Hook-and-line gear appeared to be the preferred gear in Regions V and VII, next to fishing net. In Region XI, net was favored by fishers in Dahican while most fishers in Tamisan used speargun. Fisheries in Apo I. showed exceptionally high CPUE and IPUE values when compared to other sites. A summary of fisheries data can be found in Table 2.

In Famosa, fish landings were recorded for a total of 46 days across seven months (June – December). Most catches were fished in the coastal waters of Famosa and Tacdugan, and predominantly consisted of reef and

Table 1 Summary of coral reef and fish parameters in the three regions surveyed expressed in values ± S.E. Legend: C = Simpson's Dominance Index; H' = Shannon's Diversity Index; V-1 = Baladingan; V-2 = Tacdugan; VII-3 = Bantayan Marine Sanctuary; VII-4 = Chapel Pt., Apo I.; XI-5 = Guang-guang; XI-6 = Pujada I. Categories of coral reef condition is based on benchmark data collected in 2009 (Region V), 1997 (Region VII), and 2011 (Region XI).

Site	Coral Reef Condition			Reef Fish Productivity				
	Category	Coral Cover (%)	Rugosity	No. of Spp.	C	H'	Mean Density (per 500 m^{-2})	Mean Biomass (kg 500 m^{-2})
V-1	Poor	33.35 ± 3.31	1.18 ± 0.02	52	10.65	7.54	462 ± 44	1.65 ± 0.69
V-2	Fair	32.70 ± 6.17	1.25 ± 0.06	47	5.17	4.42	288 ± 51	1.28 ± 0.29
VII-3	Poor	20.00 ± 9.86	1.27 ± 0.09	70	3.97	6.26	371 ± 43	1.83 ± 0.37
VII-4	Fair	58.93 ± 7.21	1.45 ± 0.07	75	4.37	7.54	465 ± 67	3.84 ± 0.68
XI-5	Poor	42.05 ± 3.40	1.40 ± 0.07	43	4.01	3.65	377 ± 38	0.98 ± 0.25
XI-6	Fair	40.22 ± 6.23	1.37 ± 0.02	59	1.45	5.34	253 ± 17	1.42 ± 0.22

reef-associated fishes. Tuna and mackerel (Scombridae) were observed in almost all gear throughout the sampling period and recorded a total yield of 148.67 kg. Ten other target fish families were recorded but most had total yields of ≤3.00 kg except for one instance of a 40.00kg catch of anchovies in November. Scombrids were not encountered during the FVC survey in June while other target fish families (*e.g.* Nemipteridae, Serranidae, Sphyraenidae) were recorded in both FVC and fish catch data. Hook-and-line gear was the common gear used, observed 36 times in all seven months, and showed highest values for CPUE. Other gears observed were net, speargun, and compressor diving. IPUE was highest for speargun, but this is based on just one fishing trip.

Catches were monitored in Bantayan for a total of 58 days for nine months (April – December). Fishing net and hook-and-line gears were the most commonly used gears observed in all months, although the latter appears to be the preferred gear by fishers who fish in the southward adjacent waters of Brgy. Piapi. CPUE values were highest for hook-and-line, followed by fishing net. Other gears observed in this area were fish pot, fish trap, and crab pot. Similarly, IPUE was highest for hook-and-line followed by net. Majority of catches from both these dominant gears were tunas and mackerels (Scombridae), with total landed catch reaching 316.85 kg during the survey period. Jackfishes (Carangidae) and emperors (Lethrinidae) were also commonly caught throughout this period with total catch weights of 74.75 kg and 64.20 kg, respectively. Pelagic species of needlefish (Belonidae) also contributed to overall yield (61.10 kg) despite being recorded from September to December only.

Fish catch in Apo I. was monitored by two dive wardens for 18 days in four months (April – June, and September). It was unclear if no fishing occurred at all in August, October, and November or if the lack of data was due to the conflicting schedules of the dive wardens who often moonlighted as tourist dive guides. Hook-and-line was the only gear noted during these months. From April to June, most fishers used fishing grounds on the west to northwest of the AIPLS (Katipanan, Largahan, and Coconut Pt.) where majority of their catch were large Carangidae (>50.00 cm). This is consistent with Maypa (2012) which found carangids to be most abundant in this area. Catches reported for September were relatively smaller Acanthuridae (35-40 cm) fished in the northeastern grounds of Cogon Pt.

In Dahican and Tamisan, a site co-operator was assigned to monitor fish catch landings at both sites for at least eight days a month. However, catch data from Tamisan was recorded for a total of six days only over a three-month period (June - August) while monitoring in Dahican totaled 41 days over six months (May – October). The cause of shorter monitoring period in Tamisan is unknown. All fishes landed at Tamisan were purportedly caught from Pujada I., which is a no-take marine reserve (NTMR) within the PBPS. Speargun was the most common gear used as observed in all three months and showed higher CPUE and IPUE values. Other gears observed were fishing net and troll line known as 'subid' but this was encountered only once. On the other hand, fishes landed in Dahican were caught from coastal waters, including Sitio Guang-guang. Net fishing was the main gear used by fishermen at this site, noted in all six months of monitoring and had higher CPUE and IPUE values. Speargun fishing was also noted but this was only encountered twice during this period. Catch composition in Tamisan was more diverse when compared to those landed in Dahican, and included both targeted and non-targeted fish families. However, more commercially valuable fish were abundant in Dahican, with catches pirmarily composed of rabbitfishes (Siganidae), goatfishes (Mullidae), and snappers (Lutjanidae) that ranged in sizes from small (<10 cm), medium (11-15 cm), and large (>15 cm).

Overall, there were clear differences between species recorded in FVC data and those observed in catch data. A total of 18 families were identified although not all were targeted at each site: Acanthuridae (surgeonfishes), Balistidae (triggerfishes), Belonidae (needlefishes), Caesionidae (fusiliers), Carangidae (jackfishes), Engraulidae (anchovies), Haemulidae (grunts), Kyphosidae (chubs), Labridae (wrasses), Lethrinidae (emperors), Lutjanidae (snappers), Mullidae (goatfishes), Nemipteridae (breams), Scaridae (parrotfishes), Scombridae (tunas and mackerels), Serranidae (groupers), Siganidae (rabbitfishes), and Sphyraenidae (barracudas). Scombrids were absent from all FVC data but figured prominently in catch data from Baladingan (June – December) and Bantayan (April – December), with total weights reaching up to 148.67 kg and 316.85 kg, respectively. Similarly, carangids were noticeably absent in the FVC data collected in October 2013 at VII-3 and VII-4 but catch data show that carangids were landed in Apo I between the months of April to June and in Bantayan from May to December, respectively, thus contributing 308.30 kg and 74.75 kg in

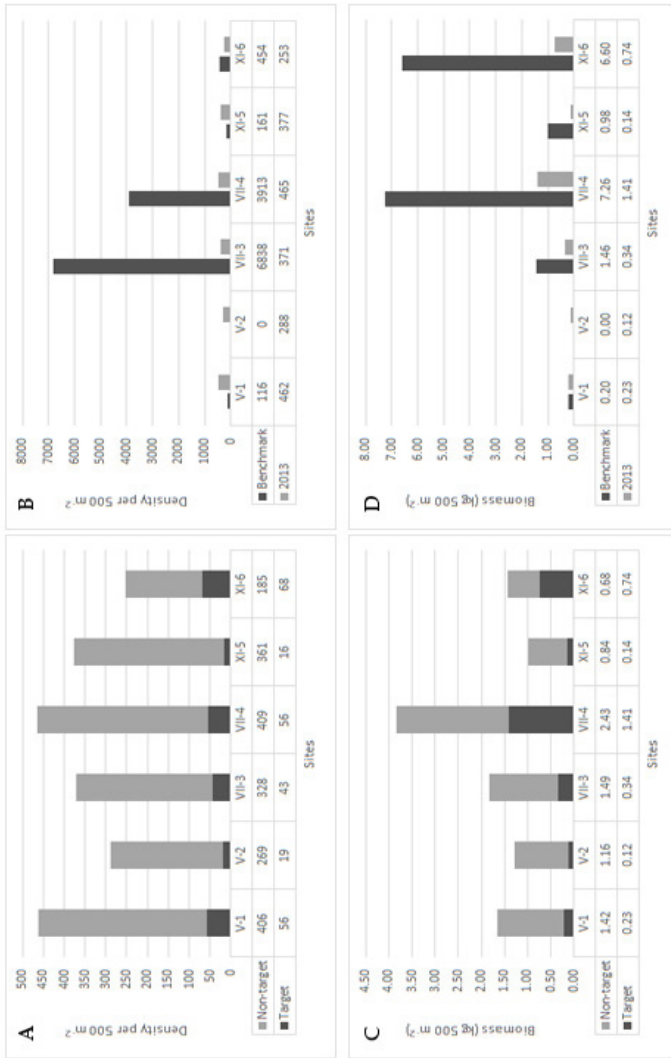


Fig. 2. Mean densities and biomass values of all fishes (non-target and target) sampled at sites in this study are shown in A, C. In B, mean total densities are compared with total densities from benchmark data. Total productivity of target fishes is compared with the same from benchmark data in D. Legend: V-1 = Baladingan; V-2 = Tacdugan; VII-3 = BMS; VII-4 = Chapel Pt., Apo I.; XI-5 = Guang-guang; XI-6 = Pujada I.

Table 2 Summary of fish catch data with corresponding mean CPUE (kg manhr^{-1} ± S.E.) and mean IPUE (Php manhr^{-1}± S.E.) values in sites studied. Legend: BAL = Baladingan; APO = Apo I.; BAN = Brgy. Bantayan; DAH = Brgy. Dahican; TAM = Brgy. Tamisan; N = sample size; MP = average man power; FTP = average fishing time per trip (hr); HL = hook and line; * = no data.

Site	Gear	No. of Months Observed	N	MP	FTP	CPUE	IPUE
BAL	compressor	1	1	1	4.00	0.75	75.00
	HL	7	36	1	4.23 ± 0.16	1.38 ± 0.70	84.47 ± 34.54
	Net	3	5	1	2.78 ± 0.40	1.13 ± 0.41	86.74 ± 19.82
	speargun	1	4	1	2.25 ± 0.48	1.25 ± 0.92	114.06 ± 95.35
APO	HL	4	40	1	4.82 ± 1.41	3.41 ± 1.02	392.39 ± 122.55
BAN	crab pot	3	5	1	5.00	0.30 ± 0.12	18.80 ± 9.71
	fish pot	6	12	1	33.28 ± 9.79	0.08 ± 0.04	1.78 ± 1.03
	fish trap	2	4	1	9.00 ± 3.00	0.14 ± 0.01	0.00*
	HL	9	127	1	3.33 ± 0.13	1.04 ± 0.14	129.92 ± 24.47
	Net	9	64	1	10.65 ± 0.61	0.68 ± 0.44	70.63 ± 52.59
DAH	Net	6	159	1.7	8.69 ± 0.29	1.61 ± 0.86	96.72 ± 55.41
	speargun	2	2	1	4.00	0.33 ± 0.03	44.25 ± 2.25
TAM	Net	1	1	1	4.00	2.14	177.14
	speargun	3	6	1	7.50 ± 2.02	1.09 ± 0.31	81.24 ± 30.53
	"subid"	1	1	1	2.00	9.75	1,462.50

total weight of catches. Lutjanids were absent in FVC data from both Region XI sites yet appeared in catch data once at Tamisan and were the second most commonly landed fishes at Dahican, contributing 468.95 kg in total weight over the course of six months (May – October). Lethrinids were not encountered at VII-3 during FVC but were consistently landed from April to December in Bantayan. Serranids were scarcely recorded in both FVC and catch data for most sites, with the exception of catch data from Bantayan which shows these fishes were landed from May to December although weighing much less (17 kg total weight) than other predatory fishes landed. Siganids dominated fish catches in Dahican, supplying up to 1,180.25 kg of total weight in just six months (May – October) but this family does not appear on FVC data for XI-5.

Relationship of Coral Reef Parameters and Fish Productivity Parameters

Areas with high coral cover and rugosity index generally support higher total densities, biomass, and number of species of fish (Table 1), except in Region XI sites where only fish density was found to be correlated with coral cover and rugosity. Fish biomass and number of species appeared to be higher in XI-6, where coral cover was lower and rugosity was less complex. Fish parameters also had low values in V-2 which had a higher rugosity index.

Results of regression analysis (Fig. 3) revealed a significant positive relationship between live hard coral (LHC) cover and fish density (r^2=0.222, p=0.048) as well as LHC cover and fish biomass (r^2=0.330, p=0.013). However, no relationship was seen when reef rugosity was tested with fish density (r^2=0.003, p=0.836) and fish biomass (r^2=0.215, p=0.053). Likewise, the number of fish species did not show a relationship with both LHC cover (r^2=0.42, p=0.414) and reef rugosity (r^2=0.021, p=0.570).

DISCUSSION

Not all coral reefs assessed as 'fair' showed high productivity. Conventional assessments of coral reefs use percentage of coral cover as a basis for determining coral reef condition (Hill & Wilkinson, 2004). However, fish assemblages are also known to be influenced by the complexity of the reef structure than the mere presence or absence of coral species

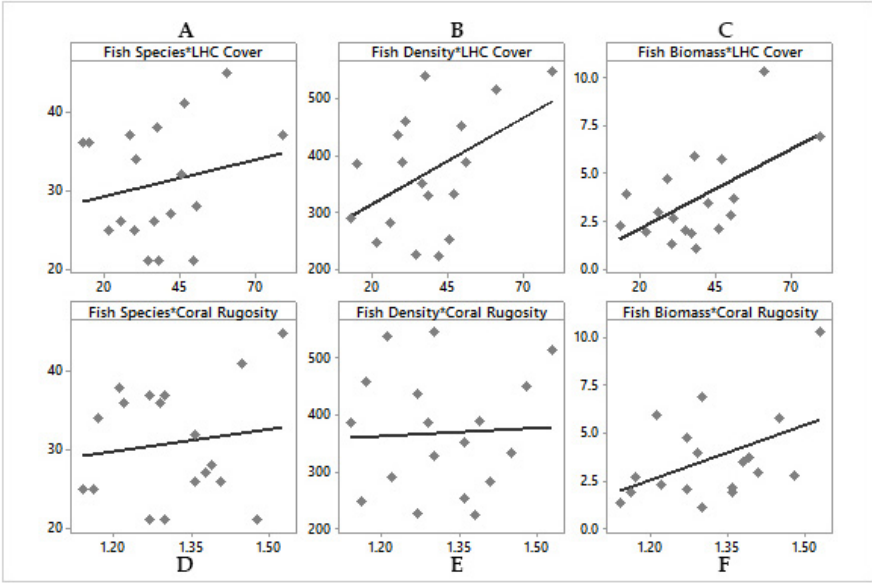


Fig. 3. Scatterplot showing positive linear relationships between fish density and biomass with live hard coral cover (B, C) and no relationship with rugosity (E, F). Number of species also did not show any relationship with LHC cover and rugosity (A, D).

(Stockwell *et al.*, 2009). Russ *et al.* (2005) found fish biomass outside of the AIPLS marine reserve to have increased relative to improved habitat complexity. In the Bahamas, increased habitat complexity was found to reduce mortality of fish recruits and increase abundance of both recruits and adults (Almany, 2004). In this study, the three sites with the highest coral cover and rugosity were VII-4, XI-5, and XI-6. Both VII-4 and XI-6 were assessed as 'fair', and while the latter ranked the lowest in total fish density, it showed higher density and biomass of targeted fish families than other sites surveyed. On the other hand, XI-5 had the lowest total fish biomass despite ranking third in total fish density. This means that the fishes were small which may be an indication of high fishing pressure.

The observed differences between sites might also be attributed to the protective status of some sites. Of the six sites surveyed, four were in protected areas: VII-3 in BMS, VII-4 in AIPLS, XI-5 and XI-6 in PBPS. However, only BMS and Pujada I. (Site XI-6) were designated as no-take marine reserves (NTMRs) while VII-4 and XI-5 are subject to fishing and recreational activities regulated by their respective governing PAMBs.

The effective implementation of NTMRs would significantly impact ecosystem condition by reducing fishing mortality of fishes. This has been examined in various studies, including an age-structured population model of the thumbprint emperor *Lethrinus harak* in Guam, Micronesia which showed that fish parameters (*e.g.* spawner biomass, total abundance, and sex ratio) remained stable over time if existing protective measures were maintained (Taylor, McIlwain, & Kerr,2012). Additionally, a study of fish biomass of targeted species inside the AIPLS marine reserve was shown by Alcala *et al.* (2005) to have strong positive relationship with the number of years the reserve was protected. Taking this into account, one would expect areas that have been protected longer to exhibit better coral reef condition and higher productivity. It should come as no surprise then that sitesVII-4, XI-5 and XI-6 ranked favorably in terms of coral reef condition and in certain fish parameters.

Trophic roles are also an interesting aspect of ecosystem services. Pomacentrids were the most abundant encountered in FVC surveys at all sites. Labrids were also observed at all sites and were among the top three most abundant fish families in Region V sites, VII-3 and XI-6. Pomacentrids are generally herbivorous fish that prevent overgrazing of turf algae on coral reefs by defending their feeding territory against other predators (Hixon & Brostoff, 1983). Turf algae are also a primary source of productivity on coral reefs and often host a diverse range of invertebrates, *i.e.* benthic crustaceans, making pomacentrids a keystone species for maintaining the integrity of microhabitats within the reef ecosystem and act as a bridge between producers and secondary consumers. For instance, harpacticoid copepods from algal turf were found to be most abundant in the gut contents of the wrasses *Thalassoma lunare, Halichoeres melanurus,* and *Stethojulis strigiventer* in the Great Barrier Reef (Kramer, Bellwood, & Bellwood, 2013). Large predatory reef fish, *i.e.* groupers (Serranidae), emperors (Lethrinidae), and snappers (Lutjanidae), were recorded in FVC surveys in only a few sites and in small numbers (<10 individuals) while jackfishes (Carangidae) were not encountered at all. It would be easy to assume that the coral reefs surveyed in this study are fished down as posited in the 'shifting baselines' paradigm by Pauly *et al.* (1998) – that is, overfishing of top predatory species will have cataclysmic cascading effects on lower trophic level species. However, carangids, lethrinids, and lutjanids contributed to most of fish catches landed especially in Regions VII and XI. It might be possible that these large

predatory fishes were not observed because of the timing of the FVC surveys, which were conducted once at each site and at variable times of the year for different regions. Species composition may show slight changes within sites when sampled at different times of the day, let alone during different seasons and monsoons. After all, monsoonal changes have been known to influence recruitment patterns of Philippine serranids (Mamauag *et al.*, 2007), clupeids and scombrids (Pauly & Navaluna, 1983), as well as pomacentrids, labrids, chaetodontids, and acanthurids (Abesamis & Russ, 2005). One other possibility is that fishers are not necessarily fishing adjacent to the FVC sites. Catch data from the landing site in Dahican notes multiple fishing grounds within the PBPS but their exact locations and proximity to the FVC site in Sitio Guang-guang (Site XI-5) are unknown. Other evidence to explain this discrepancy points to siganids (rabbitfishes), locally called 'danggit', which contributed up to 1,180.25 kg of total catches landed in Dahican within a six-month period (May – October) but which were not encountered in the FVC survey conducted in XI-5 in late May. In the Philippines, this fish resource is commonly caught in seagrass beds by a range of gears as recorded in works by Calumpong *et al.* (1997; 2014) and Fabinyi (2007). It may then be supposed that siganid catches landed in Dahican were possibly caught in seagrass beds closer to shore rather than in coral reefs.

CONCLUSION AND RECOMMENDATIONS

The results of this study show strong positive relationships between fish density and biomass with LHC cover but not with reef rugosity. However, these results are still largely preliminary and long-term temporal monitoring of the sites may reveal otherwise. Regardless, coral reefs remain to be a significant resource for municipal fisheries and should be monitored vigilantly to ensure food security for future Filipino generations. Sustainable fish stocks are not only reliant on well-regulated fisheries but more so on the effective protection of coral reefs which fishes inhabit.

ACKNOWLEDGMENTS

This study is part of a three-year project entitled, STEWaRDS: Science Towards Environmental Well-being and Resource Development For Society In A Changing Climate, funded by the Commission on Higher Education

(CHED) through the Philippine Higher Education Research Network (PHERNet). This would not have been possible without the permission of Chief Local Executives of the municipalities of Monreal (Masbate) and Dauin (Negros Oriental), the cities of Dumaguete and Mati,and the specific barangays and sitios, to conduct this study in their areas of jurisdiction. Moreover, we are grateful for the cooperation of our Higher Education Institution partners, namely the Masbate School of Fisheries, Cebu Technological University, and Davao Oriental State College of Science and Technology, and our local enumerators Jerol Almiñana, Zacharias Generoso, Wilmer Pascobello, and Medel Tabañera. We also extend our thanks to all our dive guides, field assistants, and boat crews.

REFERENCES

Abesamis, R. A., & Russ, G. R. (2005). Density-dependent spillover from a marine reserve: Llong-term evidence. *Ecological applications*, *15*(5), 1798-1812.

Abesamis, R. A., Alcala, A. C., & Russ, G. R. (2006a). How much does the fishery at Apo Island benefit from spillover of adult fish from the adjacent marine reserve? *Fishery Bulletin*, *104*, 360-375.

Abesamis, R. A., Russ, G. R., & Alcala, A. C. (2006b). Gradients of abundance of fish across no-take marine reserve boundaries: evidence from Philippine coral reefs. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *16*(4), 349-371.

Alcala, A.C. (1997). Roles of community-based fisheries management and marine reserves in coastal fisheries. *Silliman Journal*,*38* (3 & 4), 159 – 168.

Alcala, A.C., Bucol, A. A., Maypa, J. L. P., Luchavez, J. A., & Padin, J. I. M. (2012). Baseline information on the coral reef fish community and fishery resources. In Silliman University - Integrated Coastal Resource Management Project. (2012). *Final Report: Establishment of Baseline Data and Implementation of Research Projects and Technical Mentoring to ICRM Centers of Regions V, VII, & XI*. ICRMP of the Department of Environment and Natural Resources.

Alcala, A.C.,Russ, G.R.,& Maypa, A.P. (2002). Evidence for fishery enhancement effects of marine reserves in central Philippines. *UPV Journal of Natural Sciences, 7* (1 & 2), 1-5.

Alcala, A. C., Russ, G. R., Maypa, A. P., & Calumpong, H. P. (2005). A long-term, spatially replicated experimental test of the effect of marine reserves on local fish yields. *Canadian Journal of Fisheries and Aquatic Sciences*, *62*(1), 98-108.

Aliño, P.M, Miclat, E.F.B., Nañola, C.L. Jr., Roa-Quiaoit, H.A.& Campos, R.T. (Eds.). (2002). *Atlas of Philippine Coral Reefs.* Philippine Coral Reeflnformation (Philreefs). Quezon City, Philippines: Goodwill Trading.

Allen, G., Steene, R., Humann, P., & Deloach, N. (2003). *Reeffish identification. Tropical Pacific.* Jacksonville: New World Publications.

Almany, G. R. (2004). Does increased habitat complexity reduce predation and competition in coral reef fish assemblages? *Oikos*, *106*(2), 275-284.

Alvarez-Filip, L., Dulvy, N.K., Gill, J.A., Cote, I.M., & Watkinson, A.R. (2009). Flattening of Caribbean coral reefs: Region-wide declines in architectural complexity. *Proceedings of the Royal Society B 276*(pp.3019-3025).

Babcock, R. C., Shears, N. T., Alcala, A. C., Barrett, N. S., Edgar, G. J., Lafferty, K. D., McClanahan, T. R.,& Russ, G. R. (2010). Decadal trends in marine reserves reveal differential rates of change in direct and indirect effects. *Proceedings of the National Academy of Sciences*, *107*(43), 18256-18261.

Barut, N. C., Santos, M. D.,& Garces, L. R. (2004). Overview of Philippine marine fisheries. In DA-BFAR (Department of Agriculture – Bureau of Fisheries and Aquatic Resources). *In turbulent seas: The status of Philippine marine fisheries*(p.378). Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines.

Calumpong, H. P., Estacion, J. S., Cadiz, P. L., Reboton, C. T., Lucañas, J. R., Utzurrum, J. A. T., Sienes, P. M. Q., Bonsato, D. B., Pepito, A. R.,& Balaquit, R. C. (2014). *STEWARDS: Science Towards Environmental Well-being and Resource Development for Society in a Changing Climate (Terminal Report).*

Calumpong, H. P., Estacion, J. S., Lepiten, M. V., & Acedo, C. E. (Eds.). (1997). *Status of the Coastal Resources of the Negros Oriental Learning Site (Manjuyod to Dauin). Vol. 1.* Dumaguete City, Philippines: Silliman University Marine Laboratory and the Center of Excellence in Coastal Resources Management.

Dorenbosch, M., Grol, M. G., Nagelkerken, I., & Van der Velde, G. (2005). Distribution of coral reef fishes along a coral reef-seagrass gradient: Edge effects and habitat segregation. *Marine Ecology Progress Series*, *299*, 277-288.

English, S.A., Wilkinson, C.R., & Baker, V.J. (Eds.). (1997). *Survey manual for tropical marine resources* (2nd ed.) Townsville, Australia: Australian Institute of Marine Science.

Fabinyi, M. (2007). Illegal fishing and masculinity in the Philippines:A look at the Calamianes Islands in Palawan. *Philippine Studies*, 509-529.

Fabricius, K. K., & Alderslade, P. P. (2001). *Soft corals and sea fans: A comprehensive guide to the tropical shallow water genera of the central-west Pacific, the Indian Ocean and the Red Sea*. Australian Institute of Marine Science (AIMS).

Froese, R., & Pauly, D. (Eds.). (2014). FishBase. World Wide Web electronic publication. www. Fishbase.org.

Gell, F. R., & Roberts, C. M. (2003). Benefits beyond boundaries: The fishery effects of marine reserves. *Trends in Ecology & Evolution*, *18*(9), 448-455.

Gomez, E. D. (1991). Coral reef ecosystems and resources of the Philippines. *Philippine Technology Journal (Philippines)*.

Gomez, E. D., Alino, P. M., Yap, H. T., & Licuanan, W. Y. (1994). A review of the status of Philippine reefs. *Marine Pollution Bulletin*, *29*(1), 62-68.

Green, S. J., Flores, J. O., Dizon-Corrales, J. Q., Martinez, R. T., Nuñal, D. R. M., Armada, N. B. & White, A. T. (2004). *The fisheries of Central Visayas, Philippines: Status and trends.* Coastal Resource Management Project of the Department of Environment and Natural Resources and the Bureau of Fisheries and Aquatic Resources of the Department of Agriculture, Cebu City, Philippines.

Han, W., Moore, A. M., Levin, J., Zhang, B., Arango, H. G., Curchitser, E., Di Lorenzo, E., Gordon, A.L., & Lin, J. (2009). Seasonal surface ocean circulation and dynamics in the Philippine Archipelago region during 2004–2008. *Dynamics of Atmospheres and Oceans*, *47*(1), 114-137.

Hilborn, R., Branch, T.A., Ernst, B., Magnusson, A., Minte-Vera, C.V., Scheuerell, M.D., &Valero, J.L. (2003). State of the world's fisheries. *Annual Review of Environment and Resources*,*28*(15),1–15.

Hill, J., & Wilkinson, C. L. I. V. E. (2004). Methods for ecological monitoring of coral reefs. *Australian Institute of Marine Science, Townsville*, *117*.

Hixon, M. A., & Brostoff, W. N. (1983). Damselfish as keystone species in reverse: Intermediate disturbance and diversity of reef algae. *Science (Washington)*, *220*(4596), 511-513.

Jimenez, L., & Eballe, A. C.(2002). Pujada Bay. InP.M. Aliño, E.F.B. Miclat, C.L. Nañola, Jr., H.A. Roa-Quiaoit, & R.T. Campos (Eds.),*Atlas of Philippine Coral Reefs*(pp. 100-102). Philippine Coral Reef Information (Philreefs). Quezon City, Philippines: Goodwill.

Kramer, M. J., Bellwood, O., & Bellwood, D. R. (2013). The trophic importance of algal turfs for coral reef fishes: The crustacean link. *Coral Reefs*, *32*(2), 575-583.

Licuanan, W. Y., & Gomez, E. D. (2002). Philippine coral reefs: Status and the role of the academe to improve their management. *Proceedings of the Ninth International Coral Reef Symposium, Bali, 2* (pp. 835-840).

Manthachitra, V. (1994, May). Indices assessing the status of coral-reef assemblage: Formulated from benthic lifeform transect data. *Proceedings, Third ASEAN-Australia Symposium on Living Coastal Resources*, *2*(pp. 41-50).

Mamauag, S., Penolio, L., & Aliño, P. (2007). Deriving recruitment and spawning patterns from a survey of juvenile grouper (Pisces: Serranidae) occurrences in the Philippines. *Science Diliman*, *13*(1).

Maypa, A.P. (2012). *Mechanisms by which marine protected areas enhance fisheries benefits in neighboring areas* (Ph.D. Dissertation). University of Hawai'i at Mānoa. ProQuest Information and Learning registered under the United States Copyright Office. 147.p.

Maypa, A. P., Russ, G. R., Alcala, A. C., & Calumpong, H. P. (2002). Long-term trends in yield and catch rates of the coral reef fishery at Apo Island, central Philippines. *Marine and Freshwater Research*, *53*(2), 207-213.

Moberg, F., & Folke, C. (1999). Ecological goods and services of coral reef ecosystems. *Ecological Economics*, *29*(2), 215-233.

Odum, E.P. (1971). *Fundamentals of ecology*(3rd ed.).Philadelphia, USA: W.B. Saunders.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. *Science*, *279*(5352), 860-863.

Pauly, D., & Navaluna, N. A. (1983). Monsoon-induced seasonality in the recruitment of Philippine fishes. *FAO Fisheries Report (FAO)*.

Reboton, C.T.,& Candido, A. (2014). Assessment on the coral and reef fish communities in Ticao Island, Masbate. *Ecology Environment & Conservation 19 (Special Issue on Coastal Resource Management),33-43.*

Rogers, C. S. (1990). Responses of coral reefs and reef organisms to sedimentation. *Marine Ecology Progress Series. Oldendorf*, *62*(1), 185-202.

Russ, G. R., & Alcala, A. C. (1996). Marine reserves: Rates and patterns of recovery and decline of large predatory fish. *Ecological Applications*, 947-961.

Russ, G. R., & Alcala, A. C. (2010). Decadal-scale rebuilding of predator biomass in Philippine marine reserves. *Oecologia*, *163*(4), 1103-1106.

Russ, G. R., Alcala, A. C., & Maypa, A. P. (2003). Spillover from marine reserves: The case of Naso vlamingii at Apo Island, the Philippines. *Marine Ecology Progress Series*, *264*, 15-20.

Russ, G. R., Alcala, A. C., Maypa, A. P., Calumpong, H. P., & White, A. T. (2004). Marine reserve benefits local fisheries. *Ecological Applications*, *14*(2), 597-606.

Russ, G. R., Stockwell, B., & Alcala, A. C. (2005). Inferring versus measuring rates of recovery in no-take marine reserves. *Marine Ecology Progress Series*, *292*, 1-12.

Samoilys, M. A., Martin-Smith, K. M., Giles, B. G., Cabrera, B., Anticamara, J. A., Brunio, E. O., & Vincent, A. C. (2007). Effectiveness of five small Philippines' coral reef reserves for fish populations depends on site-specific factors, particularly enforcement history. *Biological Conservation*, *136*(4), 584-601.

Stockwell, B., Jadloc, C. R. L., Abesamis, R. A., Alcala, A. C., & Russ, G. R. (2009). Trophic and benthic responses to no-take marine reserve protection in the Philippines. *Marine Ecology Progress Series*, *389*, 1-15.

Taylor, B. M., McIlwain, J. L., & Kerr, A. M. (2012). Marine reserves and reproductive biomass: A case study of a heavily targeted reef fish. *PloS one*, *7*(6), e39599.

Veron, J. E. N. (2000). Corals of the World, vol. 1–3. *Australian Institute of Marine Science, Townsville*.

Veron, J.E.N.,& Wallace, C.C. (1984). *Scleractinia of Eastern Australia. Part V. Family Acroporidae. Australian Institute of Marine Science Monograph Series, 6,* 482. Canberra:Australian National University Press.

Veron, J.E.N. & Pichon, M. (1976). *Scleractinia of Eastern Australia. Part I. Families Thanmasteriidae, Astrocoeniidae, Pocilloporidae. Australian Institute of Marine Science Monograph Series,1,* 86. Canberra: Australian Government Publishing Service.

Veron, J.E.N. & Pichon, M. (1980). *Scleractinia of Eastern Australia. Part III. Families Agariciidae, Siderastreidae, Fungiidae, Oculinidae, Merulinidae, Mussidae, Pectiniidae, Caryophylliidae, Dendrophylliidae. Australian Institute of Marine Science Monograph Series,. Vol. 4,* 422.Canberra: Australian National University Press.

Veron, J.E.N. & Pichon, M. (1982). *Scleractinia of Eastern Australia. Part IV. Family Poritidae. Australian Institute of Marine Science Monograph Series, 5, 159.* Canberra: Australian National University Press.

Veron, J.E.N., Pichon, M.,& Wijsman-Best, M. (1977). *Scleractinia of Eastern Australia. Part II. Families Faviidae, Trachyphyllidae. Australian Institute of*

Marine Science Monograph Series, 3, 233.Canberra: Australian Government Publishing Service.

Wallace, C. C. (1999). *Staghorn corals of the world: A revision of the coral genus Acropora. Collingwood.* Victoria: CSIRO Publishing.

White, A. T., Vogt, H. P., & Arin, T. (2000). Philippine coral reefs under threat: The economic losses caused by reef destruction. *Marine Pollution Bulletin*, *40*(7), 598-605.


GILLMAN

Plant Diversity in the Forest Ecosystem of Bataan Natural Park, Philippines

Annie Melinda Paz-Alberto,
Shirly C. Serrano,
Daryl A. Juganas,
Institute for Climate Change and Environmental Management, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines
and Delia C. Llave
Bataan Peninsula State University, Dinalupihan, Bataan, Philippines

The diversity of plants at the forested areas of Bataan Natural Park (BNP) was assessed to determine the exploitation and conservation status of the forest ecosystem in Bataan, Philippines. Plants were collected, preserved, described, identified, and classified. The quantitative description of each plant species was determined for diversity assessment. Data were gathered using quadrat sampling method in the ten pre-selected stations. A total of 189 plant species were surveyed in the area, under 65 families of which belong to Moraceae, Rubiaceae, and Araceae. Trees, shrubs, vines and herbs are the most common, with some ferns, grasses and epiphytes and representatives of sedge and moss. Shannon's Diversity Index showed that the forest ecosystem in Bataan Natural Park exhibited high diversity. Jade vine, which is endemic to the country, is still present in the area but is already listed as endangered species in the International Union for the Conservation of Nature (IUCN) Red List of 2013. Fifteen species were endemic, 15 were introduced plant species, and two were invasive plant species. There were threats in the forest ecosystem which included timber poaching, kaingin practices, soil erosion, charcoal making, and wildlife hunting.

Keywords: Diversity, Plants, Endemic, Invasive, Degradation

INTRODUCTION

Bataan National Park (BNP) has a total land area of 18,335 hectares. It is bounded in the north by the Subic Forest and Watershed Reserve (SFWR) and the Municipalities of Dinalupihan and Hermosa. On the south, it is bounded

by the municipalities of Bagac and Balanga, on the west by the municipality of Morong, and on the east by the municipalities of Orani, Samal, and Abucay, facing Manila Bay (Ramirez, n.d.).

The BNP watershed is the main source of ground and surface water that caters to the needs of domestic, industrial, and agricultural sectors in the area. It is declared as a protected area under the National Integrated Protected Area System (NIPAS) Law (Bataan ICM Program, 2006).

Biodiversity refers to the variety of life in all its forms found on earth. It has to be conserved for it leads to a stable and balanced ecosystem, ideal for agriculture and forestry, a source for medicine, natural service for vegetative cover, recreational, aesthetic, ecotourism, scientific, and commercial values (Alberto, 2005). Likewise, natural plant biota serves to maintain air quality as they fix CO_2 release O_2 and help to assimilate other air pollutant by absorbing considerable solar radiation and by releasing water vapor through transpiration, they moderate temperature and help maintain climate (Cunningham & Cunningham, 2007).

As what Duelli and Orbist (2003) stated, biodiversity indicators could be used as quantifiable environmental factors. Therefore, regional and national agencies need to monitor species diversity before and after spending on subsidies, ecological compensation management, as well as research and development activities. The production of a threatened species list is very imperative to aid organizations working on environmental concerns to assess the potentially adverse impacts on species and to help inform conservation priorities (Possingham *et al*., 2002).

The study was conducted to assess the diversity of plants in the forest ecosystem of BNP, identify categories of plant species based on IUCN Red List, determine the presence of endemic and introduced species, and identify problems which contribute to environmental degradation of the forest ecosystem.

METHODOLOGY

Study Sites

Forested areas in Barangay Bangkal, Abucay, Bataan and the Bataan Peninsula State University (BPSU) reservation also located in Bangkal, Abucay, Bataan served as the study areas.

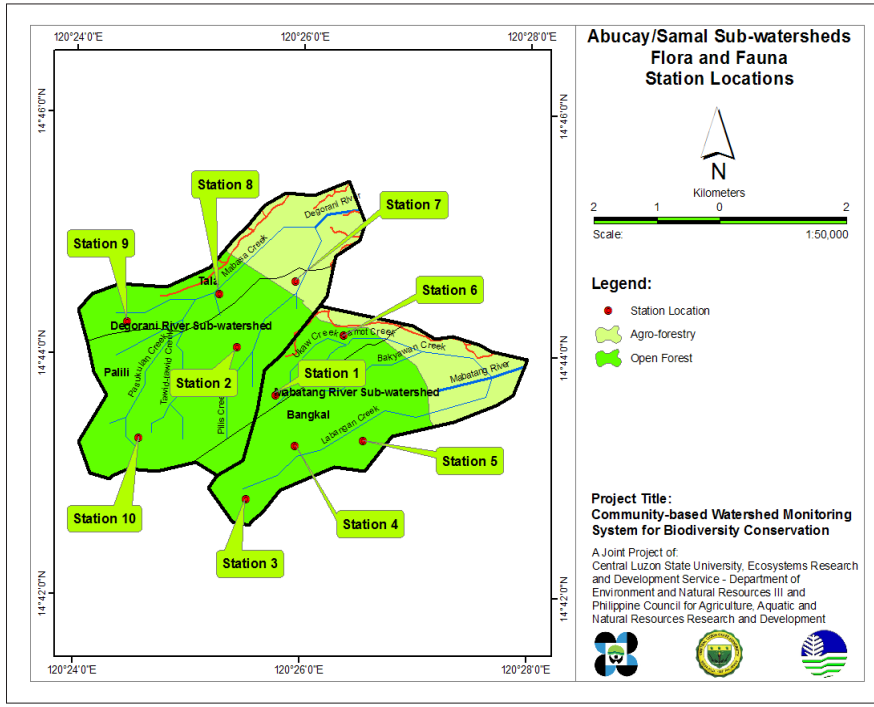


Figure 1. The map showing the locations of the different stations.

Barangay Bangkal has an estimated area of 1,154.95 has, which represents 14% of the total land area of the town, Abucay. The land area devoted to watershed consists of 100 ha; 80 ha were allotted for residential; 50 has to government establishment of the agricultural university, now the Bataan Peninsula State University, Abucay campus; and 453 hectares were awarded as community based forest management program areas. The remaining 471.95 hectares are designated as forest area and agricultural production of fruits, vegetables and upland rice. Bangkal serves as an important catchment area as a watershed, providing Bangkal and neighboring barangays with water. As a watershed, it serves as tributary to five major rivers in the area.

The sampling areas. There were ten preselected stations located within the forest ecosystem of Bataan Natural Park. Each station had ten quadrats with an area of 10 m x 12 m per quadrat. The study areas were located in Brgy. Bangkal, Abucay, Bataan and BPSU Reservation located in Brgy. Bangkal (Figure1). A total area of 12,000 sq. m. was surveyed in Bataan Natural Park.

Data gathering, documentation, and collection of samples

The local name, habit, number of individual plant per species, and the quadrats where they were present were recorded. The data were used to compute for the various ecological parameters such as frequency, relative frequency dominance, relative dominance, density, relative density, species importance value, and diversity index value.

The plants were photographed in their natural habitat. In case of very tall trees whose leaves were not observable due to their height and the understory trees that obscured viewing, barks or young individuals were photographed instead.

Samples were collected to aid in identification and to be preserved as herbarium specimens. As much as possible, parts with reproductive organs were collected. Small shrubs, ferns, mosses, and herbs were collected whole.

Specimens were also categorized based on the IUCN Red List of Threatened Species version 2013.

Information on uses of the plants recorded and associated beliefs if there were any were also gathered.

Sources and Level of Impacts of Environmental Degradation of the Terrestrial Ecosystems

The condition of the ecosystem was assessed through ocular inspections. Checklist 1, i.e. sources and level of impacts on environmental degradation of forest ecosystems (Alberto, 2005), was utilized.

The checklist was rated using the values 1-4 by a minimum number of ten evaluators from the DENR, CLSU, BPSU, and PCARRD, DOST to determine the present condition of the forest ecosystem. Four levels of impacts in each source of environmental degradation were used. For each level a value was assigned. The level of impact was estimated based on the percentage of impact/damage in the study area.

To get the mean of the answers of the respondents, the sum of the answers for each level was divided by the total number of respondents, and a scale was used to interpret the scores in the level of impacts on the environmental degradation of any ecosystem. This scale is presented in Table 1.

RESULTS

Assessment of Plants in Bataan Natural Park

There were a total of 189 plants observed in the forest ecosystems of Bataan Natural Park. Of the 189 plants, 165 had already been identified, of these 83 were identified up to species level, 58 species were identified up to genus level while 24 species were identified up to family level only. There were still 24 unidentified species.

Trees and shrubs made up most of the plants that were seen in the forest ecosystem. Several herbs, ferns, vines, and grasses were also observed in the study area. There were 83 tree species, 47 shrubs, 21 herbaceous plants, 14 vines, 13 fern species, two grasses, seven epiphytic plants, one sedge, and a single moss species (Figure 2).

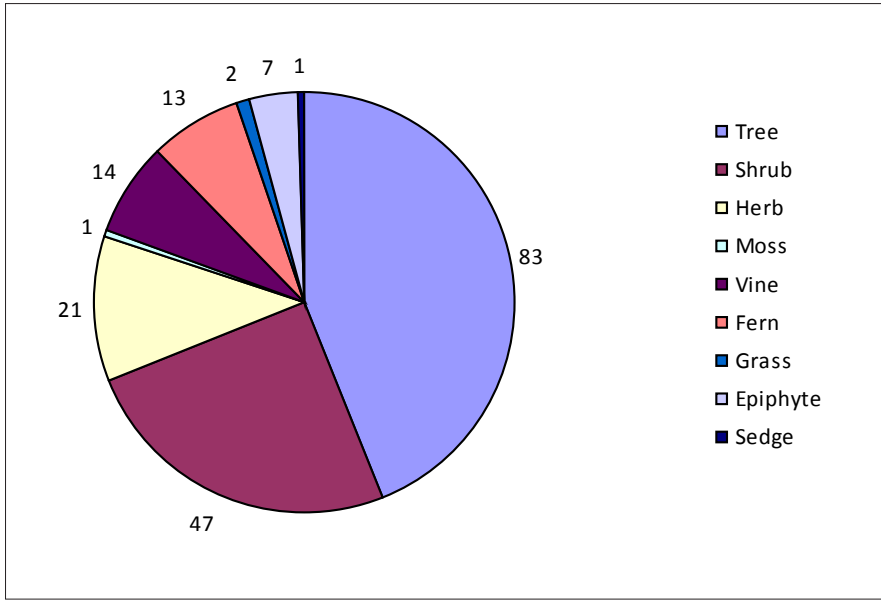


Figure 2. Types of plants observed at Bataan Natural Park

Identified plants were classified into 65 different families. Family Moraceae, Rubiaceae and Araceae had more than 10 representative species. Many of the families were represented by one to three different species only. Members of the genus *Ficus* had the most number of observed plants in the study area.

Station 10 exhibited the highest number of species with 75 recorded plants followed by Station 4 with 73 plants. Station 10 and Station 4 are located in land devoted to residual forest and forest plantation maintained by the DENR and Bangkal Bataan Upland Farmers Association, Incorporation (BBUFAI); thus, these areas are protected from anthropogenic activities such as logging/timber poaching and kaingin. Station 7 had the lowest number of species with only 26 plants. Station 7 is located in an agroforestry land cultivated by the locals and indigenous people for reforestation and agro forestry project (Table 2).

In addition, a member of Family Araceae, locally known as "gabi-gabihan" (*Aglaonema commutatum* Schott.) showed the highest percentage occurrence with 90% occurrence. "Kakawati" [*Gliciridia sepium* (Jacq.) Steud.], "balagtakan" (*Freycinetia apayaoensis* Merr.) and "yantok" [*Calamus usitatus* Blanco.] obtained 80% occurrence. One hundred fifty-seven (157) or about 83% of the plants had less than 50% occurrence.

As to the uses of the plants, eight trees, shrubs, and bamboo were harvested as source of wood and timber for various applications such as for construction, woodworking purposes, and production of charcoal. Twenty-two of the identified plants were used for medicinal purposes. Fifteen species produce edible fruits and leaves as well as spices.

Bambusa sp. in Station 6 at Brgy. Bangkal, Abucay, Bataan had the highest importance value index of 77.52%. *Bambusa sp.* is a member of a grass family that grows in clumps and is spread by rhizomes. The stems are hollow except the nodes; the long thin leaves are shed from the lower parts of the stem (James Cook University, 1995). This was followed by *Amphineuron terminans* (J. Sm.) Holttum in Station 4 and *Trichomanes thysanostomum* (Makino.) in Station 3 with 76.01% and 63.75% IVI, respectively (Table 3).

"Lokdo" *A. Terminans* is a long creeping ornamental plant usually found in areas with distinct dry season, and *T. thysanostomum* is a filmy terrestrial or epiphytic fern found commonly on wet shaded rocks of cliffs ranging from 400-400 masl. In addition, *Calamus usitatus* (Blco.) in Station 9 had the lowest IVI of 14.53%. *C. usitatus* is a slender to moderate clustering, thicket-forming rattan with stems to rarely more. It is widespread in the Philippines and is used for tying purposes, baskets, fish traps; apparently, it is fairly durable (PALMweb, n.d.).

Critically Endangered, Endangered, Vulnerable, Near Threatened and Least Concerned Plant Species in Bataan Natural Park

Out of the 189 plants observed at Bataan Natural Park, eight were listed in the IUCN Red List 2013.1 (Table 4). Jade vine (*Strongylodon macrobotrys* A. Gray), considered as one of the plants with the most beautiful flowers in the world and is endemic to the Philippines, was evaluated as endangered. The population of this vine in Bataan is threatened by logging of trees for charcoal production. Three other plants recorded were endemics listed as vulnerable such as "antipolo" [*A. blancoi* (Elm.) Merr.],"is-is" (*F. ulmifolia* Lam.) and "pahutan" (*Mangifera altissima* Blanco). Based on the DAO 2007-01 list of threatened species, *Medinilla magnifica* Lindl. was listed as endangered while *Mangifera altissima* Blanco and *Asplenum nidus* L. were listed as vulnerable.

Endemic, Introduced and Invasive Plant Species in Bataan Natural Park

Fifteen plant species were found out to be endemic to the country and Southeast Asia (Table 5). Of these, eight species were endemic only in the Philippines and seven species are both endemic in Philippines and Southeast Asia. Aside from the endemic species recorded, there were also introduced species. So far, there were five species which were non-native to the Philippines. Two of these were trees: *Gliciridia sepium* (Jacq.) Steud. and *Gmelina arborea* Roxb. Currently, there is an order to cut down all the paper trees present within the forest area since they tend to disrupt normal water cycle by absorbing almost all water present near them. There were also two introduced and invasive plants such as *Chromolaena odorata* (L.) R.M. King and H. Robinson and *Lantana camara* L.

Diversity Indices of the Plants in Ten Stations Located at Bataan Natural Park

The diversity indices of the plants for the various stations in Bataan Natural Park is shown in the diversity index map (Figure 3). Station 9 which had 55 plant species and 1638 number of individuals obtained the highest value for Shannon's Diversity Index, with 3.801 as its diversity value index. This is followed by Station 10 with 3.746 diversity index

value. Station 7 recorded the lowest biodiversity index value for plants among the stations, with only 3.074. Still, this shows that the area has high floral diversity. All the stations showed high to very high diversity of plant species.

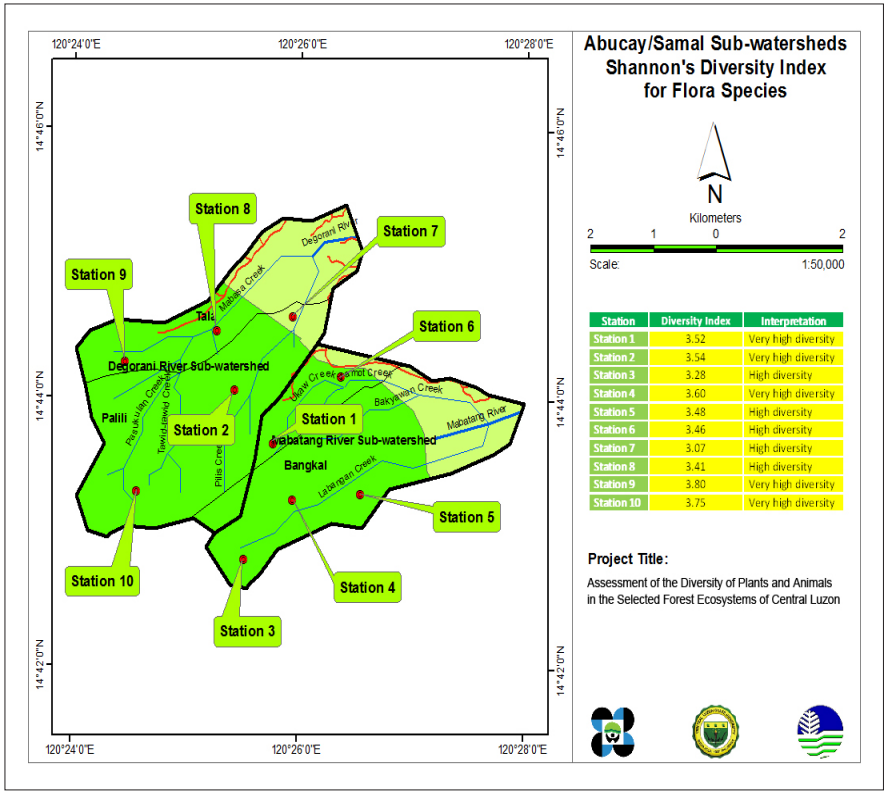


Figure 3. Diversity index map of fora in Bataan Natural Park

Major Sources of Environmental Degradation in the Forest Ecosystem of Bataan Natural Park

Illegal logging or timber poaching posed moderate impact to the forest ecosystem of Bataan Natural Park. It was observed that there is logging/ timber poaching going on in the immediate areas near the watershed; however, according to the respondents, this was for construction of their houses and charcoal making, which is part of their livelihood activities in the community.

Most of the threats in the forest ecosystem of Bataan Natural Park were caused by activities which are part of the livelihood of the Aetas in the area. Areas near the foot of the mountain were often cleared for kaingin. Mango, pineapples, and vegetables were the common crops planted in these areas (Table 6).

Another threat was the harvesting of bamboo utilized by the community for their personal use or as marketable goods. Charcoal making was also observed in the area. Oftentimes, parts of the forest near the water systems also served as area for making charcoal which is one of the main income generating products of the community.

The Aetas, being expert hunters hunt wildlife as part of their culture. Many of these animals were caught as food, while others served as pets and the animals were being sold for money. Hunted animals include monitor lizards, phytons, flying foxes, and birds.

DISCUSSION

Generally, BNP is rolling to moderately steep with portions of flat and steep topography. Elevation ranges from 300 to 400 meters above sea level. It is drained with Baksawan River and Yamot Creek which consist of major water sources in the locality. It has two distinct seasons: wet and dry seasons; wet season starts in May and ends in October while the rest of the year is dry with occasional rains. The average rainfall is 1, 203.70 mm and the temperature throughout the year ranges from 25-30 °C.

The soil composition is generally Anti-polo series characterized by its reddish brown to almost red color with friable clay surface comprising the Hydrosol (de Guzman, 2010).

The major land use types found in BNP are forests and reservation areas. Due to the physical factors present in the area, the forest ecosystems are favorable to have good growth for trees and other plants; hence, the result of the diversity assessment study is still high.

Several herbs, ferns, vines, and grasses were also observed in the study area. There were 83 tree species, 47 shrubs, 21 herbaceous plants, 14 vines, 13 fern species, two grasses, seven epiphytic plants, one sedge and a single moss species. However, there were four species of plants which were found to occur in most stations that were surveyed and these are *Aglaonema commutatum* Schott (gabi-gabihan), *Gliciridia sepium (*Jacq) Steud (kakawate), *Freycinetia apayaonensis* Merr (balagtakan) *and Calamus usitatus* Blanco (yantok).

Gliricidia sepium is a small to medium-sized, thornless tree which usually attains a height of 10-12 m. Branching is frequently from the base with basal diameters reaching 50-70 cm. The bark is smooth and can vary in colour from whitish grey to deep red-brown. The stem and branches are commonly flecked with small white lenticels. Trees display spreading crowns. Despite mixed perceptions of gliricidia as a forage crop, it has been widely promoted by development agencies and researched, due largely to its high productivity and quality. Interest has increased in recent years following the widespread defoliation of *Leucaena* by psyllid. Gliricidia is one of the few forage trees capable of leaf and will grow on a wider range of soils, tolerating low pH provided that this is not associated with high aluminium saturation. Recently they are being been integrated into farming practices for poles, firewood, hedges, forage, green manure, and soil stabilization (Suttie, 2016).

Oncosperma horridum is a slender, tall, clump-forming palm, with usually 6 - 12 mature stems per clump. The plant is particularly valued in its native range for its edible, apical bud which is gathered from the wild. The tree also provides a useful timber. It is commonly observed in Valleys or hill slopes in rainforests at elevations up to 1,500 metres with their crowns sometimes reaching up to the canopy of the rainforest (Fern, 2014).

A. *commutatum,* known as the Philippine evergreen loves shady tropical forest habitat. It is perennial herbs with stems growing erect or decumbent and creeping. Stems that grow along the ground may root at the nodes ("How to survive", 2015)

However, it is very interesting to note that introduced species or invasive plants are already present in the study area.

Chromolaena odorata which is a candidate for one of the top 100 worst weeds in the world and tolerates a wide range of soil conditions and severe drought is already present in the area. It rapidly forms dense thickets in disturbed/cleared areas and could create a fire hazard. It has also an allelopathic property (prevents other plants from growing nearby) and could be an allergen/toxic to humans (causes skin problems and asthma in allergy-prone people). This species can also be toxic to animals, causing diarrhea and death in extreme cases; can host recognized pests and pathogens that can grow and spread from cut stems; can mature in a year and begin producing seed; and can produce many wind-dispersed seeds (up to 800,000 per plant) persisting more than a year in soil. And its seeds are easily spread unintentionally by hikers, vehicles, equipment, and mammals (OISC, n.d.).

Management and control of this invasive plant should be done before it could affect and harm the endemic and native plant species in the forest ecosystems of BNP. Results revealed that at the present time this plant has no significant impact yet in the forest ecosystems of the BNP, but in time, if no management action will be made, this invasive plant can lead to loss of diversity of plants in the watershed.

A number of environmental conditions posed threats to the forest ecosystems in BNP. Illegal logging or timber poaching showed high value with moderate impacts to the forest ecosystems.

Lands near the foot of the mountain and even in higher areas were used for cultivating vegetables such as tomatoes and eggplants. The soil of these areas is often exposed after harvest season, making them vulnerable to soil erosion and landslides during rainy season. Evidences of timber poaching were also observed in one of the field days of the research team; trees were being harvested with a chainsaw and the farmers admitted that this practice is rampant due to low income of the people living nearby. Wildlife hunting also posed small impact on the forest ecosystem. During the duration of the study, selling of the local community of monitor lizards and "labuyo" were observed. It was found out that these animals were trapped/hunted in the forest.

CONCLUSIONS

Bataan Natural Park has "high diversity" in terms of its plants species. There are still many endemic plants species thriving in the National park which need to be conserved and protected. Anthropogenic activities such as illegal logging/ timber poaching, kaingin practices, charcoal making, and wildlife hunting are the main contributors in the degradation of the forest ecosystem.

RECOMMENDATIONS

The research team recommends further studies on the flora of the other areas not surveyed during the duration of the study. These include the forest areas in other mountains present in the other side, facing Subic Bay Metropolitan Area and Zambales. It is also recommended that intensive survey on the economic uses of the plants be done with interviews of the

local community. Collection of samples is better done during months when trees are most likely to bloom (November to January). This is to make sure that identification of plants will be easier. Moreover, further studies on the impacts of invasive species should be conducted in the BNP to verify the extent of growth and distribution as well as damage on the endemic and native trees in the watershed. Results could be used as guide in the establishment of ecological tourism spot for forest ecosystems in Central Luzon.

ACKNOWLEDGMENT

The authors would like to thank the following: PCAARRD – DOST for the funding support; CENRO-Muñoz for the secondary data they shared; military detachments of the respected barangays for ensuring the safe passage of the research team and the National Museum of the Philippines for the identification of several species.

AUTHOR NOTE

*Annie Melinda Paz-Alberto is University Professor and Director, Institute for Climate Change and Environmental Management, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, 3120; melindapaz@gmail.com
*Shirly C. Serrano is Faculty, Institute for Climate Change and Environmental Management, Central Luzon State University; scserrano@yahoo.com
*Daryl A. Juganas is Science Research Assistant, Institute for Climate Change and Environmental Management, Central Luzon State University.
*Delia C. Llave is Faculty, Bataan Peninsula State University, Dinalupihan, Bataan, Philippines.

Table 1 Scale for the levels of impact of environmental degradation.

SCALE	IMPACT LEVEL
1.01 – 1.75	No Significant Impact
1.76 – 2.50	Small Impact
2.51 – 3.25	Moderate Impact
3.26 – 4.00	Major Impact

Table 2 Summary of the occurrence of plants present in Bataan Natural Park, Abucay, Bataan

Station	Number of Species Occurred/Station
Station 1 (Bgry. Bangkal, Abucay)	50 Species
Station 2 (Bgry. Bangkal, Abucay)	54 Species
Station 3 (Bgry. Bangkal, Abucay)	55 Species
Station 4 (Bgry. Bangkal, Abucay)	73 Species
Station 5 (Bgry. Bangkal, Abucay)	48 Species
Station 6 (Bgry. Bangkal, Abucay)	50 Species
Station 7 (Bgry. Bangkal, Abucay)	26 Species
Station 8 (Bgry. Bangkal, Abucay)	36 Species
Station 9 (Bgry. Bangkal, Abucay)	55 Species
Station 10 (Bgry. Bangkal, Abucay)	75 Species

Table 3 Importance value index of flora per station in Bataan Natural Park, Abucay, Bataan

Station	Scientific Name	IVI
Station 1	Alpinia haenkei Presl.	18.01
Station 2	SP 10 (Unidentified)	59.76
Station 3	Trichomanes thysanostomum (Makino.)	63.75
Station 4	Amphineuron terminans (J. Sm.) Holttum	76.01
Station 5	Lygodium circinnatum (Burm.) Sw.	29.29
Station 6	Bambusa sp.	77.52
Station 7	Trichomanes thysanostomum (Makino.)	39.01
Station 8	Alocasia sp.	44.85
Station 9	Calamus usitatus (Blco.)	14.53
Station 10	Amphineuron terminans (J. Sm.) Holttum	38.19

Table 4 Critically endangered, endangered, vulnerable, near threatened and least concerned species observed at Bataan Natural Park, Bataan

Species	Ecological Status	
	IUCN 2013.1	**DAO 2007-01**
Strongylodon macrobotrys A. Gray	Endangered	---
Artocarpus blancoi (Elm.) Merr.	Vulnerable	---
Ficus ulmifolia Lam.	Vulnerable	---
Mangifera altissima Blanco	Vulnerable	Vulnerable
Calophyllum inophyllum L.	Least concern	---
Coffea arabica L.	Least concern	---
Colocasia esculenta (L.) Schott.	Least concern	---
Knema glomerata (Blco.) Merr	Least concern	---
Medinilla magnifica Lindl.	---	Endangered
Asplenum nidus L.	---	Vulnerable

Table 5 Endemic, introduced and invasive species observed at Bataan Natural Park, Bataan

Species	Ecological Status
Strongylodon macrobotrys A. Gray	Endemic (Philippines)
Artocarpus blancoi (Elm.) Merr.	Endemic (Philippines)
Ficus ulmifolia Lam.	Endemic (Philippines)
Mangifera altissima Blanco	Endemic (Philippines and Southeast Asia)
Aglaonema commutatum Schott.	Endemic (Philippines and Southeast Asia)
Areca catechu L.	Endemic (Philippines)
Caryota mitis Lour.	Endemic (Philippines and Southeast Asia)
Ficus nota (Blco.) Merr.	Endemic (Philippines and Southeast Asia)
Livistona rotundifolia (Lam.) Mart. *var. luzonensis* Becc.	Endemic (Philippines)
Macaranga grandiflora (Blco.) Merr.	Endemic (Philippines)
Medinilla magnifica Lindl.	Endemic (Philippines)
Melicope triphylla (Lam.) Merr.	Endemic (Philippines and Southeast Asia)
Oncosperma horridum (Griff.) Scheff.	Endemic (Philippines and Southeast Asia)
Schizostachyum lumampao (Blco.) Merr.	Endemic (Philippines)
Spathiphyllum commutatum Schott.	Endemic (Philippines and Southeast Asia)
Chromolaena odorata (L.) R.M. King & H. Robinson	Introduced, invasive
Gliciridia sepium (Jacq.) Steud.	Introduced
Gmelina arborea Roxb.	Introduced
Lantana camara L.	Introduced, invasive
Philodendron lacerum (Jacq.) Schott.	Introduced

Table 6 Major sources of environmental degradation observed at the forest ecosystem of Bataan Natural Park, Abucay, Bataan

Sources of environmental degradation	Computed value	Interpretation
Illegal logging/ Timber poaching	2.63	Moderate impact
Soil erosion/ silt run-off	2.38	Small impact
Charcoal making	2.30	Small impact
Kaingin/ Shifting cultivation	2.19	Small impact
Wildlife hunting	2.12	Small impact

REFERENCES

Alberto, A.M.P. (2005). *Biodiversity*. Nueva Ecija, Philippines: Environmental Management Institute. Central Luzon State University, Science City of Muñoz.

Bataan ICM Program (2006, December). The Bataan sustainable development strategy. Retrieved from pemsea.org/sites/default/tiles/bataan-sds.pdp

Cunningham, W.P., & Cunningham, M.A. (2007). *Principles of environmental science: Inquiry and application* (4th ed). Asia: McGraw-Hill Education.

Duelli, P., & Orbist, M.K. (2003). Biodiversity indicators: The choice of values and measures. *Agriculture Ecosystems and Environment*. Retrieved from www. science direct.com

Fern, K. (2014). *Useful tropical plants database* (web interface by Ajna Fern with help from Richard Morris.). Retrieved from http://manoa.hawaii.edu/hpicesu/DPW/chrodo_flier.pdf

How to survive your first Aglaonema Commutatum. (2015). Retrieved from tipsplants.com/community/plant-care/how-to-survive-your-first-aglaonema-commutatum.

James Cook University. (1995). Bambusa spp. Retrieved from https://www.jcu.edu.au/discover-nature-at-jcu/plants/plants-by-scientific-name2/bambusa-spp.

OISC. (n.d.). Chromolaena odorata. Retrieved from manoa.hawaii.edu/hpicesu/chrado_flier.pdf

PALMweb. (n.d.) Calamus usitatus Blanco, FI: Filip.: 265 (18367). Retrieved from www.palmweb.org/cdm_dataportal/taxon/54f7183-0698-4368-92ad-e38c3ee5cce4

Possingham, H.P., Andelman, S.J., Burgman, M.A., Medellin, R.A., Master, L.L., & Keith, D.A. (2002). Limits to the use of threatened species lists. *Trends in Ecology and Evolution*, *17*(11).

Ramirez, M.G. (n.d.). Bataan National Park: Eco tourism management plan. Retrieved from http://www.scribd.com/document/329597645/Bataan-National-Park


GILLMAN

The Ecotourism-Based Administration and Development of Pandin Lake, San Pablo City, Philippines[1]

Bing Baltazar C. Brillo
Institute for Governance and Rural Development
College of Public Affairs and Development
University of the Philippines
Los Baños, Laguna, Philippines

Rhina A. Boncocan
Department of Social Sciences
College of Arts and Sciences, University of the Philippines Los Baños, Laguna, Philippines

This study assesses the administration of Pandin Lake for ecotourism development. Premised on ecotourism's benefits to the lake (specifically, in providing livelihood to residents and in ensuring the conservation of the natural resource), the paper contends that the ecotourism in Pandin Lake evolved completely due to a local community initiative, without the involvement of its two administrative agencies— the Laguna Lake Development Authority (LLDA) and the City Government of San Pablo City. It further argues that in sustaining the success of ecotourism and in dealing with the current issues in Pandin Lake (particularly, the need for a zoning development plan, the need to further develop the lake for tourism and the need to address the threat on the ecotourism enterprise), the local community organization, Samahang Mangingisda ng Lawa ng Pandin (SMLP), needs the intervention and commitment of the LLDA and the City Government. This study addresses the dearth in lake literature in the Philippines – a field dominated by natural science-based studies such as in limnology and aquaculture, and overwhelmingly concentrated on big lakes. The paper focuses on the area of development-governance of a small lake in the country.

Keywords: Administration, Development, Ecotourism, Pandin Lake, Philippines and Small Lake

1 This study is part of a long-term research project of documenting and conducting development studies on small lakes in the country.

INTRODUCTION

Conceptualized in 2003, the Pandin Lake Tour project gradually transformed into a full-fledged ecotourism enterprise. Managed by the local community organization, Samahang Mangingisda ng Lawa ng Pandin (SMLP), the ecotourism enterprise in Pandin Lake has provided residents a steady source of income, has empowered the locals (especially the women who have played an active role in the formation of the ecotourism enterprise as well as in its present-day operations), and has administered the conservation of the water resource. SMLP's efforts have resulted in Pandin Lake being consistently regarded as the best managed and the cleanest among the seven crater lakes of San Pablo.[2] With these achievements, Pandin Lake has become a premier tourist destination in the city (rivaling Sampaloc Lake[3]) and a potential model of sustainable development for a small lake in the Philippines.

Local development programs are typically a function of the local government unit or the specialized agency created to manage the natural resource. However, ecotourism in Pandin Lake developed unconventionally since it evolved mainly despite the absence of government involvement. In particular, the ecotourism project was established without any development plan or financial support from the two administrative agencies of Pandin Lake, the LLDA and the City Government. Taking off from this, the study assessed the ecotourism administration and development that transpired in Pandin Lake. The study proceeded to explain the following: first, the importance of addressing the shortfall in administrative-development studies and small-lake studies in the Philippines; second, the current status and administration of Pandin Lake, a small lake; third, the development of ecotourism in Pandin Lake; and finally, issues threatening the modest gains of the ecotourism enterprise and why it is critical for the administrative agencies to be involved.

STUDYING PHILIPPINE LAKES, SMALL LAKES AND PANDIN LAKE[4]

Since water is essential to maintain life, lakes are undeniably critical resources for human survival and well-being. Lakes are estimated to contain over ninety percent of the liquid freshwater on the earth's surface (Shiklomanov,

2 Together with its twin lake— Yambo Lake.
3 Sampaloc Lake is traditionally the tourism emblem of San Pablo City. The lake is located within the city proper and the biggest among the seven lakes of San Pablo.
4 Portions of this section were derived from the previous works of the author on Philippine lakes.

1993; ILEC, 2007; Rast, 2009; Nakamura & Rast 2011, 2012). These lakes provide mankind's needs from the basic – nourishment and transportation – to industrial-agricultural uses such as irrigation, fisheries, flood and drought management, and hydroelectric power. Humans also value lakes for other functions: tourism, recreation, religious, and historical values. In addition, lakes provide life-supporting services to the ecosystem through climate mediation, nutrient cycling, and preservation of biodiversity.

Through the years, human impacts such as population growth, intensive food production, industrial development and massive urbanization have become direct threats, bringing degradation to many lakes around the world. The existence of many lakes is put at risk by eutrophication, acidification, toxic contamination, water-level changes, salinization, siltation, overfishing, and exotic species/weed infestation (Kira, 1997; Bronmark & Hansson, 2002; World Lake Vision Committee, 2003; ILEC, 2005). This global trend has been confirmed by the Global Environment Facility-Lake Basin Management Initiative (GEF-LBMI) study of 28 major lakes around the world from 2003 to 2005.[5] Similar ecological threats endanger many lakes in the Philippines including organic pollution, high concentration of heavy metals, organophosphates and organochlorines, high sedimentation and oil contamination (Malayang, *et al.*, 2002). This was also reported during the First National Congress on Philippine Lakes held in 2003 (Cuvin-Aralan *et al.*, 2005). The Second National Congress on Philippine Lakes held in 2011 body declared that lakes in the country remain vulnerable despite incremental improvements (LakeCon2011, 2011).

Under the backdrop of deteriorating conditions, lake studies in the country have been increasing through the years. However, most of the scholarly works were natural-science-based, particularly limnology and aquaculture studies, and are heavily concentrated on the big lakes, namely Laguna de Bay, Taal Lake, Naujan Lake, Lake Lanao, Lake Mainit, Lake Buluan, Lake Buhi and Lake Bato[6] (e.g. Pantastico & Baldia, 1981; Petersen & Carlos, 1984; Santiago, 1988; Cardenas *et al.,* 1988; Manalili & Guerrero, 1995; Fellizar, 1995; Platon, 2001; Guerrero, 2001; Araullo,

5 The 28 lakes studied: Aral Sea, Baikal, Baringo, Bhoj Wetland, Biwa, Chad, Champlain, Chilika Lagoon, Cocibolca/ Nicaragua, Constance, Dianchi, Great Lakes (N. American), Issyk-Kul, Kariba Reservoir, Laguna de Bay, Malawi/ Nyasa, Naivasha, Nakuru, Ohrid, Peipsi/Chudskoe, Sevan, Tanganyika, Titicaca, Toba, Tonle Sap, Tucurui Reservoir, Victoria, and Xingkai/Khanka.

6 Laguna de Bay (93,000 ha), Lake Taal (23, 420 ha), Lake Naujan (8,125 ha), Lake Lanao (34,000 ha), Lake Mainit (17,340 ha), Lake Buluan (6,134 ha), Lake Buhi (1,707 ha) and Lake Bato (2,810 ha).

2001; Mercene-Mutia, 2001; Zafaralla, 2001; Siringan & Jaraula, 2005; Roa *et al.*, 2005; Guerrero 2005).[7] This highlights the scarcity of scholarly outputs in Philippine lake studies on two areas: one, on social-science-based, particularly administrative-development studies; and two, on small-lake research (i.e. lakes with a surface area of only 200 hectares or less) (Brillo 2015a).[8]

A significant number of administrative-development studies and small-lake studies are necessary to address this scholarly imbalance. To enhance better understanding of issues and problems in water resource management and conservation, administrative-development studies must also progress along with natural science-based studies. The two perspectives are essential in clarifying the complexities and in pointing out the appropriate solutions to water resource issues and problems. While natural science-based studies have advanced steadily, administrative-development studies have yet to move forward and deal with the shortfall in scholarship. Not engaging both perspectives can pose barriers to attaining more integrative analyses and resolutions to water resource concerns.

Small lakes comprised the majority of the existing lakes in the country (around 70 percent), yet little information was written about them as shown by the very few lists of such lakes that exist. The Philippine Council for Aquaculture and Marine Research and Development (PCAMRD) revealed only 72 known lakes (in Guerrero, 2001); this list did not include many small lakes and many ones on the list need to be verified. The World Lake Database of the International Lake Environment Committee Foundation (ILEC) registered only the five major Philippine lakes and no small lake.[9] The LakeNet Global Lake Database[10] and the Wikipedia's list of Philippine lakes[11] recorded only 42 and 94 lakes, respectively, in which a substantial number of small lakes were unaccounted for. The Philippine Lakes Network (PlaNet), which was conceived in LakeCon2003 to comprehensively supply data on Philippine lakes, still had to take off and account for small lakes.[12] This lack of

7 The most extensive studies are on Laguna de Bay.

8 The author arrived at the '200 hectares or less' threshold by surveying the sizes of the least-studied lakes in the country.

9 Listed lakes: Lake Bato, Lake Buhi, Laguna de Bay, Lake Lanao and Lake Taal (http://wldb.ilec.or.jp/LakeListCountryCode.asp?CountryCode=PH&RoutePrm=0%3A%3B6%3Aload%3B).

10 http://www.worldlakes.org/searchlakes.asp?countryid=461&Submit2=Search

11 http://en.wikipedia.org/wiki/List_of_lakes_of_the_Philippines

12 The key proponents of PLaNet, Dr. Raymundo Punongbayan, Dr. Norman Tungol and Dr. Jessie Daligdig, died in a tragic helicopter crash in 2005.

information on small lakes was due to (a) the perception that they were less important compared to large lakes. This led to tangential peripheral attention from government agencies, private-funding institutions and scholars, and (b) the small lakes' geographical remoteness which means more resources required to study them (Brillo 2015b; Brillo 2015c).

There are three reasons why it is vital to take up the challenge of addressing the deficit in small lakes studies: (1) a shorter time span for ecological degradation to become irreparable and permanent; (2) the necessity of information required to avert deterioration; and (3) the need to document the water resource for posterity. First, small lakes are inherently more fragile and vulnerable to environmental degradation compared to big lakes. Due to their physical size, small lakes have reduced absorptive capacity to neutralize pollutants and these lakes reach ecological irreversibility faster. Second, critical information is required if the precarious conditions of small lakes are to be improved. Expansion of the knowledge base is fundamental in properly managing and preserving the natural resource. Third, small lakes must be documented for future generations given that while all lakes eventually die, small lakes perish faster than big lakes (Brillo 2015b; Brillo 2015c). It is especially important to study small lakes in the Philippines because of their vast number and the role they play in improving impoverished conditions of many lakeside communities through aquaculture and ecotourism.

The above-mentioned gap in administrative development and small Philippine lake studies, and the importance of addressing such gap brought about this study on Pandin Lake, with the objective of documenting the small lake and assessing its administrative and ecotourism development. Except for news articles and internet blogs,[13] there are few scholarly materials on Pandin Lake, especially in areas of management and development (in Guerrero, 2001; LakeCon2011, 2011). Expectedly, the few materials found are studies in limnology (specifically water quality assessment) and aquaculture (LLDA, 2005; LLDA, 2008; Zafaralla, 2010).[14] Furthermore, explaining and sharing the success story of ecotourism in Pandin Lake is probably the best impetus in precipitating and influencing the development-conservation of many other small lakes in the country.

13 Pandin Lake is probably the most blogged-about lake in the country.

14 The two written works on ecotourism in Pandin Lake are unpublished student reports (see Abao E. et al. 2010 and Atiqah B. J. et al. 2012).

THE CURRENT STATUS AND ADMINISTRATION OF PANDIN LAKE[15]

Pandin Lake is located in Barangay Santo Angel, San Pablo City[16] and is one of the city's seven crater lakes.[17] With a surface area of only 24 hectares, it is considered a small lake (LLDA, 2005). It is about eight kilometers from the city proper, and is accessible through an entry path via Werner Schetelig Avenue in Barangay Santo Angel. Pandin Lake is shaped like a circle and is considered a catchment area of Mount San Cristobal, just like the other six crater lakes. The lake is widely believed to be volcanic in origin, formed through a phreatic eruption when shallow lava from Mount San Cristobal flowed into groundwater causing an explosion that resulted in a crater-like depression (LLDA, 2008). The lake's water comes from rainfall, surface runoff, and surrounding natural springs; it discharges through seepage, evaporation, and outflow to Palakpakin Lake via a Prinsa creek, the lake's only outlet.

The practice of tilapia cage farming spread to the seven crater lakes after the LLDA successfully introduced it in Laguna de Bay in 1974 (Radan 1977; MNR 1982). This began with Bunot Lake in 1976. However, unlike in the other crater lakes where tilapia cage farming became extensive, aquaculture in Pandin Lake was limited. This was largely due to Pandin Lake being oligotropic— poor in nutrients, low in organic matter and high in dissolved oxygen level (e.g. its phytoplankton counts were considerably low compared to the rest of the crater lakes). This condition prolongs the culture period of fish stocks and requires more feeding which, in turn, makes fish farming more costly (LLDA, 2005). The recent efforts by lake residents and members of the SMLP to abide by the 10 percent limit rule on the total area allotted for fish structures on the lake which was prescribed by the Philippine Fisheries Code (see Republic Act [RA] 8550, section 51) served as another barrier to aquaculture expansion. In 2005, the LLDA reported that only three percent of Pandin Lake contained aquaculture structures. In 2013, the Provincial Government of Laguna claimed that there were only 14 registered fish pen operators in the lake (LLDA, 2005; Provincial Government of Laguna, 2013). The insignificant number of fish farming operations has allowed Pandin

15 Portions of this section were derived from the previous works of the author on Philippine lakes.
16 Pandin Lake and Yambo Lake are considered twin lakes.
17 The seven lakes are Sampaloc (104 ha), Bunot (30.5 ha), Calibato (43 ha), Mohicap (22.89 ha), Palakpakin (47.98 ha), Pandin (24 ha), and Yambo (30.5 ha).

Lake to avoid the many problems associated with proliferation of fish cages common to the seven crater lakes (e.g. water pollution, illegal settlements, and algal blooms).

Pandin Lake is governed by a multitude of overlapping laws and is managed by the LLDA and the City Government of San Pablo.The mandate of the LLDA was derived from The Laguna Lake Development Authority Act of 1966 (as amended by Presidential Decree 813, October 1975) or RA 4850, the main law in the administration of Laguna de Bay— the largest lake in the country, with a watershed area which includes the seven crater lakes of San Pablo City. RA 4850 established the LLDA and designated it as the main agency to supervise and manage the water bodies in the Laguna de Bay region (see RA 4850, section 1 and section 4).[18] It is the primary responsibility of the LLDA to promote the development of the Laguna de Bay region, while ensuring environmental management and control, preserving of the quality of life and ecological systems, and preventing undue ecological disturbance, deterioration, and pollution (LLDA, 2005).

Executive Order No. 927, issued by President F. Marcos in December 1983, gave the LLDA exclusive rights over the lakes in the Laguna de Bay region. In this arrangement, the LLDA had principal concern over Laguna de Bay while its jurisdiction over the seven crater lakes as part of the watershed was incidental. The disadvantage of this administrative arrangement was that the attention and resources of the LLDA were focused on Laguna de Bay. The small lakes within the region— the seven crater lakes and Tadlac Lake— only received marginal consideration.

The mandate of the City Government, on the other hand, came from The Local Government Code of 1991 or RA 7160, which had given the local government unit the authority over Pandin Lake – its municipal water. There was a "coordinative-supplementary" arrangement between the LLDA and the City Government as RA 4850 conferred the administration of Pandin Lake to the LLDA while RA 7160 bestowed the City Government territorial jurisdiction. This was formalized in a Memorandum of Agreement (MOA) signed by the LLDA and the City Governments of Laguna in 1997.[19] The LLDA was in charge of overall

18 The Laguna de Bay region includes the Provinces of Rizal and Laguna; the Cities of San Pablo, Pasay, Caloocan, Quezon, Manila and Tagaytay; the Towns of Tanauan. Sto. Tomas and Malvar in Batangas Province, the Towns of Silang and Carmona in Cavite Province; the Town of Lucban in Quezon Province, and the Cities of Marikina, Pasig, Taguig, Muntinlupa, and Pateros in Metro Manila.

19 MOA was signed by the LLDA General Manager, the Governor of Laguna and the Mayors of San Pablo City, Nagacarlan, and Rizal. Nagcarlan and Rizal towns have area jurisdiction over a part of Yambo Lake and Calibato Lake, respectively.

management, laid down the comprehensive development framework, and had the authority to approve plans and projects submitted by the City Government. Meanwhile, the City Government developed plans and projects to implement the LLDA's strategy, enacted the necessary ordinances, and enforced LLDA's regulations through the police force and the barangay units. This tactical role gave the City Government leverage over the LLDA's supposedly higher authority, as enforcement of the latter's regulatory actions on the seven crater lakes were almost always dependent on the former's cooperation and assistance. Problems arose when the City Government was unwilling to enforce LLDA's directives (e.g. demolition of illegal settlers) or when the LLDA delayed its decision over projects submitted by the City Government.

The LLDA and the City Government also utilized the Fisheries and Aquatic Resources Management Council (FARMC) in its administration of the seven crater lakes. The council was the principal organization mandated by law, specifically the Philippine Fisheries Code of 1998 or RA 8550, to assist government agencies in the management, utilization, and preservation of the water resources throughout the country. The FARMCs were created from the national level to cities and municipalities and set up locally by fisherfolk organizations and NGOs in the locality with the assistance of the government agencies. In the Laguna de Bay region, FARMCs' formation and supervision, which according to the Philippine Fisheries Code is under the Department of Agriculture, was devolved to the LLDA in recognition of its exclusive jurisdiction. The Philippine Fisheries Code also guaranteed the organization's funding (see section 79) and provided that the FARMC be multi-sectoral in its composition (see section 75). In Pandin Lake, however, the membership of FARMC lacked diversity, as its organization was mainly led by and consists of fisherfolks and lake residents, particularly members of the Samahang Mangingisda ng Lawa ng Pandin (SMLP). FARMC is also limited in funding, with its leaders often complaining of inadequate funds to effectively execute and sustain the responsibilities of the organization.

Besides the Philippine Fisheries Code, the two other laws that were relevant on the management and development of Pandin Lake were the Philippine Clean Water Act of 2004 or RA 9275 and the Tourism Act of 2009 or RA 9593. While, in principle, the laws balance and complement each other, these are also a source of divergence on the ground since each

statute holds disparate programs over the utilization of the water resource. In particular, the Philippine Clean Water Act underscores the preservation of the water resource; the Tourism Act promotes ecotourism for socio-economic development, while the Philippine Fisheries Code advances the interest of the fisherfolks and the fishing industry. The proponents of each law competed and negotiated over the utilization of the lake. Consequently, the plans, programs, and projects in Pandin Lake were drawn within the range of these laws and the interlocking interests they represent.

THE ECOTOURISM DEVELOPMENT IN PANDIN LAKE

With its limited aquaculture and clean water, Pandin Lake has long been held as ideal for tourism development. Even the LLDA has suggested the suitability of the lake for ecotourism development (LLDA, 2005). Ecotourism was deemed as the most viable alternative in providing decent livelihood to the mostly poor residents of the lake and in ensuring the conservation of the natural resource. The local fisherfolks were also less resistant to develop ecotourism in Pandin Lake since fish farming was not as lucrative in the lake compared to the other crater lakes in San Pablo City where aquaculture was extensive. One would expect the swift and smooth progress of ecotourism in Pandin Lake with the above favorable conditions; however, ecotourism development took time to materialize.

The LLDA's and the City Government's preference for Sampaloc Lake's development and failure to jump-start any development initiative for Pandin Lake were the early hindrance to ecotourism development in Pandin Lake. The bias on Sampaloc Lake was anchored on its status as the premier lake and long held trademark of San Pablo City. In 2009, the LLDA and the City Government, through the Short-Term Eco-Tourism Development Plan of the city, had the understanding that Sampaloc Lake would be prioritized and would serve as the model for the tourism development of the other crater lakes (San Pablo City Tourism Council, 2008). However, there has not been much progress in this endeavor. For example, no move has been observed since early 2000s to completely relocate illegal residents around the lake and get rid of the illegal structures in the area.[20] Sampaloc Lake also lacked a zoning-development plan which

20 Approximately two-thirds of Sampaloc Lake's bank is still occupied by illegal settlers/structures and around 100 families still need to be relocated.

was necessary to facilitate development in the lake (Brillo, 2015d). These unsettled issues significantly impacted Pandin Lake and the rest of the crater lakes, because unless these are resolved, the government agencies will continue to focus their efforts on Sampaloc Lake.

With no support from the LLDA and the City Government, ecotourism in Pandin Lake evolved mainly as an endogenous initiative spurred on by non-lucrative fish farming in the lake and the exposure to the citizen-initiated movement to save Sampaloc Lake in the early 2000. The latter underscored to Pandin Lake residents and to local environmentalists the pressing need to safeguard the water resource and prevent it from suffering the fate of Sampaloc Lake. Under this context, the members of the local environmentalist group— Pundasyon ng Kalikasan (Foundation of the Environment)— took the initiative to help in the conservation of the lake.[21] A dialogue between the Foundation and the lake residents took place in which the latter, specifically the wives of fishermen, appealed for assistance in finding work. In response, the Foundation initiated training activities, particularly gardening and soap making, designed to help the residents earn extra income. The Foundation had expected that by introducing alternative sources of livelihood to the residents, they would restrain them from over exploiting the lake. However, except for establishing the link between the lake residents and the Foundation, the initiative had limited success. A key reason was that many residents, especially the men, were distrustful of the assistance provided by the Foundation, after having been exposed to politicians and rich people who did not fulfill their promises to help. The residents were also suspicious of the Foundation's motives since the members came from well-off families. This distrust was evident when many residents (mostly men) did not support the training activities and did not sign the memorandum of agreement between the Foundation and the lake residents.

In 2003, a year after the unsuccessful training activities, the link between the locals and the Foundation was re-established. A group of mostly women residents of Pandin Lake approached the Foundation with the concept of the Pandin Lake Tour project. The Foundation helped the lake residents launch the project by advising them on how to organize and manage the enterprise, seek initial capitalization, and promote/market the

21 Pundasyon ng Kalikasan was one of the first groups to call for the City Government and the LLDA to take action and save Sampaloc Lake.

endeavor.[22] From the modest beginning of offering raft ride, native foods,[23] and the lake's scenic beauty, the Pandin Lake Tour project gradually transformed into a full-fledged enterprise, as local and foreign tourists kept coming over the years. In 2005, buoyed by the success of their project, the locals decided to formally organize themselves by establishing the SMLP to directly manage the ecotourism enterprise. At present, the SMLP's ecotourism success in Pandin Lake is well-acknowledged on three aspects: one, in operating an income-generating enterprise; two, in safeguarding the natural resource; and three, in empowering the locals, especially the women who are actively involved in the management and operation of the enterprise.

THE DEVELOPMENT ISSUE: ADMINISTRATIVE AGENCIES' INVOLVEMENT IN PANDIN LAKE

The central issue in Pandin Lake's development was the absence of the LLDA and the City Government in the ecotourism enterprise's conceptualization and development. These agencies were also not involved in improving the ecotourism enterprise's operations as the suggestions for improvement came from academic studies (Abao, *et al.,* 2010 and Atiqah *et al*., 2012). However, the administrative agencies' involvement is imperative to sustain the success in ecotourism and in the conservation of the lake. The LLDA and the City Government must now move in to assist the SMLP in dealing with pressing issues in the Pandin Lake; specifically (1) ensuring that the lake has a zoning-development plan, (2) transforming the lake into a full-fledged tourist hub, and (3) dealing with the brewing threat to the viability of the ecotourism enterprise. Authority and resources are required to resolve these issues: these are two things that SMLP does not have which the two agencies can provide and thus the need to involve them.

The formulation of the zoning-development plan has been a principal item on the agenda in forums on the seven crater lakes since the early 2000s. The LLDA and the City Government have recognized the need for such a plan; the former had acknowledged this in its 2005 water quality report in Pandin Lake, and the latter in its 2014 citizen's charter report. A zoning-development plan is a basic requirement, critical to the administration, manage the of

22 Mr. Amando Marino and Ms. Beatriz "Patis" Tesoro were most instrumental in this undertaking.

23 Their usual lunch package: grilled tilapia, fern salad, small shrimps cooked in coconut milk, rice wrapped in leaves, and fresh coconut juice at P180 per person.

use, and protection of Pandin Lake. The plan serves as the map to which the development initiatives and projects in the lake must conform in order for these initiatives and projects to be systematic, coherent, and effective. It is the first step in the administration of the water resource, as it gives guidance to succeeding plans and precipitates subsequent actions. The plan also provides the direction and the extent of progress that may be allowed in the lake.

As of this study, the LLDA and the City Government had signified their intention to develop a zoning-development plan. The LLDA had declared that the agency, on its own initiative, would develop such a plan for Pandin Lake by December 2014. The City Government had announced that its Tourism Office would spearhead the creation of a Technical Working Group that would formulate a Tourism Master Development Plan of the City by October 2014. Though the Tourism Master Development Plan was broader in scope and technically not a zoning-development plan for Pandin Lake, it would facilitate the development of a zoning-development plan. The actions of the LLDA and the City Government were commendable, but it wa yet too early to tell (especially with the precedence of losing steam before the targets are achieved) if this would result in concrete outcome— a completed, promulgated, and implemented zoning development plan.

The transformation of Pandin Lake into a full-fledged tourist destination is another issue. Despite years of ecotourism success, Pandin Lake was still underdeveloped, particularly in terms of the essential facilities and infrastructure required for a first-rate tourist destination. Among the immediate needs were (1) a well-developed road and parking space, (2) a peripheral trail around the lake (and into Yambo Lake, its twin lake), (3) a convention center and rooms, and (4) electricity and water supply in the area. Evidently, these needs were beyond the capacity of the SMLP's ecotourism enterprise to deliver, as they entailed huge capital investments but were within the capability of the LLDA and the City Government to provide. Thus, the agencies' involvement was critical if the ecotourism success in Pandin Lake will be expanded and further developed.

The third issue was the potential ownership of land in Pandin Lake area ending up with a single entity if a businessman's efforts to buy most of the land leading to and around the lake are successful. The LLDA and the City Government must intervene and address this, since the "monopolization" of land (which currently is about a third of the surrounding area and covers the entire entry point to the lake) will lead to accessibility issues and constrain further

development of Pandin Lake, thus threatening the viability of the ecotourism enterprise. As of this study, the landowner had reluctantly allowed access to the traditional route to the lake (which divides and runs across his land). This right of way issue must not be left to the discretion of the land owner but must be guaranteed and legally fortified by the lake's administrative agencies, either by negotiating with the owner, encumbering the title or outright purchasing of the private land. Moreover, if the rumor was true that the businessman planned to put up a high-class resort in the lake, then the assistance from the LLDA and the City Government would be more indispensable, particularly in preparing the SMLP's enterprise for future challenges posed by a big business moving in to Pandin Lake.

CONCLUSION

Ecotourism in Pandin Lake evolved wholly as a local community initiative instead of the conventional government-driven development. Aware of the need to preserve the natural resource and for an alternative to fish farming as a source of income, lake residents, supported by a local environmentalist group—Pundasyon ng Kalikasan (Foundation of the Environment—established a financially viable ecotourism enterprise. Through the years, ecotourism in Pandin Lake has brought many benefits to its people particularly in a decent livelihood and the conservation of their small lake. Overall, the experience in Pandin Lake illustrated that by cooperating and taking actions, the locals (sans government support) can be principal drivers of development and can empower themselves to manage the natural resource. With this lesson, the ecotourism success in Pandin Lake is a good template for the sustainable development of the many small lakes in the country.

The potential of SMLP's ecotourism enterprise to grow and expand is threatened by the lack of a zoning-development plan, the inability of SMLP to transform the lake into a fully-developed tourist destination, and the ownership of land leading to and around the lake. Resolving these issues require resources that only the LLDA and the City Government can supply. If these government agencies continue to ignore these pressing issues, SMLP's achievements on Pandin Lake ecotourism would be wasted.

In closing, the study addressed the lacuna in literature in Philippine lake studies— the lack of studies under development-governance area, as the field is dominated by limnology and aquaculture studies. The study also fills

the gap in literature on small lakes as scholarly outputs were overwhelmingly concentrated on big lakes. Such objective was achieved by studying how Pandin Lake ecotourism evolved, developed, and managed. Two key agenda were advanced in this article: one, studies in management and development of lakes must move forward and engage the studies in limnology and aquaculture; and two, studies on small lakes are imperative since they are pervasive in the country and crucial for local development. These agenda are interconnected and critical. To get a complete picture of the plight of lakes in the country, small lakes must be accounted for. To meaningfully improve the conditions of lakes in the country, both the development-governance-based studies and limnology-aquaculture-based research must progress side by side. With these in mind, the study hopes to set off more studies on the development-governance aspects of lakes and on small lakes in the country.

Authors:

Bing Baltazar C. Brillo is Associate Professor, Institute for Governance and Rural Development, College of Public Affairs and Development, University of the Philippines Los Baños, Laguna, Philippines. Email: bbbrillo@yahoo.com

Rhina A. Boncocan is Assistant Professor, Department of Social Sciences, College of Arts and Sciences, University of the Philippines Los Baños, Laguna, Philippines.

ACKNOWLEDGMENT

This paper benefited, one way or another, from conversations with the following individuals: Ms. Cristina Abrigo, Samahang Mangingisda ng Lawa ng Pandin (SMLP) / Mr. Vic Anyayahan, Fisheries and Aquatic Resources Management (FARMC), San Pablo City (SPC) / Mr. Pando Espallardo, FARMC, SPC / Mr. Mandy Mariño, Pundasyon ng Kalikasan (Foundation of the Environment) / Mr. Roberto Azores, Friends of the Seven Lakes Foundation (FSLF) / Engr. Felimar Torrizo, Seven Crater Lakes and Watershed Management Council (SCLWMC) / Dr. Lope Calanog, Consultant, Seven Lakes Tourism Master Development Plan / Ms. Maria Donalyn Eseo, Tourism Council, SPC / Mr. Ramon De Roma, Environment and Natural Resource Office, SPC (ENRO) / Mr. Emilio Tirones, Mayor's

Office, SPC /Ms. Emiliana Casbadillo, Bureau of Fisheries and Aquatic Resources (BFAR) / Ms. Adelina Santos-Borja, Laguna Lake Development Authority (LLDA) / Mr. Diego Reyes, LLDA / Ms. Florita Moredo, LLDA.

REFERENCES

Abao, E. et al. (2010). *The assessment of Lake Pandin for sustainable ecotourism development and natural resource management* (A class report in the Course ENS 275), UPLB, Philippines.

Araullo, D. (2001). Aquaculture practices and their impact on Philippine lakes. In C.B. Santiago, M.L. Cuvin-Aralar and Z.U. Basiao (Eds.), *Conservation and ecological management of Philippine Lakes in relation to fisheries and aquaculture*. Iloilo, Los Banos and Quezon City, Philippines: SEAFDEC/AQD, PCAMRD BFAR,.

Atiqah B. J. et al. (2012). *Pandin Lake: Ecotourism project* (A group report presented in the 49th IATSS Forum). Retrieved from http://www.iatssforum.jp/english/forum/docs/group_49b_report.pdf

Brillo, B.B. (2015a). The status of Philippine lake studies: Scholarly deficit on Social Science studies and on small-lake research. *Asia-Pacific Social Science Review, 15*(1), 78-101.

Brillo, B.B. (2015b). Development issues of Bunot Lake: The lesser lake among the seven lakes of San Pablo City, Philippines. *Lakes & Reservoirs: Research & Management, 20*(3), 155-165.

Brillo, B.B. (2015c). Developing Mohicap Lake, San Pablo City, Philippines. *The Social Sciences, 11* (3), 283-290.

Brillo, B.B. (2015d). Politics of urban lake administration in the Philippines: The Case of San Pablo City's Sampaloc Lake." (undergoing review).

Brönmark, C., & Hansson, L. (2002). Environmental issues in lakes and ponds: Current state and perspectives. *Environmental Conservation, 29*(3), 290-307.

Cardenas, M.L. et al. (1988). Laguna De Bay Region. In S.E. Jorgensen & R.A. Vollenveider (Eds.), *Guidelines of lake management: Principles of lake management (Volume 1)*. Shiga, Japan: ILEC and UNEP.

Cuvin-Aralar, M. L. et al. (Eds.). (2005). *LakeCon2003: Proceedings of the First National Congress on Philippine Lakes*. Los Baños, Philippines: SEARCA.

Fellizar, F.P. (1995). An overview of lake fisheries in the Philippines. In E. Manalili &

R. Guerrero (Eds.), *Lake fisheries management in the Philippines: Proceedings of the National Symposium-Workshop on Lake Fisheries Management*. Los Baños, Philippines: PCAMRD.

Guerrero III, R. (2001). Sustainable development of Philippine lake resources: An agenda for research and development. In C.B. Santiago, M.L. Cuvin-Aralar, & Z.U. Basiao (Eds.), *Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture*. Iloilo, Los Banos and Quezon City, Philippines: SEAFDEC/AQD, PCAMRD and BFAR.

Guerrero III, R. (2005). Issues, challenges, and lessons learned in lake resources management in the Philippines. In M.L. Cuvin-Aralar et al. (Eds.), *LakeCon2003: Proceedings of the First National Congress on Philippine Lakes*. Los Baños, Philippines: SEARCA.

ILEC. (2005). *Managing lakes and their basins for sustainable use: A report for lake basin managers and stakeholders.* Kusatsu, Japan: ILEC Foundation.

ILEC. (2007). *Integrated lake basin management: An Introduction.* Kusatsu, Japan: ILEC Foundation,.

Kira, T. (1997). Survey of the state of world lakes. In S.E Jorgensen &and S. Matsui (Eds.), *Guidelines of lake management: The world's lakes in crisis*. Kusatsu, Japan and Nairobi, Kenya: ILEC and UNEP.

LakeCon2011. (2011). *Second National Congress on Philippine Lakes: Building on the Pillars of Integrated Lake Basin Management*. Los Baños, Philippines: SEARCA,.

LLDA. (2005). *Water quality report on Pandin Lake 1996-2005*. Rizal, Philippines: LLDA-EQRD.

LLDA. (2008). *Water quality report of the seven crater lakes 2006-2008*. Rizal, Philippines: LLDA-EQRD.

Malayang, B. S. III , et al. (2002). Policy options to encourage community support for the sustainable development of Philippine lakes: Insights from Laguna de Bay. *Aquatic Ecosystem Health & Management, 5*(2), 147-154.

Manalili, E., & R. Guerrero (Eds.). 1995. *Lake fisheries management in the Philippines: Proceedings of the National Symposium-Workshop on Lake Fisheries Management.* Los Baños, Philippines: PCAMRD.

Mercene-Mutia, M.T. (2001). Assessment of local government's implementation of open access policy in Taal Lake, Philippines: Effects on lake conservation and management. In C.B. Santiago, M.L. Cuvin-Aralar, & Z.U. Basiao (Eds.),

Conservation and ecological management of Philippine lakes in relation to fisheries and aquaculture. Iloilo, Los Banos and Quezon City, Philippines: SEAFDEC/AQD, PCAMRD and BFAR.

MNR. (1982). The culture of tilapia. *MNR Instructional Series No. 1*. Quezon City, Philippines: Ministry of Natural Resources.

Nakamura, M., & Rast, W. (2011). *Development of ILBM platform process: Evolving guidelines through participatory improvement.* Kusatsu, Japan: RCSE-ILEC and Shiga University.

Nakamura, M., & Rast, W. (2012). *Guidelines for lake brief preparation*. Kusatsu, Japan: RCSE-ILEC and Shiga University.

Pantastico, J.B. & Baldia, J.P. (1981). An assessment of algal growth in net cages in Laguna Lake. *Fisheries Research Journal of the Philippines, 6*(1), 19-25.

Petersen, F., & Carlos, M. (1984). A review of Zooplankton in Philippine lakes. *Fisheries Research Journal of the Philippines, 9*(1-2), 56-64.

Platon, R. (2001). SEAFDEC contribution to the ecological awareness of Philippine lakes. In C.B. Santiago, M.L. Cuvin-Aralar, & Z.U. Basiao (Eds.), *Conservation and ecological management of Philippine lakes in relation to fisheries and aquaculture*. Iloilo, Los Banos and Quezon City, Philippines: SEAFDEC/AQD, PCAMRD and BFAR.

Provincial Government of Laguna. (2013). *Annual accomplishment report: Fishpen/ Fishcage operators registration in the seven lakes of San Pablo*. Retrieved from http://laguna.gov.ph/content/annual-accomplishment-report

Radan, R.R. (1977). The floating fish cages of Lake Bunot. *Greenfields, 7*(4), 20-24.

Rast, W. (2009). Lakes: Freshwater storehouses and mirrors of human activities." *WWAP*

Briefing Notes Series. Retrieved from http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/single-view-earth/news/lakes_freshwater_storehouses_and_mirrors_of_ human_ activities /#.VgX9nn13HMw

Republic Act 4850. (1966). *The Laguna Lake Development Authority Act (as amended by Presidential Decree 813, October 1975).*

Republic Act 7160. 1991. *The Local Government Code.*

Republic Act 8550. 1998. *The Philippine Fisheries Code*.

Republic Act 9275. 2004. *The Philippine Clean Water Act.*

Republic Act 9593. 2009. Tourism Act.

Roa, E. et al. (2005). Nutrient and bacterial load profile of Lake Mainit, Mindanao, Philippines. In M.L. Cuvin-Aralar et al. (Eds.), *LakeCon2003: Proceedings of the First National Congress on Philippine Lakes*. Los Baños, Philippines: SEARCA.

San Pablo City Tourism Council. (2008). *San Pablo City Short-Term Eco-Tourism Development Plan.*

Santiago, A. (1988). Limnological notes on the finfish production problem of Laguna de Bay. *Natural and Applied Science Bulletin, 40*(2), 119-121.

Shiklomanov, I. (1993). World fresh water resources." In P.H. Gleick (Ed.), *Water crisis: A guide to the world's fresh water resource*. New York, U.S.A.: Oxford University Press.

Siringan, F., & Jaraula, C.M. (2005). Changes in lake morphology as source of basic information for lake management: A case study on Laguna Lake, Philippines. In M.L. Cuvin-Aralar et al. (Eds.), *LakeCon2003: Proceedings of the First National Congress on Philippine Lake*. Los Baños, Philippines: SEARCA.

World Lake Vision Committee. (2003) .*World Lake Vision: A call to action*. Kusatsu, Japan: ILEC and IETC-UNEP.

Zafaralla, M. (2001). An ecological assessment of seven major lakes in the Philippines. In C.B. Santiago, M.L. Cuvin-Aralar, & Z.U. Basiao (Eds.), *Conservation and ecological management of Philippine Lakes in relation to fisheries and aquaculture*. Iloilo, Los Baños and Quezon City, Philippines: SEAFDEC/AQD, PCAMRD and BFAR.

Zafaralla, M. et al. (2002). The ecological status of Lake Laguna de Bay, Philippines. *Aquatic Ecosystem Health and Management, 5*(2), 127-138.

Zafaralla, M. (2010). *Plankton biodiversity, water quality and environmental status of Los Banos' Crocodile Lake and San Pablo City's Seven Lakes (Lakes Sampaloc and Pandin).* UPLB-NRCP / PCAMRD-DOST.

In situ Temperature Profile of Shallow Reef Communities in Negros and Apo Island: 2013-2014

Persie Mark Q. Sienes and
Hilconida P. Calumpong
Silliman University-Institute of Environmental and Marine Sciences, Dumaguete City, Philippines

Coral reefs provide a wide variety of ecosystem services and goods that benefit humankind. However, the survival and health of reefs are threatened by natural and anthropogenic factors such as climate change and pollution. Increased seawater temperature often results in bleaching of certain coral species. This study aimed at profiling in situ temperature of shallow reef communities in Apo I. and Sibulan, Negros I. using data loggers programmed to record hourly. Results for Apo showed temperature peaked in the months of May, June, and July. For Sibulan site, peaks were observed in May, June, and September. The lowest temperature for both sites was observed in February. Comparison with satellite-derived sea surface temperatures (SST) for the Bohol Sea indicated Apo Island recorded lower temperatures (>0.5°C) except for the months of October, November, and December whereas in Sibulan site, logger-derived temperature recordings were mostly higher by <0.5 °C in the months of March, May, October, November, December, and February. Between sites, variation may be explained by differences in coastal profiles, depths of reefs, and influences of different water current systems. Variation from satellite-derived data may be due to depth differences since the latter were taken only from the surface. Continuous in situ temperature monitoring is recommended to provide a more localized profile especially in this period of changing climate.

Keywords: in situ temperature, Negros I., Apo I., Sibulan, PHERNet, coral bleaching

INTRODUCTION

Coral reefs are one of the most productive marine ecosystems providing a variety of services and goods benefitting human population (Moberg & Folke, 1999, Barbier, *et al.*, 2011). However, coral reefs are continuously threatened or destroyed by natural and/or anthropogenic causes (Veron *et al.*, 2009; Pandolfi, Connolly, Marshall, & Cohen, 2011; Hoegh-Guldberg, 2011). Coral bleaching is one of the results triggered by a coral's exposure to at least 1 to 2°C increase in temperature based on summer monthly mean temperature (Berkelmans & Willis, 1999 in NOAA-Coral Reef Watch [CRW], 2000) above its tolerance level.

During the 1997-1998 El Niño (NOAA, 2000), coral bleaching events were observed in most reefs of the Philippines (Chou, 2000) including in the Bohol Sea (Divinagracia, 2000). It becomes increasingly important therefore to profile localized temperature in coral communities because it provides valuable information regarding its seasonal temperature fluctuations. The objective of this study was to profile in situ temperatures of shallow reef communities in Sibulan, Negros Island and Apo Island, and to compare the results with available data in the Bohol Sea.

METHODS

Seawater temperatures of shallow coral reef communities in two sites were monitored by deploying replicate HOBO Pendant Temperature/Light Data Loggers. For Apo Island site, reef communities include Rock Pt. (9.071923°N; 123.268002°E) on the southwestern tip of the island, and inside the Apo Marine Sanctuary (9.07489°N; 123.27197°E) on the eastern side of the island about 500 m apart. Data logger was fixed at approximately 6 m deep for both reefs. Approximately 30 kilometers north of Apo Island, in Sibulan site, one logger was deployed for each reserve namely Cangmating and Agan-an Marine Reserves which are about 2.5 km apart. These loggers were fixed at approximately 3-4m deep for both reserves.

For Sibulan site, temperature-logging period was from March 5, 2013 to February 28, 2014 while for Apo, the period was from March 26, 2013 to February 28, 2014. Daily composite temperature (mean of 24 hrs. from 19:00 to 18:00) and daily nighttime temperature (mean of 10 hrs. from 19:00-05:00) were computed for each station, and both stations were averaged to represent each site

(N=2). A non-parametric Mann-Whitney U Test was employed to determine significant difference between sites. Daily nighttime in situ temperature was used to compare sites with satellite-derived SST data for the Bohol Sea for the period March 4, 2013 to February 27, 2014 (NOAA CRW, 2000).

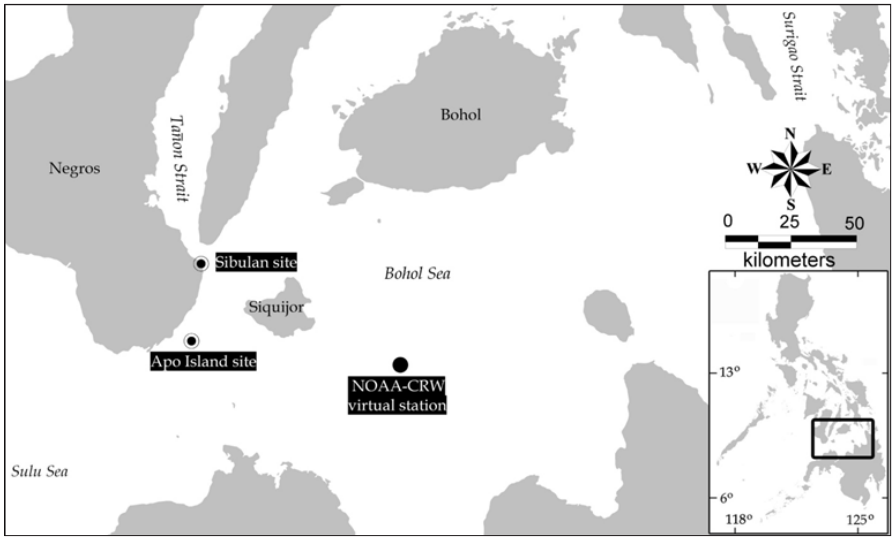


Figure 1. In situ temperature sampling sites. Two data loggers were deployed for each site in different coral reef communities. Also shown is the NOAA Coral Reef Watch virtual station in the Bohol Sea (9°N; 124°E) taken from http://coralreefwatch.noaa.gov/satellite/vs/index.php.

RESULTS

Daily composite mean temperature for Apo was 28.71 °C ± 0.85 with a range of 26.48-30.01 °C for a total logging period of 340 days from March 26, 2013 to February 28, 2014. For Sibulan, mean temperature was 28.93 °C ± 0.86 with a range of 26.61-30.44 °C for a total logging period of 361 days from March 5, 2013 to February 28, 2014. Using Mann-Whitney U Test, a significant difference (U= 49987.5, p= 0.000022) was determined in the daily composite mean temperatures between the two sites during the logging period. For daily nighttime mean temperature comparison, Apo I. had a mean of 28.58 °C ± 0.83 (range 26.35-29.83 °C) while Sibulan, was slightly higher at 28.82 °C (range 26.33-30.29 °C) for the same logging period mentioned above. The daily nighttime mean temperature between two sites indicated to be significantly different using the Mann-Whitney U Test (U= 48934.5, p= 0.000003).

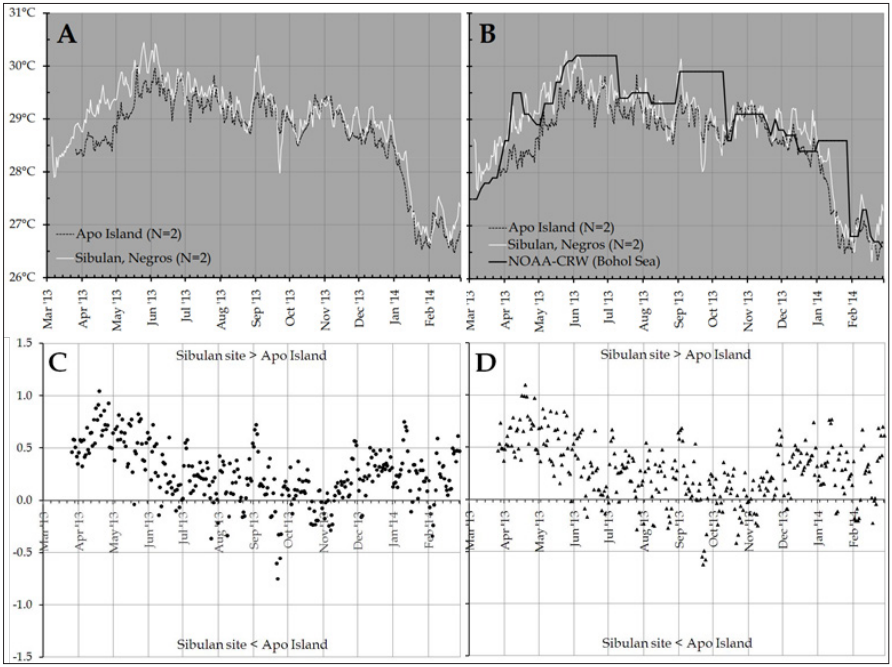


Figure 2. Temperature comparison between sites during the temperature-logging period: (A) Daily composite; (B) Daily nighttimeoverlayed with satellite-derived SST data from the Bohol Sea (NOAA-CRW, 2000); (C) Temperature difference for daily composite; and (D) daily nighttime. For C & D, values above the x-axis denotes higher temperature recording for Sibulan site than Apo Island, and below the x-axis indicates the opposite. Values below the x-axis are absolute values.

Seasonal fluctuations for daily composite mean temperature in Apo I. indicated peaks in the months of May (30.0 °C ± 0.05), June (29.96 °C ± 0.04 & 29.96 °C ± 0.04), and July 2013 (29.82 °C ± 0.08), while lowest recordings in January (26.53 °C ± 0.13) and February 2014 (26.56 °C ± 0.06 & 26.48 °C ± 0.11)(Fig. 2 A&B). For Sibulan, peaks were recorded in May (30.44 °C ± 0.14), June (30.42 °C ± 0.12) and September 2013 (30.19 °C ± 0.07) with an abrupt decrease to 27.98 °C ± 0.06 observed in the same month. Lowest temperatures were recorded in February 2014 (26.65 °C ± 0.06 & 26.61 °C ± 0.07). Likewise, for daily nighttime mean temperature, peaks in Apo I. were recorded in the months of June (29.80 °C ± 0.07), July 2013(29.83 °C ± 0.19), and the lowest temperatures were in January (26.48 °C ± 0.11) and February 2014 (26.49 °C ± 0.08 & 26.35 °C ± 0.08). Sibulan records showed the following: May (30.29 °C ± 0.06); June (30.19 °C ±

0.05); September 2013 (30.13 °C ± 0.08) with an abrupt decrease to 28.02 °C ± 0.04. The lowest temperature was in February 2014 (26.50 °C ± 0.03 & 26.33 °C ± 0.05).

The temperature difference between the two sites was less than 0.5 °C, with Apo I. recording mostly lower temperatures relative to Sibulan for both composite and nighttime periods (Fig. 2 C&D). However, marked in situ temperature differences greater than 0.5 °C but less 1 °C were observed in the months of April, May, to early June, further increasing temperature differences between the two sites.

Comparison with satellite-derived sea-surface temperature (SST) in the Bohol Sea (NOAA-CRW, 2000) indicated a similar pattern in temporal fluctuations for both sites with late May, June, and early July having the highest temperature recordings and February having the lowest during the comparative period (Fig. 2B). It should be noted that during an ocular survey in Apo in July 2013, it was observed that there were dead coral recruits and juveniles due to bleaching inside the Apo Marine Sanctuary (Reboton, unpublished data). Apparently, this period was also categorized as "Bleaching Watch" level by the NOAA-CRW (2000).

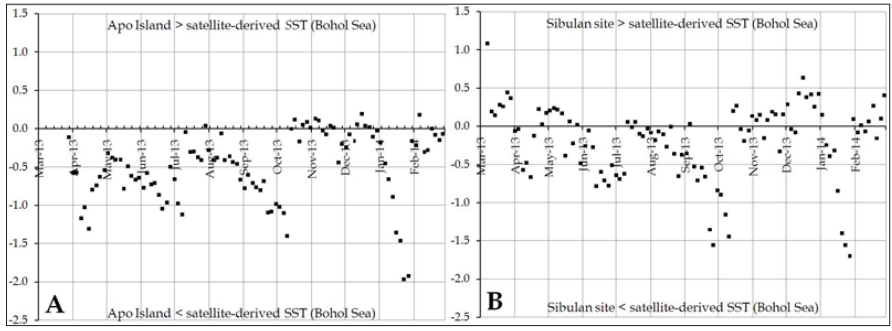


Figure 3. Temperature difference between data logger-derived and satellite-derived SST (NOAA-CRW - Bohol Sea) for (A) Apo Island, and (B) Sibulan site. Dots above the x-axis denote higher temperature recording for logger-derived than satellite-derived temperatures, and dots below the x-axis indicate the opposite. Values below the x-axis should be taken as absolute value.

Temperature differences between the two sites against satellite-derived SST for the Bohol Sea (NOAA-CRW, 2000) indicates that Apo had lower temperature recordings except for October, November, and December (Fig. 3A). For Sibulan, March, May, and February recorded high temperatures

in addition to October, November, and December (Fig. 3B). Maximum temperature difference was less than 2 °C during the later part of January for both sites.

DISCUSSION

Observed temperature variations between sites may have been due to the varying depths where these data loggers were deployed, different coastal profiles of these sites as well as influences of the different water current systems affecting these areas. Apo is an offshore coastal island while Sibulan is a coastal area of a channel (Serate & Maypa, 1997). Moreover, there may be different water current systems affecting each site. For example, Tañon Strait may have significant influence on the coastal waters of Sibulan site compared to Apo I. In the Bohol Sea, two different water current patterns were observed: the Bohol Jet which brings water from the Pacific Ocean to Sulu Sea through Surigao Strait passing by north of Siquijor and entraining it with deeper and colder waters; and the Iligan Bay Eddy located in the southwestern basin of the Bohol Sea (Cabrera, Villanoy, David, & Gordon, 2011). The Bohol Jet may have had major influence on the waters of Apo Island while the Iligan Bay Eddy may have had influence on the satellite-derived SST recordings.

CONCLUSIONS

Seasonal temperature fluctuations in coral reefs monitored in Apo Island and Sibulan showed similar patterns with highest recordings in late May, June, and early July, and low recordings in February, except in September where a temperature spike was recorded for the Sibulan site. Temperature differences in Apo and Sibulan reefs showed the latter having higher recordings with temperature differences reaching more than 0.5 °C but less than 1 °C, particularly during the months of April, May, and early June. Comparison with satellite-derived SST for the Bohol Sea indicated Apo Island having lower temperature recordings than Sibulan site. Highest difference (<2 °C) was observed during the month of January. It is recommended that in situ temperature monitoring of these reefs be continued as this will provide a more localized profile especially during this period of changing climate.

ACKNOWLEDGMENTS

We are grateful for the financial support provided by the Commission on Higher Education (CHED) through the Philippine Higher Education Research Network (PHERNet). We acknowledge Dr. Jean B. Tanangonan of Kinki University, Osaka, Japan for providing temperature data for Cangmating and Agan-an Marine Reserves. We appreciate the dedication of Sidney Mendez, warden of Apo Island Protected Landscape and Seascape, in maintaining the data loggers in Apo Island, and we are thankful to the staff and graduate students of Silliman University-Institute of Environmental and Marine Sciences (SU-IEMS) who made generous contributions to this study. The first author would like to express his deep personal gratitude to DOST-PCAARRD for the academic scholarship. This study is one of the components of the second author's project, Science Towards Environmental Well-being and Resource Development for Society in a Changing Climate (STEWARDS).

REFERENCES

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., & Silliman, B.R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs, 81*(2), 169-193.

Berkelmans, R., & Willis, B.L. (1999). Seasonal and local spatial patterns in the upper thermal limits of corals on the inshore Central Great Barrier Reef. *Coral Reefs, 18*, 219-228. (Abstract only)

Cabrera, O.C., Villanoy, C.L., David, L.T., & Gordon, A.L. (2011). Barrier layer control of entrainment and upwelling in the Bohol Sea, Philippines. *Oceanography, 24*(1), 130-141.

Chou, L.M. (2000). Southeast Asian reefs – status update: Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. *In* C. Wilkinson (Ed.), *Status of coral reefs of the world: 2000* (pp. 117-129). Australia: Australian Institute of Marine Science.

Divinagracia, M.F.B. (2000*). Extent and degree of coral bleaching in selected reefs in Central Visayas* (master's thesis). Silliman University, Dumaguete City, Philippines.

Hoegh-Guldberg, O. (2011). Coral reef ecosystems and anthropogenic climate change. *Regional Environmental Change*, 11(Suppl. 1), S215-S227.

Moberg, F., & Folke, C. (1999). Ecological goods and services of coral reef ecosystems. *Ecological Economics, 29,* 215-233.

NOAA Coral Reef Watch. (2000). *NOAA Coral Reef Watch 50-km Satellite Virtual Station Time Series Data for Bohol Sea, Mar. 4, 2013-Feb. 27, 2014.* Silver Spring, Maryland, USA: NOAA Coral Reef Watch. Retrieved from http://coralreefwatch.noaa.gov/satellite/vs/index.php

Pandolfi, J.M., Connolly, S.R., Marshall, D.J., & Cohen, A.L. (2011). Projecting coral reef futures under global warming and ocean acidification. *Science, 333*, 418-422.

Serate, E.B., & J.L.P. Maypa. (1997). Bathymetry and Hydrography. *In* H.P. Calumpong, J.S. Estacion, M.V. Lepiten, & C.E. Acedo (Eds.), *Status of the coastal resources of the Negros Learning Site (Manjuyod to Dauin)* (pp. 29-36). Dumaguete City: Silliman University Marine Laboratory and the Center of Excellence in Coastal Resource Management, Silliman University.

Veron, J.E.N, Hoegh-Guldberg, O., Lenton, T.M., Lough, J.M., Obura, D.O., Pearce-Kelly, P., Sheppard, C.R.C., Spalding, M., Stafford-Smith, M.G., & Rogers, A.D. (2009). The coral reef crisis: The critical importance of <350 ppm CO_2. *Marine Pollution Bulletin, 58*, 1428-1436.

The Potential of Psidium guajava in Lowering Blood Glucose Levels of Diet-induced Hyperglycemic Female White Sprague Dawley Rats

Carlo B. Limbaga and

Socorro Z. Parco

Biology Department, Silliman University

Diabetes mellitus is a chronic metabolic disease that affects a lot of people worldwide. In line with this, aqueous leaf extracts from different varieties of Psidium guajava were evaluated for their potential in lowering elevated total blood glucose levels (hyperglycemia) by using diet-induced female Sprague Dawley rats. Both young and old leaves of the varieties of P. guajava were also examined. Sixteen healthy female Sprague-Dawley rats weighing about 140-150 grams, bought from Java Pet Shop in Cebu, were used in the study. Diabetes in the rats was induced by feeding the animals with food of high glycemic index (white bread and sugar solution) for at least four weeks. After Diabetes induction, the rats were treated by the specific variety of P. guajava leaf aqueous extracts at a dose of 500 mg/kg body weight, and the synthetic drug, Metformin (500 mg) at a dose of 3 mg/kg daily for three days, once a day. After the three days of treatment, the total blood glucose level of the rats decreased significantly ($P<0.05$). Furthermore, this was comparable to the antidiabetic drug, Metformin. Paired t-test revealed that based on one-tailed and two tailed test, blood glucose levels of rats treated with Native Guava (Young Leaves), Native Guava (Old Leaves), Pink Guava (Young Leaves), Pink Guava (Old Leaves), Apple Guava (Young Leaves), and Apple Guava (Old Leaves) all showed significant difference ($P<0.05$) compared with the hyperglycemic control. Pink Guava (Young Leaves) was found to be the most effective in treating hyperglycemia in the rats at a highest significant difference ($p= 0.0001<0.05$) compared with the Hyperglycemic control. There was no significant difference ($P>0.05$) compared with the synthetic drug, Metformin, which suggests that the effect of P. guajava aqueous extracts is as effective as the established drug for Diabetes mellitus in the market.

Keywords: Psidium guajava, anti-hyperglycemic, Diabetes, blood glucose, ethno-medicinal

INTRODUCTION

Diabetes mellitus is a chronic metabolic disease, which can be classified into type 1 diabetes (insulin-dependent diabetes mellitus or IDDM) and type 2 diabetes (non-insulin dependent diabetes mellitus or NIDDM) (Oh *et al.,* 2005). It results from shortage or lack of insulin or the reduced ability of the body's tissues to recognize insulin (Prasad *et al.,* 2009). The prevalence of diabetes is rapidly increasing in industrialized countries, and type 2 diabetes accounts for 90% of the disease (Oh *et al., 2005*). It is also noteworthy that diabetes mellitus is also increasing in developing countries. In type 2 diabetes, insulin resistance is a characteristic feature and several drugs to increase the insulin sensitivity are currently being used in clinic. However, currently available drugs in the market for type 2 diabetes have a number of limitations, such as adverse effects and high rates of secondary failure (Oh *et al.,* 2005). This is why having treatments for diabetes mellitus that have no side effects is still a big challenge for the medical community (Prasad *et al.,* 2009).

Psidium guajava is an important food crop and medicinal plant in tropical and subtropical countries. It is widely used as a food and in folk medicine around the world (Gutierrez, Mitchell, & Solis*, 2008*). More recent ethnopharmacological studies reveal that *Psidium guajava* is used in many parts of the world for the treatment of a number of diseases, such as anti-inflammatory, for diabetes, hypertension, caries, wounds, pain relief and reducing fever (Gutierrez *et al.,* 2008). Because there are a lot of accounts that put *Psidium guajava* as a cure for many diseases including *Diabetes mellitus*, then there is a need to establish a clear scientific or clinical data about the ethno-medicinal use of the plant.

MATERIALS AND METHODS

Plant Material

Fresh leaves of the different varieties of Guava plants (Fig. 1, 2, 3) were collected from *Psidium guajava* trees of Tanjay City, Negros Oriental. The authenticity of the plant varieties was confirmed by Renee B. Paalan from the Biology Department of Silliman University, Dumaguete City.

Figure 1. Photo of leaves and young fruits of Native Guava also locally called "Bayabas Bisaya."

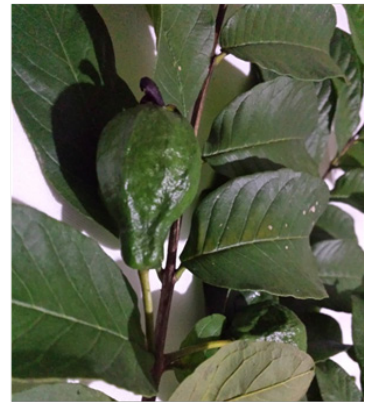


Figure 2. Photo of leaves and young fruits of Apple Guava.

Preparation of Plant Extract (Biswas et al., 2011; Reddy et al., 2012)

The collected leaves were air dried for thirty minutes. After air drying, the leaves (1 kg) of the different varieties of *Psidium guajava* were boiled in H2O (5 l), and the liquid portion of the strained decoction were orally-administered to the animal models.

Figure 3. Photo of Pink Guava or locally called "Supiro"

Test Animals

Sixteen healthy female Sprague-Dawley rats (Fig. 4) weighing about 140-150 grams, bought from Java Pet Shop in Cebu, were used in the study. These rats were chosen for they were best suitable for this type of study.

Sprague-Dawley rats are fast growing rats; they are docile and easy to handle (Janvier Labs, 2015). They are albino outbred with elongated heads and tails that are longer than their body (Janvier Labs, 2015). Their breed/strain was created by R.W. Dawley in 1925 from a hooded male hybrid of unknown origin and an albino female, which is probably Wistar, and was then crossed with the female's progeny for seven generations.

The animals were housed individually in appropriate cages containing sterile sawdust as bedding, maintained under standard conditions (12 hrs light and 12 hrs dark cycle, 25 +5°C and 40-60% humidity) (Prasad *et al.*, 2009). All the rats were given a period of acclimatization for two weeks before starting the experiment. They were given pigeon and general developer pellets and tap water *ad libitum* at room temperature (Sobrevilla

et al., 2011). The mice considered to be "fasting" were deprived of food for at least 16 hours but were allowed free access to drinking water (Prasad *et al.*, 2009).

Figure 4. Photo of rats in individual cages that prevented them from interacting with one another.

Induction of Diabetes (Adeyi et al., 2012)

Diabetes in the rats was induced by feeding the animals with food of high glycemic index for at least four weeks. White bread, which has glycemic index value of 70, was fed to the rats while granulated sugar with glycemic index value of more than 100 was dissolved in drinking water at a concentration of 1g/ml. Surviving rats after four weeks with blood glucose concentration of approximately 180-200mg/ml were considered as food-induced hyperglycemic rats.

Metformin

Metformin is a hypoglycemic drug, which is effective in the treatment of non-insulin-dependent *Diabetes mellitus*. It is increasingly used in Canada and Europe (Klip & Leiter, 1990). The compound is often called insulin sensitizer as it increases the effects of insulin (Mestrovic, 2015). The major effect of the drug is on glucose utilization; it acts on the insulin receptors and

glucose transporters (Klip & Leiter, 1990). Metformin stimulates the insulin-induced component of glucose uptake into skeletal muscle and adipocytes in both diabetic individuals and animal models, with an enhanced action of the drug in the hyperglycemic state (Klip & Leiter, 1990). The increase in glucose uptake is also reflected in an increase in the insulin-dependent portion of glucose oxidation (Klip & Leiter, 1990). In human and rat muscle cells in culture, metformin increased glucose-analogue transport independent of and additive to insulin, suggesting an insulin-independent action. In human and rat muscle cells in culture, metformin increase glucose-analogue transport independent of and additive to insulin, suggesting that it had an insulin-independent action (Klip & Leiter, 1990). Results of studies suggest that the basis for the hypoglycemic effect of this biguanide is probably at the level of skeletal muscle by increasing glucose transport across the cell membrane (Klip & Leiter, 1990).

Experimental Design

The procedures of this study were conducted in compliance with the ethical guidelines for animal care of Silliman University, which are based on the Department of Agriculture Administrative Order No. 40 Series of 1999.

Sixteen female Sprague-Dawley rats were divided into four groups (Prasad *et al*., 2009):

Group I: The group consisted of four rats which first served as Hyperglycemic Control. They were given a diet composed of white bread (Mrs. Bread-worth) and sugar solution (1g/ml). After hyperglycemia had been induced, blood glucose level measurements were obtained for three consecutive days. After this, the rats were given two weeks of rest and were given the standard pellet diet. After two weeks, they were given a diet composed of food with high glycemic index. After hyperglycemia had been induced, they were treated orally with aqueous extract of the young leaves of the first variety (Native guava) of *P. guajava* leaves at the dose of 500 mg/kg body weight daily for three days, once a day. After treatment, the rats were again given two weeks of rest. After two weeks of rest, they were again given a diet composed of food with high glycemic index. After hyperglycemia had been

induced, they were treated orally with aqueous extract of the old leaves of the first variety (Native guava) of *P. guajava* leaves at the dose of 500 mg/kg body weight daily for three days, once a day.

Group II: The group consisted of four rats which first served as Normal Control and were given the standard pellet diet and water only. Blood glucose measurements were obtained for three consecutive days. After this, the rats were given two weeks to rest. After two weeks, they were given a diet composed of food with high glycemic index. After hyperglycemia had been induced, they were treated orally with aqueous extract of the young leaves of the second variety (Apple guava) of *P. guajava* leaves at the dose of 500 mg/kg body weight daily for three days, once a day. After treatment, the rats were again given two weeks of rest. After two weeks of rest, they were given a diet composed of food with high glycemic index. After hyperglycemia had been induced, they were treated orally with aqueous extract of the old leaves of the second variety (Apple guava) of *P. guajava* leaves at the dose of 500 mg/kg body weight daily for three days, once a day.

Group III: This group consisted of four rats which were given a diet composed of food with high glycemic index. After hyperglycemia had been induced, they were treated orally with aqueous extract of the young leaves of the third variety (Pink guava) of *P. guajava* leaves at the dose of 500 mg/kg body weight daily for three days, once a day. After treatment, the rats were given two weeks of rest. After two weeks of rest, they were again given a diet composed of food with high glycemic index. After hyperglycemia had been induced, they were treated orally with aqueous extract of the old leaves of the third variety (Pink guava) of *P. guajava* leaves at the dose of 500 mg/kg body weight daily for three days, once a day.

Group IV: This group consisted of four diet-induced hyperglycemic rats that were treated with Metformin at the dose of 3 mg/kg for three days, once day. Blood glucose levels were measured every day.

Blood glucose level was measured before the treatment on Day 1, Day 2, and Day 3 (which was the last day of experiment) with the help of a glucometer using a strip method (One-touch glucometer) (Fig. 5). Blood was sampled from the tip of the tail. The tail of each rat was slightly cut just enough to produce a round blood that can be measured by One-touch Glucometer, which uses a test strip that is inserted into it. The test strip sucked the blood from the rat's tail and the meter processed the total blood glucose level in the blood. Glucose in the blood sample was mixed with special chemicals in the test strip and a small electric current was produced (LifeScan, Inc., 2010). The strength of this current changed with the amount of glucose in the blood sample (LifeScan, Inc., 2010). The measured total blood glucose level served as the initial total blood glucose level and the baseline for the next measurement.

Figure 5. Photo of the One Touch ® Select Simple ™ Blood Glucose Monitoring System (OneTouch® Select ® Test Strips, Lancing Device, OneTouch ® SelectSimple™ Meter) that was used in measuring the blood glucose levels of the rats.

Body weight measurement (Prasad et al., 2009; Hemamalini et al., 2012)

Body weight was totally measured four times during the course of the study period [i.e., before induction of Hyperglycemia (initial values), and on the first, second, and the third day after the treatment period], using a weighing scale.

Computation of Dose for Positive Control

The dose of the drug Metformin solution that was administered on the rats that belonged to Group IV was computed using the formula below (Prasad *et al*., 2009):

$$\frac{\text{(Dosage) x (Weight of rat in kg)}}{\text{(Concentration of solution)}} = \text{volume to be administered on the rat}$$

Example:

$$\frac{\text{(3 mg/kg) x (0.150 kg)}}{\text{(10 mg/ 2 ml)}} = 0.09 \text{ ml}$$

Statistical Analysis

The results are presented as mean + SEM. Statistical significant differences in the blood glucose levels on the initial and Day 3 of treatment for each group were analyzed using paired t-test, with the help of Microsoft Office Excel 2016. Before conducting a paired t-test, a Shapiro Wilk Normality Test was done in order to determine if the data were normally-distributed. One-way analysis of variance (ANOVA) was then employed followed by the post hoc Neuman-Keuls test with the help of Statistica®. A p value < 0.05 was considered as a significant difference in the analyses.

RESULTS

Effects of the Native Guava, Apple Guava, Pink Guava, and Metformin on elevated total blood glucose levels

After feeding the rats with high glycemic food specifically white bread and sugar solution for four weeks, the blood glucose levels of the rats increased and reached approximately 200 mg/dl. This blood glucose increase was about 2.2 fold when compared with the normal control rats. After the three days of treatment of leaf aqueous extracts from the different varieties of *Psidium guajava* at a dose of 500 mg/kg body weight on the experimental groups, the total blood glucose level of the rats decreased significantly (P<0.05) (Fig. 1 and Fig. 2). Meanwhile,

the treatment of commercial antidiabetic drug, Metformin, at a dose of 3 mg/kg body weight, had also significantly decreased ($P < 0.05$) the total blood glucose level of rats belonging to Metformin group, based on a Paired t-test. Paired t-test also revealed that based on one-tailed and two tailed test, blood glucose levels of rats treated with Native Guava (Young Leaves), Native Guava (Old Leaves), Pink Guava (Young Leaves), Pink Guava (Old Leaves), Apple Guava (Young Leaves), and Apple Guava (Old Leaves) all showed significant difference ($P<0.05$) compared with the hyperglycemic control. On the other hand, the blood glucose levels of all the rats from all the treatments showed significant difference ($P<0.05$) compared with the normal control group.

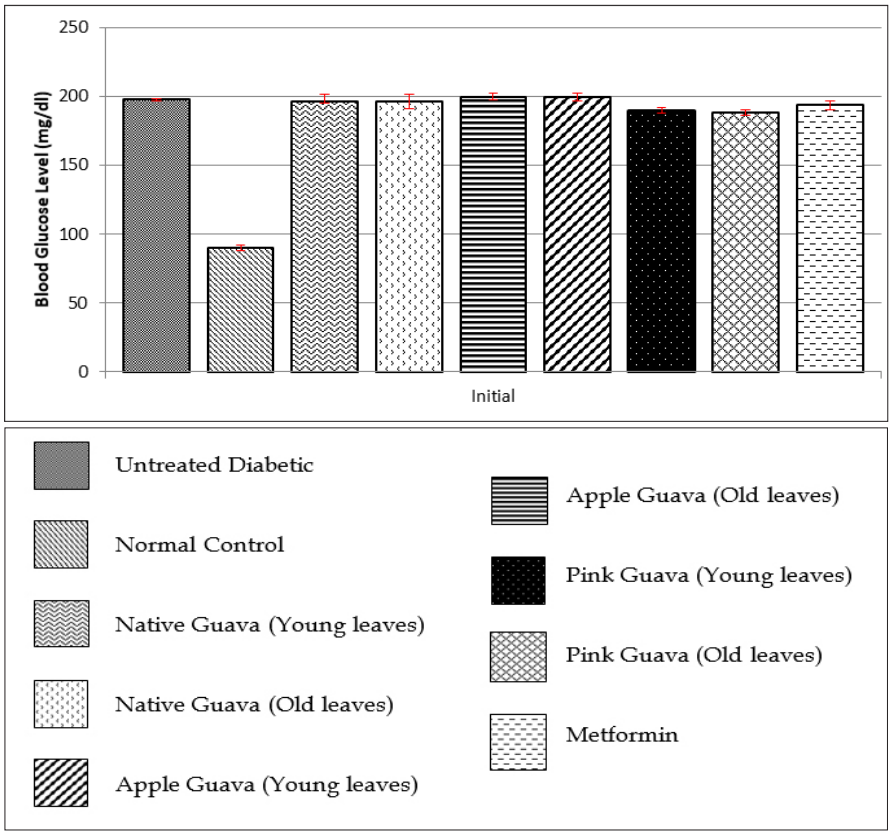


Figure 1. Mean of the total blood glucose levels before treatment (initial)

One-way Analysis of Variance (ANOVA) revealed that the p-value of the first variable (different varieties of *P. guajava*) and second variable (days of treatment) corresponding to the F-statistic were lower than the level of

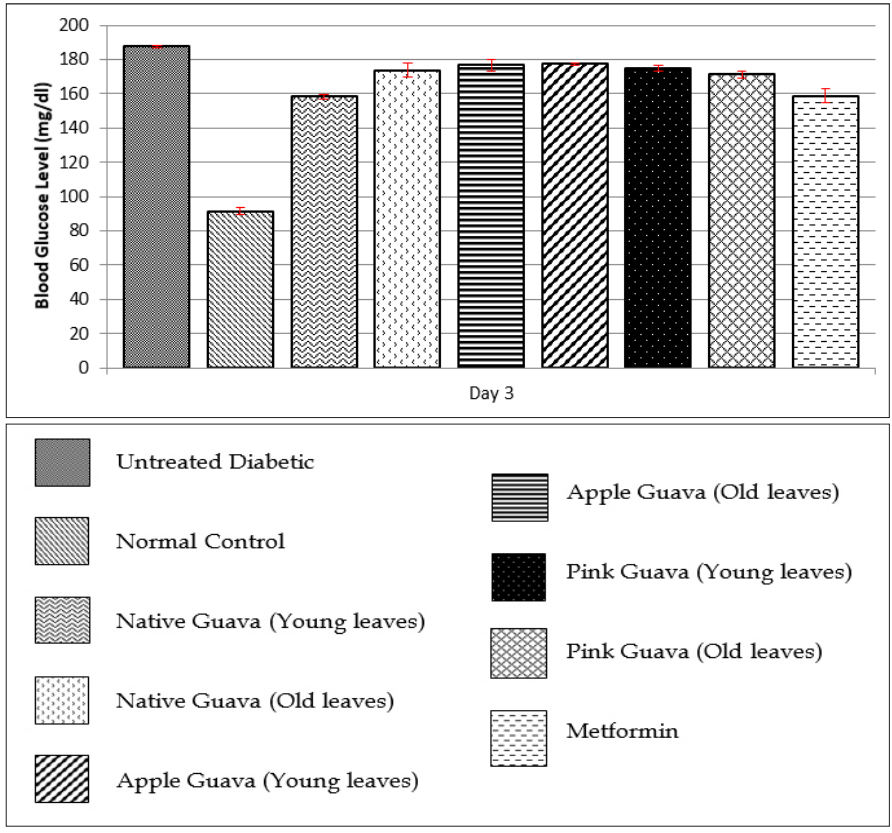


Figure 2. Mean of the total blood glucose levels on Day 3.

significance, which is 0.05, implying that one or more of the treatments in the study were significantly different. Thus, Student Newman Keuls Test (SNK) was employed in order to identify which among the treatments were or was significantly different. SNK revealed that treatment of Native Guava (Young Leaves) had a significant difference ($p=0.0001<0.05$) with the normal control group and the hyperglycemic control group ($p=0.0001<0.05$). Native Guava (Old Leaves) also showed a significant difference ($p=0.0009<0.05$) with the hyperglycemic control and normal control group ($p=0.0001<0.05$). Apple guava (Young Leaves) also had a significant difference ($p=0.016<0.05$) with the hyperglycemic control group and normal control group ($p= 0.0001<0.05$). Apple guava (Old Leaves) also showed significant difference with the hyperglycemic group ($p=0.011<0.05$) and normal control group ($p=0.0001<0.05$). Pink guava (Young Leaves) also showed significant difference with the hyperglycemic group ($p= 0.0001<0.05$) and normal

control group ($p=0.0001<0.05$). Pink guava (Old Leaves) showed significant difference with the hyperglycemic group ($p=0.0001<0.05$) and normal control group ($p=0.0001<0.05$). Lastly, Metformin also showed a significant difference with the hyperglycemic group ($p= 0.00011<0.05$) and normal control group ($p= 0.0001<0.05$). A comparative account of the antihyperglycemic activity of the different varieties of *P. guajava* is well displayed in this study. Statistics revealed that Pink Guava (Young Leaves) has the highest statistical significance ($p=0.000113<0.05$) among the three varieties. Meanwhile, treatment of the rats with Metformin at the dosage of 3 mg/kg, had significantly decreased ($p=0.00011< 0.05$) the total blood glucose levels of rats belonging to the Metformin-treated group. Moreover, the reduction of blood glucose levels in Pink Guava (Young Leaves) did not show any significant difference ($P>0.05$) with the blood glucose levels of the Metformin-treated group, suggesting that both treatments have equal efficacy.

DISCUSSION

Knowledge when it comes to Diabetes can be traced back even to the Brahmic Period (Dhanukar & Thatte, 1989). Even during that time, they were already able to distinguish two types of diabetes: one that is attributed to the genes and the other to dietary factors (Dhanukar & Thatte, 1989). Several treatments have been formulated and the Indian ancient pharmacopoeia revealed treatments including dietary modifications and herbal treatments (Prasad *et al.,* 2009).

Since then, researches have revealed that there are a lot of possible plant and plant-based therapies that have a potential in controlling blood glucose levels and treating diabetes (Prasad *et al.,* 2009). Studies in the antihyperglycemic potential of plants usually use Streptozotocin(STZ)-induced hyperglycemic rats as animal models (Ivorra, Paya, & Villar, 1989). However, there are also studies that make use of diet-induced hyperglycemic rats just like the study of Adeyi *et al.*

Difference in the blood glucose levels can be attributed to the food intake of an individual. This is affected by the intake of foods with different glycemic index (GI). To determine the glycemic index of a food, volunteer individuals are typically given a test food that provides 50 grams of carbohydrate and a control food (white bread or pure glucose) that provides

the same amount of carbohydrate on different days (oregonstate.edu). In the same way, rats can also be induced using a specific diet in order to obtain hyperglycemia. This study also made use of diet-induced hyperglycemic rats, following the methods of Adeyi *et al.* They were induced by feeding the animals with food of high glycemic index for approximately four weeks (Adeyi *et al.,* 2012). White bread which has glycemic index value of 70 was fed to the rats, while granulated sugar with glycemic index value of more than 100 was dissolved in the drinking water at a concentration of 1g/ml (Adeyi *et al.,* 2012).

Several phytochemicals have been speculated to account for the possible hypoglycemic activity of the leaves of *P. guajava.* Tannins, flavonoids, pentacyclic triterpenoids, guiajaverin, quercetin, and other chemical compounds present in the plant are the ones speculated to account for the observed hypoglycemic activity of the leaf extract (Ojewole, 2005). These phytochemicals have been speculated to have an action similar to insulin which is hypoglycemic (Ojewole, 2005). However, the specific chemical(s) that can be attributed for such hypoglycemic action, which was found in all the varieties of *P. guajava* have not yet been identified. A study by Oh *et al.* in 2005 suggested that the extract from *P. guajava* leaves possesses antidiabetic effect in type 2 diabetic mice model and these effect is, at least in part, mediated via the inhibition of Protein tyrosine phosphatase1B (PTP1B). The results of this study also correspond with the results of Ojewole in 2005, who used methanolic extracts of only variety of *P. guajava* and Streptozotocin-induced diabetic rats. Thus, Ojewole concluded that *P. guajava* had such hypoglycemic and even hypotensive properties.

After the induction of diabetes using the special diet, blood glucose levels in the rats increased. When treated with the different varieties of *P. guajava* and the synthetic drug for diabetes, Metformin, blood glucose levels decreased within the span of the treatment which was three days. When it comes to efficacy in lowering blood glucose levels, Pink Guava (Young Leaves) showed the highest potential which is the same with the established synthetic drug, Metformin. Blood glucose levels of rats treated with Pink Guava (Young) Leaves did not show any significant difference ($P>0.05$) with the blood glucose levels of the rats treated with Metformin. This implies that treatment with the aqeous extract of young leaves of Pink guava is comparable with Metformin in lowering blood glucose levels ($P>0.05$). Blood Glucose levels of rats treated with Native Guava (Young Leaves and Old Leaves) also

did not show significant difference (P>0.05) with the blood glucose levels of those treated with Metformin. Although the reduction of blood glucose level due to the native guava (young and old leaves) was numerically more than that by the Pink guava (Fig. 17), paired t-test value showed otherwise since the P value obtained was lower than that of the Native guava (Young and Old Leaves). The P-value was always compared with the positive control, Metformin. This hypoglycemic activity in the Guava plant can be attributed to the different phytochemicals present in the leaves such as Tannins, flavonoids, pentacyclic triterpenoids, guiajaverin, quercetin as proposed and investigated by Ojewole (2005). The molecular mechanism by which these phytochemicals in lowering blood glucose levels is still to be established.

CONCLUSION

The analysis of the data indicated Pink Guava (Young Leaves) to have the highest potential in treating hyperglycemia in diet-induced Sprague-Dawley rats. The other varieties of *P. guajava* also have significant hypoglycemic properties. The difference between Pink Guava (Young Leaves) and the synthetic drug for Diabetes, Metformin, which is not statistically-significant suggests that Pink Guava (Young Leaves) has a hypoglycemic activity which is comparable to the commercial drug, Metformin. Leaves of the Pink Guava are as effective as Metformin. Thus, among the three varieties of *Psidium guajava* namely Native Guava, Apple Guava, and Pink Guava, the Pink Guava (Young Leaves) has the highest efficacy in maintaining normal blood glucose level. This potential of a readily available and palatable food product is most significant that it deserves utmost attention.

REFERENCES

Adeyi, A., Idowu, B., Mafiana, C., Oluwalana, C., Ajayi, O., & Akinloye, O. (2012). Rat model of food-induced no-obese-type 2 diabetes mellitus: Comparative pathophysiology and histopathology. *International Journal of Physiology, Pathophysiology and Pharmacology, 4*(1), 51-58.

Dhanukar, S., & Thatte, U.. (1989). *Ayurveda revisited.* Bombay: Popular Prakashan.

Gutiérrez, R. M. P., Mitchell, S., & Solis, R. V. (2008). < i> Psidium guajava</i>: A review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, *117*(1), 1-27.

Ivorra, M.D., Paya, M., & Villar, A. (1989). A review of natural products and plants as potential antidiabetic drugs. *Journal of Ethnopharmacology, 27,* 243-275.

Janvier Labs. (2015). Retrieved from https://www.janvier-labs.com

Klip A., & L. Leiter. (1990). Cellular mechanism of action of Metformin. *Diabetes Care, 13*(6), 696-704.

Mestrovic, T. (2015). *Metformin mechanism.* Retrieved from http://www.news-medical.net/health/Metformin-Mechanism.aspx

Ojewole, J. A. O. (2005). Hypoglycemic and hypotensive effects of Psidium guajava Linn.(Myrtaceae) leaf aqueous extract. *Methods and findings in experimental and clinical pharmacology*, *27*(10), 689-696.

Oh, W. K., Lee, C. H., Lee, M. S., Bae, E. Y., Sohn, C. B., Oh, H., & Ahn, J. S. (2005). Antidiabetic effects of extracts from< i> Psidium guajava</i>. *Journal of ethnopharmacology*, *96*(3), 411- 415.


GILLMAN

Lowering the Total Coliform of Vermicompost From Solid Waste Materials Produced By African Night Crawler Worm Eudrilus Eugeniae

Robert S. Guino-o II,
Joan Y. Tura, and
Jean Henri M. Oracion
Biology Department, Silliman University

Vermicomposting is an established ecological sanitation program of Bayawan City in Negros Oriental, Philippines that aims to produce low-cost organic fertilizers as an alternative to expensive commercial fertilizers. However, the vermicomposts from biodegradable and human sludge contain high total coliform levels above the limit set by WHO. The study developed coliform-reducing strategies such as agricultural and hydrated lime applications at three concentrations (1:1, 1:0.5, 1:0.25) in two types of vermicomposts. Prior to the experiment, a preliminary study for 15 months made use of air drying and direct sunlight exposure as methods to reduce total coliform levels. Results show that aeration and exposure to the environment did not reduce coliform levels in vermicompost produced by the African Night Crawler earthworm Eudrilus eugeniae. From an initial level of 54,000,000 cfu/100 mL, the levels of total coliform were 208,000 and 307,000 cfu/100 mL using these methods, respectively. Application of lime, either agricultural or hydrated, significantly reduced the levels of coliform beginning 30 days after treatment. Between Day 45 and Day 60, total coliform levels were reaching zero values and near zero values in both types of lime application. Post hoc analysis indicated higher total coliform levels in vermicompost applied with lower lime concentration. The study recommends the use of agricultural lime over hydrated lime as it reduced coliform levels without impairing the NPK levels of the vermicompost.

Keywords: African Night Crawler earthworm, Coliform, Escherichia coli, Vermicompost, solid waste, Bayawan City

INTRODUCTION

Vermicomposting in Bayawan City on Negros Island, Central Philippines is a large-scale composting program by the local government using African Night Crawler earthworm *Eudrilus eugeniae* to convert biodgradable waste material into humus-rich soil. Its main purpose is to provide a source of organic fertilizer for agricultural production such as corn, coffee, banana, and fruit trees as part of the local government drive to address food security. This makes the program congruent to the UN Sustainable Development Goals of promoting sustainable agriculture in Bayawan City, the agriculture capital of Negros Oriental province. The unique feature of vermicomposting in this city makes use of two types of substrate materials, namely biodegradable wastes from households and dried sludge from septic tanks; they are brought in and processed in a 10-hectare sanitary landfill facility.

Vermicomposting is a low cost biotechnology in fertilizer production that addresses the perennial need of farming communities for fertilizer input. There are three earthworm species commonly used to perform this function, namely Red Tiger worm *Eisenia fetida,* African Night Crawler *E. eugeniae,* and Indian Blue Worm *Perionyx excavatus* (Sinha, Bharambe & Chaudhari, 2008). The work of Joshi, Singh, and Vig (2014) underscores the advantages of vermicompost being an excellent soil additive, bio-control agent, and organic fertilizer, which makes it better than commercial fertilizers. The main problem with vermicompost material, however, is the high levels of bacterial coliform contamination which render fruits and vegetables unsafe for direct consumption due to pathogens such as E. coli, total coliform, fecal coliform, and enterococci bacteria (EPA, 2006; Paruch & Maehlum, 2012; Abakpa *et al.*, 2013). The study of Tura-Mutya, Relles, Jayme, and Guino-o (2013) documented coliform count of 54,000,000 cfu/gram of dried 30-day old vermicompost material. Depending on the substrate used, vermicomposts produced from human sludge contain high population levels of microbial pathogens. The studies of Monroy, Aira, and Dominguez (2009) and Lalander, Hill, and Vinneras (2013) indicated that Red Tiger worm *Eisenia fetida* significantly reduced total coliform level in a sludge that has undergone processing in its gut. However, pilot test of total coliform level using African Night Crawler pointed to contrasting results (Tura-Mutya *et al.*, 2013). These studies suggest the urgency to limit the pathogenic bacterial contamination from vermicompost which is the

target of the waste management facility. Thus, this paper aims to develop strategies that lower bacterial coliform at an acceptable level based on the World Health Organization standards.

Specifically, the study has the following goals: a) conduct a preliminary study on the effects of aeration on total coliform; b) provide baseline data on total coliform levels in vermicompost; c) determine the NPK levels of vermicompost; and d) test the effects of bacterial reducing treatments involving lime application.

CONCEPTUAL FRAMEWORK

Bayawan City became the first city in the Philippines to utilize an integrated ecological sanitation (EcoSan) program through its constructed wetlands and sanitary landfill (SLF) to treat liquid and solid wastes into ecological products. The wastewater treatment facility of Bayawan City, otherwise known as constructed wetland, was built in September 2006. Guino-o, Aguilar and Oracion (2010) documented its technical efficiency and positive social acceptability in a study. Sometime later in 2010, the local government unit of Bayawan City embarked on a sanitary landfill that incorporates a biodigester and vermicompost production from biodegradable waste materials. These developments were responses to the Clean Water Act of 2004 (Republic Act 9275) and the Ecological Solid Waste Management Act of 2000 (Republic Act 9003). With the integrated waste management program, Bayawan was awarded the Presidential Lingkod Bayan during the 113th Philippine Civil Service Anniversary on October 24, 2013.

The production of vermicompost is critical to input in agricultural activities. The success of vermicomposting lies on the bedding material of the earthworm, food source or substrate, moisture, adequate aeration, adequate temperature, and suitable pH (Garg, Gupta, & Yadav, n.d.). The substrates for the earthworms may come from various organic materials derived from agricultural or domestic wastes. In the case of Bayawan, the substrates used in vermicomposting include biodegradable solid wastes and human fecal matter from domestic and business establishments' septic tanks that have been decomposed for some time inside a biodigester tank. The use of vermicompost has the following advantages over chemical fertilizers. For example, the studies by Garg *et al.* (n.d.), Monroy *et al.* (2009), and Yadav, Tare & Ahammed (2011) have shown that vernicompost restores microbial

population, which provides major and micronutrients to the plants. It also improves soil texture and water-holding capacity of the soil, provides good aeration to soil, and improves the structural stability of the soil, which helps in preventing soil erosion. Certain elements in vermicomposting help in improving root growth and proliferation of beneficial soil microorganisms, which decreases the use of pesticides for controlling plant pathogens. Vernicompost likewise enhances the quality of grains and fruits of plants or trees where it is applied due to increased sugar content.

There are noted disadvantages of vermicompost produced from human waste substrate in the form of high population of pathogens on the material. Nonetheless, Yadav, Tared and Ahmmed (2012) have provided some insights on how to control the bacterial levels of the vermicompost by experimentally subjecting it to high temperatures during the drying stage prior to vermicomposting. Yadav, Tared, and Ahammed (2010) concluded that pathogens were killed by *E. fetida* "earthworm actions involving intestinal actions, secretion of fluids and selective grazing." However, this is not the case of vermicompost produced by *Eudrilus eugeniae*, which is characteristically high in total coliform. Hence, this study aimed to come up with strategies to lower the coliform load of vermicompost to promote biosafety among the agricultural users and public consumers.

MATERIALS AND METHODS

Test Sites

Two areas in Bayawan City served as test sites, namely GK Multipurpose Hall of the Fishermen's Village in Bgy. Villareal and Bayawan Waste Management and Ecology Center (BWMEC) in Bgy. Anini-i. Each test site corresponds to a particular trial, which lasted for 90 days. The experiment took place from the month of June 2015 to August 2015 while laboratory tests lasted until February 2016.

Vermicompost

Two types of vermicomposts were produced by the local government unit of Bayawan City. The first type is a biodegradable-waste vermicomposts from domestic households that are mechanically sieved prior to being fed

to the African Night Crawler worm *E. eugeniae*. The second type is human-sludge vermicomposts that have been stored from a biodigester tank at the BWMEC and then sundried and grinded before acted upon by *E. eugeniae*. The vermicomposting process took place in separate rectangular tanks in a roofed facility. The finished products are bagged and labelled in polyethylene sacks.

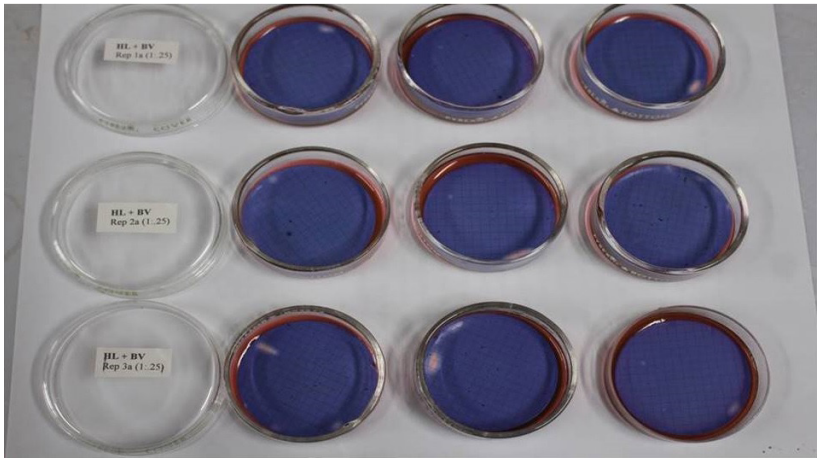


Figure 1. Membrane filtration results of hydrated lime to biodegradable vermicompost

Total Coliform Test

The total coliform test made use of the membrane filtration method as outlined by the World Health Organization. In this procedure, a gram of vermicompost from a composite sample was dissolved in 100 mL of distilled water, and then serially diluted between 10^4 and 10^5. The composite sample was taken from three areas of the treated vermicompost derived from the top, middle and bottom parts of a vermicompost sample.The same sample was filtered using a membrane filter of 0.45 µm pore size, 45 mm in diameter and with grid lines. The membrane was transferred aseptically to an EMB agar microplate and incubated at 37° C for 18 hours using Heraeus incubator. Bacterial colony count was expressed in terms of colony forming units per 100 mL (cfu/100 mL) using a Rocker-Galaxy 230 model colony counter.Total coliform test was performed every two weeks for a period of six weeks.

Preliminary Test

A preliminary test was conducted to determine the time for the total coliform bacteria from sludge-based vermicompost to decrease using air dry and direct exposure methods. In the air-dry method, the vermicompost material was spread in a clean working space and regularly turned. The second method placed the vermicompost in a pvc barrel and the sunlight exposed it to natural irradiance. Each treatment observed three replicates per vermcompost type while each replicate had three pseudoreplicates. A total of 18 replicates per month was observed for the preliminary test. Total coliform tests were performed on a monthly basis for a period of one year.

Baseline data for total coliform, and nitrogen, phosphorus, potassium (NPK)

Total coliform test was conducted on biodegradable-based vermicompost and sludge-based vermicompost prior to treatment application using WHO-approved membrane filtration method. Results of the test served as baseline data for comparison. Furthermore, nutrient analyses specifically on the levels of Nitrogen, Phosphorus, and Potassium (NPK) were analysed on the type of vermicompost using Kjeldahl method (AOAC International), spectrophotometry, and atomic absorption spectrophotometry, Flame method (Shimadzu AAS, AA-6300), respectively.

Treatments

Twelve treatments were tested for their effects in lowering total coliform in vermicompost. These treatments revolved around two kinds of lime application (agricultural lime and hydrated lime) in two kinds of vermicompost (biodegradable- and sludge-based) with three ratios of lime application relative to vermicompost volume (1 part vermicompost:1 part lime , 1 part vermicompost: 0.5 part lime, and 1 part vermicompost: 0.25 part lime). Each treatment had nine replicates including pseudoreplicates, which were observed every two weeks prior to total coliform determination at day 15, 30, 45 and 60. Meanwhile, each set-up was subjected to daily manual mixing using shovel specifically assigned for each treatment.

The set-ups were covered with a clean paper to prevent contamination from accidental droppings of birds or rodents or unnecessary exposure to heavy moisture when it rained.Table 1 shows a summary of the treatments in the experiment.

Table 1. Treatments used in lowering total coliform in vermicompost

Agri Lime (1:1) + SVC (treatment 1)	Hydrated lime (1:1) + SVC (treatment 4)	Agri Lime (1:1) + BVC (treatment 7)	Hydrated lime (1:1) + BVC (treatment 10)
Agri Lime (1:0.5) + SVC (treatment 2)	Hydrated lime (1:0.5) + SVC (treatment 5)	Agri Lime (1:0.5) + BVC (treatment 8)	Hydrated lime (1:0.5) + BVC (treatment 11)
Agri Lime (1:0.25) + SVC (treatment 3)	Hydrated lime (1:0.25) + SVC (treatment 6)	Agri Lime (1:0.25) + BVC (treatment 9)	Hydrated lime (1:0.25) + BVC (treatment 12)

Agrilime – agricultural lime; SVC – sludge vermicompost; BVC – biodegradable vermicompost

Figure 2. Agricultural lime from site source (left); experimental set-up (right)

Statistical Treatment

Shapiro-Wilk's test was employed for normality test of the data followed by Levene's test for homogeneity test. In case of a non-normal distribution, data set was log transformed and then, proceeded to One-way Analysis of Variance. Post-hoc analysis used Tukey's HSD to determine where the significant difference lies among the 12 treatments. The level of significance was observed at $\alpha = 0.05$.

RESULTS

Preliminary Test

Figure 3 indicates trends of total coliform reduction in sludge-based vermicompost using air-dry method against direct exposure to sunlight. Initial total coliform population was 54,000,000 cfu/100 ml in the first month. By the end of 16 months, total coliform using air-dry method was 208,000 cfu/100 mL as compared to 307,000 cfu/100 mL using direct sunlight method. T-test showed no significant difference in either methods ($p = 0.32$).

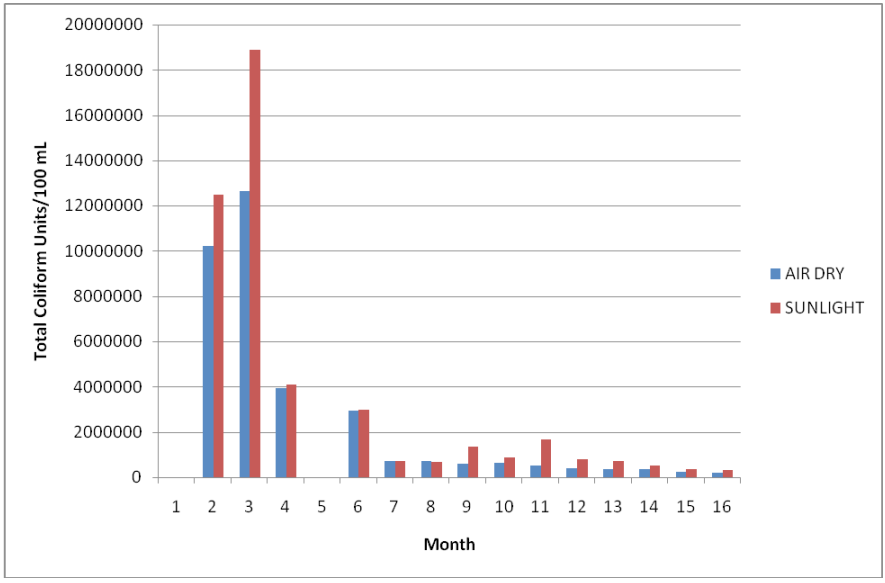


Figure 3. Coliform reduction strategies using air drying method versus direct sunlight exposure of vermicompostfrom August 2013-November 2014

Baseline Data of Total Coliform

Figure 4 shows that raw sludge contained the highest total coliform of 6,300,000 cfu/100 mL while raw biodegradables consisted of 2,550,000 cfu/100 mL of total coliform. When these base materials were processed in the gut of the African Night Crawler worm, sludge-based vermicompost contained 540,000 cfu/100 mL of total coliform while biodegradable

vermicompost had 400,000 cfu/100 mL of total coliform. All four materials tested positive for *Escherichia coli*, which is a bacterium indicative of human fecal contamination.

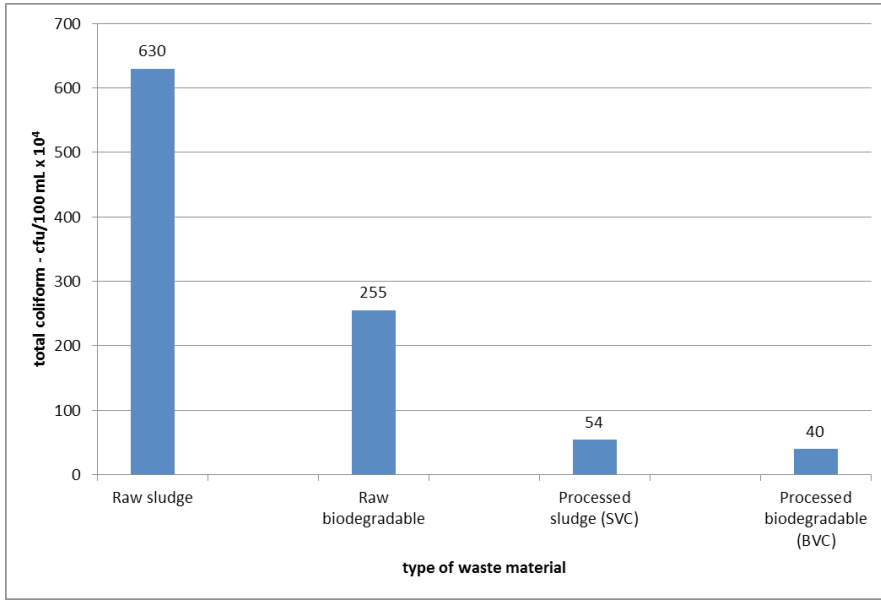


Figure 4. Baseline of total coliform levels of four types of vermicompost-related material

NPK Levels of Vermicompost Materials

When vermicompost materials were analysed for NPK, Nitrogen was highest in sludge-based vermicompost but lowest in the same vermicompost type that was added with hydrated lime. However, sludge-based vermicompost that was added with agricultural lime had intermediate levels of Nitrogen. Phosphorus was noted to be highest in raw sludge and lowest in sludge-based vermicompost that was added with hydrated lime. Those that were treated with agricultural lime showed intermediate values of Phosphorus as well. Lastly, Potassium was highest in biodegradable vermicompost and lowest in sludge-based vermicompost that was added with agricultural lime. The vermicompost with hydrated lime showed the lowest levels of NPK, indicating the nutrient-lowering effect of this lime as compared with agricultural lime.

Table 2. NPK Levels and pH of Raw Sludge, Biodegradable and Sludge-based Vermicomposts

Parameters	Raw Sludge	BVC	SVC	AL + SVC (1:1)	AL + SVC (1:1)	HL + SVC (1:1)
Nitrogen (%)	1.08 (+ 0.01)	0.64 (+0.08)	1.67 (+0.40)	0.92 (+0.05)	0.48 (+0.01)	0.28 (+0.05)
Phosphorus (%)	1.31 (+ 0.16)	0.34 (+0.04)	0.75 (+0.04)	0.65 (+0.03)	0.37 (+0.02)	0.20 (+0.04)
Potassium (%)	0.42	0.65	0.58	0.53	0.35	0.51

BVC – biodegradable-based vermicompost; SVC – sludge-based vermicompost; AL + SVC = Agricultural lime + Sludge-based vermicompost; AL + SVC = Agricultural lime + sludge-based vermicompost; HL + SVC = Hydrated lime + sludge vermicompost

Trends in Trial 1

Figure 5 shows that lime application hastened total coliform reduction in both types of vermicompost across 12 treatments. Generally, treatments with hydrated lime showed the faster reduction of total coliform within 15 to 30 days from application (1-B versus 1-A; 1-D versus 1-C of Figure 3, respectively). Meanwhile, those with agricultural lime showed slower reduction rate of total coliform in the same period. At the end of 60 days, however, total coliform was greatly reduced at levels below 1000 cfu/100 mL across all treatments.

Analysis of Variance test showed significant difference among 12 treatments in all observation periods: Day 15, Day 30, Day 45, and Day 60 (p=0.000). However, based on type of lime applied relative to their concentrations (i.e., agricultural lime, hydrated lime), Tukey's HSD indicated that lower lime concentrations (1:0.25>1:0.50>1:1) harbored higher total coliform population. The longer the day of treatment (>30 days), the more that the total coliform levels dropped significantly (p=0.000).

Trends in Trial 2

Figure 6 confirms that lime application hastened total coliform reduction across 12 treatments. Like in Trial 1, hydrated lime application had faster reduction rate of total coliform bacteria within 15 to 30 days after application.

It was likewise noted that at the end of 60 days post lime application, the total coliform was reduced below 1,000 cfu/100 mL across all treatments. Regardless of type of lime that was applied, total coliform levels were reduced at acceptable levels two months after lime application.

Analysis of Variance test shows significant difference among the twelve treatments at all observation periods: Day 15, Day 30, Day 45, and Day 60. Similar to the results in Trial 1, agricultural lime application significantly reduced total coliform levels at Day 30 onwards, while hydrated lime showed faster reduction rate as early as Day 15 relative to lime concentrations.

DISCUSSION

Vermicompost fertilizers are organic materials that come from plant and animal sources. The top sources of organic fertilizers come from bat guano, crab and shrimp wastes, blood meal, bone meal, kelp, and chicken manure among others. Their NPK ratios can reach > 6: 4:1:5 as compared to commercial fertilizers, which contain >15:11:5 NPK ratios (OSU Extension Services, n.d.; EPA, 1999). Commercial fertilizers are noted for their rapid effects on soil nutrient improvement; however, long-term use renders the soil acidic and the cost of operation expensive. Organic fertilizers are economical in the long run and promote sustainable agriculture practices since they complement and balance microbial ecology and nutrient in the soil which the plants need (Monroy *et al*.,2009; Yadav *et al.*, 2011).

This study makes use of vermicompost from biodegradable waste materials and dried sludge from human wastes, which form the bulk material in the study site. Annually, a total of 1,200 tons of biodegradable material and 2,250 tons of septic materials were received by the sanitary landfill facility. From these volumes, only 56 and 48 tons were processed as biodegradable and sludge vermicompost products, respectively (BCWMEC, 2015). The rest were bagged as "garden soil" which served as enrichment material for fruit tree production. In effect, there was a great potential to produce vermicompost but was hindered because of the high coliform levels present in the vermicompost products.

The type of earthworm used is critical in the production of low coliform level in the vermicompost (Yadav *et al.*, 2010; 2011; & 2012). Unfortunately, the African Night Crawler earthworm does not possess this trait as seen in the preliminary test of this study. To reduce coliform pathogens, agricultural

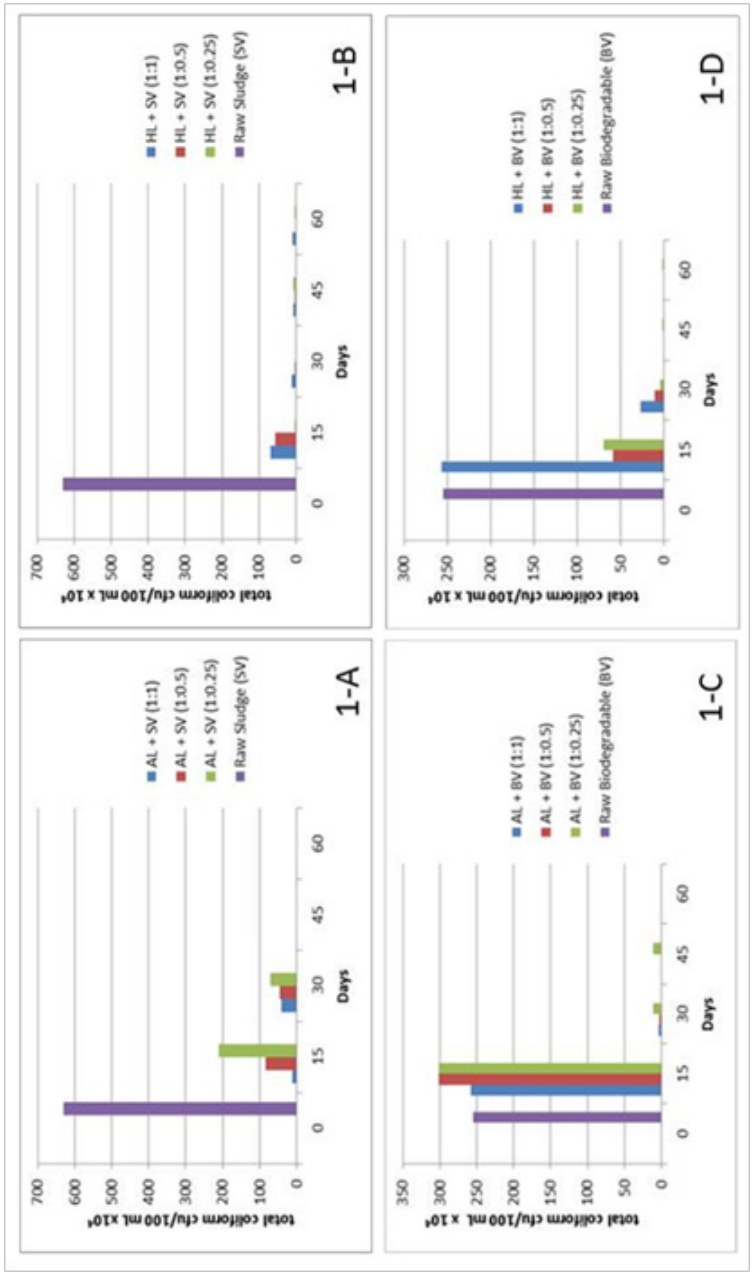


Figure 5. Trends in total coliform reduction in trial 1 using agricultural lime application + sludge vermicompost (1-A), hydrated lime application + sludge vermicompost (1-B), agricultural lime + biodegradable vermicompost (1-C) and hydrated lime + biogdegradable vermicompost (1-D). Each treatment had three kinds of ratio of lime application relative to vermicompost volume (1:1, 1:0.5 and 1:0.25)

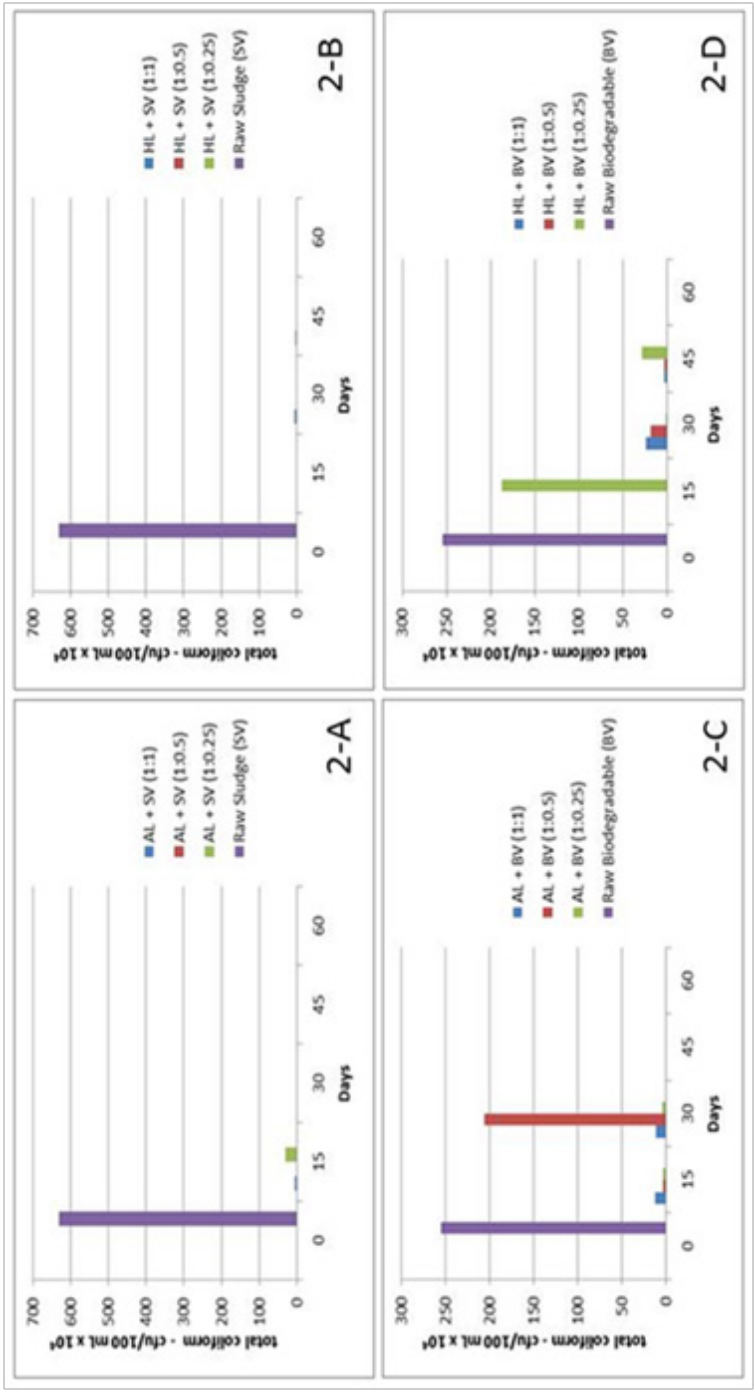


Figure 6. Trends in total coliform reduction in trial 2 using agricultural lime application + sludge vermicompost (2-A), hydrated lime application + sludge vermicompost (2-B), agricultural lime + biodegradable vermicompost (2-C) and hydrated lime + biogdegradable vermicompost (2-D); each treatment had three kinds of ratio of lime application relative to vermicompost volume (1:1, 1:0.5 and 1:0.25)

and hydrated lime were applied from low to high concentrations. In Trial 1, agricultural lime application to sludge vermicompost (Treatments 1, 2, and 3) showed no significant variations in the levels of coliform at Day 30 ($p = 0.898$). This was because total coliform levels were still high at this period; however, Day 45 and Day 60 showed significant coliform variations where Treatment 3, which had the lowest lime concentration, showed higher coliform level although at an acceptable level by WHO.

The agricultural lime application to biodegradable vermicompost (Treatments 7, 8 and 9) showed significant variations in the levels of coliform at Days 30 and 60 ($p=0.002$, $p=0.000$, respectively). The significant difference lies in the treatment with the lower concentration of agricultural lime which resulted to a higher total coliform level (Treatment 9 > Treatment 7 = Treatment 8). Nevertheless, at Day 60, total coliform levels were at acceptable levels (0-1000 cfu/100 mL) across all three concentrations of agricultural lime. In contrast, hydrated lime application (Treatment 4, 5, and 6) to sludge vermicompost resulted in significant variations at Day 15 ($p=0.000$)and Day 30 (p=0.000) while no significant variations were noted at Days 45 and 60. This suggests that 45 days after treatment, hydrated lime in Treatments 4, 5 and 6 greatly reduced, if not eliminated, coliform bacteria present in the sludge vermicompost. Hydrated lime application to biodegradable vermicompost (Treatments 10,11 and 12) showed significant variations at Days 15, 30, 45 and 60($p=0.000$, $p = 0.000$, $p=0.000$, respectively) where the lowest concentration of hydrated lime showed the highest coliform levels although at an acceptable level set by WHO.

Trial 2 confirmed the results in Trial 1; agricultural lime application to sludge vermicompost (Treatments 1,2, and 3) showed no significant variations in the levels of coliform at Days 15, 30, 45 and 60 ($p = 0.171$, $p = 0.132$, $p = 0.151$ and $p=0.383$, respectively). This was because total coliform levels were high at the early days after treatment. The same treatments showed very low levels of total coliform after 45 and 60 days. However, the agricultural lime application to biodegradable vermicompost showed significant variations in the levels of coliform at Days 15, 30 and 60 ($p=0.004$, $p=0.000$, $p=0.039$, respectively). The significant difference lies in the treatment with the higher concentration of agricultural lime which resulted in the lowest total coliform level (Treatment 7 < Treatment 8 = Treatment 9). Nevertheless, at Day 45 and 60, total coliform levels were at acceptable levels (0-1000 cfu/100 mL).

In contrast, hydrated lime application (Treatment 4, 5, and 6) to sludge vermicompost showed significant variation at Day 30 (*p=0.016)* while no significant variations were noted at Days 45 and 60. It was apparent that 30 days after treatment, hydrated lime in Treatments 4, 5 and 6 greatly reduced, if not eliminated, coliform bacteria present in the sludge vermicompost. Hydrated lime application to biodegradable vermicompost (treatments 10, 11 and 12) showed significant variations at Days 15, 30, and 45*(p=0.000, p = 0.000, p=0.001)*. The significant difference lies in the treatment with the lowest concentration of hydrated lime, which likewise contained higher coliform bacteria although at an acceptable according to WHO standards. No variation was noticed at Day 60 (*p=0.123)*, indicating that coliform levels were zero to near zero values.

The study of Lalander *et al.* (2013) showed that pH contributed the highest impact in reducing pathogens present in vermicomposted human wastes. Since the optimum pH range of *E. coli* is between 6 and 7 (Desmarchelier & Fegan, 2003 as cited by Yates, n.d.), this serves as a basis for the coliform-reducing activity of lime application. However, the interaction between NPK and high lime application (Table 2) suggests that hydrated lime reduces NPK levels of vermicompost which impairs optimal plant growth. The study of Jensen (2010) supports this negative interaction where high pH causes precipitation of phosphorus, thus, making it less available to plants.

It is, therefore, practical to use agricultural lime rather than hydrated lime to target good plant growth and low coliform levels in the vermicompost. Based on economics, hydrated lime is costlier than agricultural lime; however, both lime materials reduce the total coliform level effectively within 60 days after treatment across three concentrations. Thus, this study suggests that lowest concentration (1:0.25) of agricultural lime offers the best option in lowering coliform while maintaining nutrient availability when using vermicompost produced by African Night Crawler earthworm.

CONCLUSION

Aeration and exposure to the environment for 15 months did not reduce coliform levels in vermicompost produced by the African Night Crawler earthworm *E. eugeniae*. From an initial level of 54,000,000 cfu/100 mL, the levels of total coliforms were 208,000 and 307,000 cfu/100 mL using aeration method and exposure to sunlight method, respectively. Application of lime,

either agricultural or hydrated, significantly reduced the levels of coliform beginning 30 days after treatment. Between Day 45 and Day 60, total coliform levels were reaching zero values and near zero values in both types of lime application. It was clear that hydrated lime reduced the coliform levels faster than agricultural lime as early as Day 15 and Day 30. In terms of concentration of lime and its effects on coliform, higher agriculture lime application to biodegradable vermicompost (1:1) resulted in lower coliform levels (p=0.000).

Meanwhile, when agriculture lime was added to sludge vermicompost, no significant variations of coliform were noticed regardless of agriculture lime concentrations (p=>0.05). Hydrated lime application to sludge vermicompost showed significant variation where high concentration lowers coliform levels 30 days after treatment (p = 0.016), but then at Day 45 onwards, no significant difference was noted (p=>0.05) in the treatments as coliform levels were reduced to zero values. Hydrated lime application to biodegradable vermicompost showed no significant difference at Day 15, Day 30, Day 45 as coliform levels were greatly reduced regardless of concentrations of hydrated lime (p=>0.05).

Lime application is an effective way of reducing vermicompost produced by African Night Crawler Earthworm, *E. eugeniae*. It is recommended that the SLF of Bayawan City consider the following options to improve the status of its vermicompost production targets:

1. Perform cost analysis of each treatment related to coliform reduction strategies in the vermicompost of Bayawan City;

2. Optimize the production of vermicompost as yearly biodegradable vermicompost production of the facility is 56 tons from a raw biodegradable material of 1,200 tons. Sludge vermicompost production, in like manner, has to be optimized as yearly barely reached 50 tons from a raw sludge material of 2,250 tons;

3. Do trial application of lime-treated vermicompost to identified agricultural farms. This can be undertaken by Bayawan LGU to serve as baseline production data;

4. Compare total coliform levels in the vermicompost produced by alternative earthworms such as Red Tiger worm Eisenia fetida, and Indian Blue Worm Perionyx excavates;

5. Explore other ways of reducing total coliform such as addition of ash from burned rice hulls and sugar waste, which are abundant in the agricultural landscape of Bayawan City.

ACKNOWLEDGMENT

The authors acknowledge CHED-PHERNet for funding this study; Dr. Enrique G. Oracion as program leader for the insightful discussions and comments that improved the paper; Professor Roy Olsen D. De Leon for the comments on the statistical treatment of the data.

REFERENCES

Abakpa, G.O, Umoh, V.J, Ameh, J.B. &Yakubu, S.E. (2013). Microbial quality of irrigation water and irrigated vegetables in Kano State. *International Food Research Journal*, *20* (5), 2933-2938.

BCWMEC. (2015, December 31). Monthly monitoring report

EPA. (2006). Bacteria indicators of potential pathogens. In *Voluntary estuary monitoring manual: A methods manual* (2nd ed.). Retrieved from http://www.epa.gov/owow/estuaries/monitor

Garg, V. K., Gupta, R. and Yadav, A., (n.d.). Vermicomposting technology for solid waste management. Retrieved from www.environmental-expert.com

Guino-o, R., Aguilar A.,& Oracion, E., (2010). Technical efficiency and social acceptability of the constructed wetlands of Bayawan City, Negros Oriental. *Silliman Journal, 50* (1), 65-92.

Jensen, T. L. (2010). Soil pH and the availability of plant nutrients. *IPNI Plant Nutrition TODAY*, *2*. Retrieved from www.ipni.net/pnt

Lalander, C.H., Hill, G.B., & Vinnerås, B. (2013). Hygienic quality of faeces treated in urine diverting vermicomposting toilets. *Waste Management*, *33*, 2204–2210.

Monroy, F., Aira, M., & Domínguez, J. (2009). Reduction of total coliform numbers during vermicomposting is caused by short-term direct effects of earthworms on microorganisms and depends on the dose of application of pig slurry.

Science of the Total Environment, 407, 5411–5416.

OSU Extension Services (n.d.). *Nitrogen-Phosphate-Potassium values of organic fertilizers.*

Paruch, A.M. & Maehlum, T. (2012). Specific features of Escherichia coli that distinguish it from coliform and thermotolerant coliform bacteria and define it as the most accurate indicator of faecal contamination in the environment. *Ecological Indicators, 23,* 140–142.

Republic Act 9003. An act providing for an ecological solid waste management program, creating the necessary institutional mechanisms and incentives, declaring certain acts prohibited and providing penalties, appropriating funds therefore, and for other purposes. Congress of the Philippines, Republic of the Philippines, 26 January 2001.

Sinha, R.K., Bharambe G, & Chaudhari, U. (2008). Sewage treatment by vermifiltration with synchronous treatment of sludge by earthworms: A low-cost sustainable technology over conventional systems with potential for decentralization. *Environmentalist, 28,* 409–420.

Tura-Mutya, J., Relles, M., Jayme, J. & Guino-o, R, (2013). Coliform characterization of the liquid and solid wastes of Bayawan City (Unpublished report). Graduate School, Silliman University, Dumaguete City.

Yadav, K.D., Tare, V. & Ahammed, M., (2010). Vermicomposting of source-separated human faeces for nutrient recycling. *Waste Management, 30,* 50–56.

Yadav, K.D., Tare V., & Ahammed, M., (2011). Vermicomposting of source-separated human faeces by Eisenia fetida: effect of stocking density on feed consumption rate, growth characteristics and vermicompost production. *Waste Management, 31,* 1162–1168.

Yadav, K.D., Tare, V,& Ahammed, M. (2012). Integrated composting–vermicomposting process for stabilization of human faecal slurry. *Ecological Engineering, 47,* 24– 29.

Yates, A. (n.d.). *Shiga toxin-producing Escherichia coli.* Retrieved from www.foodstandards.gov.au/publications/documents/e%20coli.pdf

APPENDIX

Appendix - A. T-test Comparing Air Dry Method Versus Direct Sunlight

t-Test: Two-Sample Assuming Equal Variances		
	Air dry Method	**Direct Sunlight**
Mean	2,459,000	3,316,357.143
Variance	1.58218E+13	3.01353E+13
Observations	14	14
Pooled Variance	2.29786E+13	
Hypothesized Mean Difference	0	
Df	26	
t Stat	-0.473204947	
P(T<=t) one-tail	0.320007919	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.640015838	
t Critical two-tail	2.055529439	

Appendix - B. Summarized ANOVA values in Trial 1 and Trial 2 with Tukeys HSD in parenthesis

Trial 1

Treatments 1-3 Trt 1 – AL + SVC (1:1) Trt 2 – AL + SVC (1:0.5) Trt 3 – AL + SVC (1:0.25)	**Treatments 4-6** Trt 4 – HL + SVC (1:1) Trt 5 – HL + SVC (1:0.5) Trt 6 – HL + SVC (1:0.25)
Day 15 p = 0.000 (Trt 1 < Trt 2 < Trt3) Day 30 p = 0.898 Day 45 p = 0.032 (Trt 3 > 1=2) Day 60 p = 0.005 (Trt 3 > 1=2)	Day 15 p = 0.000 (Trt 6 < Trt 4 = Trt 5) Day 30 p = 0.000 (Trt 4 > Trt 5 = Trt 6) Day 45 p = 0.440 Day 60 p = 0.062
Treatments 7-9 Trt 7 – AL + BVC (1:1) Trt 8 – AL + BVC (1:0.5) Trt 9 – AL + BVC (1:0.25)	**Treatments 10-12** Trt 10 – HL + BVC (1:1) Trt 11 – HL + BVC (1:0.5) Trt 12 – HL + BVC (1:0.25)
Day 15 p = 0.06 Day 30 p = 0.002 (Trt 9> Trt 7 = Trt8) Day 45 p = 0.000 (Trt 9> Trt 7 = Trt8) Day 60 p = 0.853	Day 15 p = 0.000 (Trt 10 > Trt 11 = Trt 12) Day 30 p = 0.000 (Trt 10 > Trt 11 = Trt 12) Day 45 p = 0.000 (Trt 12 > Trt 10 = Trt 11) Day 60 p = 0.000 (Trt 12 > Trt 10 = Trt 11)

AL – Agricultural lime; BVC – Biodegradable vermicompost; HL – hydrated lime; SVC – Sludge-based vermicompost

Trial 2

Treatments 1-3 Trt 1 – AL + SVC (1:1) Trt 2 – AL + SVC (1:0.5) Trt 3 – AL + SVC (1:0.25)	**Treatments 4-6** Trt 4 – HL + SVC (1:1) Trt 5 – HL + SVC (1:0.5) Trt 6 – HL + SVC (1:0.25)
Day 15 p = 0.171 Day 30 p = 0.132 Day 45 p = 0.151 Day 60 p = 0.383	Day 15 – no variation in the data Day 30 p = 0.016 (Trt 4 > Trt 5 = Trt 6) Day 45 p = 0.090 Day 60 – no variation in the data
Treatments 7-9 Trt 7 – AL + BVC (1:1) Trt 8 – AL + BVC (1:0.5) Trt 9 – AL + BVC (1:0.25)	**Treatments 10-12** Trt 10 – HL + BVC (1:1) Trt 11 – HL + BVC (1:0.5) Trt 12 – HL + BVC (1:0.25)
Day 15 p = 0.004 (Trt 7 > Trt 8 = Trt 9) Day 30 p = 0.000 (Trt 7 > Trt 8 = Trt 9) Day 45 p = 0.653 Day 60 p = 0.039 (Trt 7 < Trt 8 = Trt 9)	Day 15 p = 0.000 (Trt 12 > Trt 10 = Trt 11) Day 30 p = 0.000 (Trt 12 < Trt 10 = Trt 11) Day 45 p = 0.001 (Trt 12 > Trt 10 = Trt 11) Day 60 p = 0.123

AL – Agricultural lime; BVC – Biodegradable vermicompost; HL – hydrated lime; SVC – Sludge-based vermicompost

Synergizing Traditional Knowledge and Sustainable Local Practices for Enhancing Coastal Resource Education and Management- an Indian Scenario

J. Logamanya Tilak,

C. Sheeba Anitha Nesakumari,

R.W. Alexander Jesudasan,

Department of Zoology, Madras Christian College (Autonomous), Tambaram East, Chennai – 600 059, Tamil Nadu, India.

and N. Thirunavukkaras

Department of Advanced Zoology & Biotechnology, Dr. Ambedkar Government Arts College, Vyasarpadi, Chennai - 600 039, Tamil Nadu, India

The diverse marine and coastal habitats in India harbor a wide range of biodiversity which has not been fully understood due to logistic constraints. The variety of coastal ecosystems along the Indian coastline measuring 8,129 km encompassing nine maritime states and four union territories include estuaries, lagoons, mangroves, backwaters, and coral reefs. The marine floral and faunal diversity is immense that India stands third in fish production and second in aquaculture in the world. This vast coastline, which has such rich coastal resources, has always been under threat, atleast in the recent past due to reasons, viz. nature, anthropogenic factors, and urbanization. These factors have contributed to the loss in biodiversity endangering few species to the brink of extinction. As a part of the conservation campaign for coastal resource management in India, traditional knowledge that helped in sustainable fishery has to be revived through synergizing the activities of the academicians, policy makers, and NGOs to draft a proposal for an effective and successful coastal resource management. Inculcating the need for coastal resource management in the minds of future generation would warrant the introduction of this focal point at different levels of education, and the wealth of traditional knowledge of the fisherfolk of Pulicat Lake in Tamil Nadu would be an added feature on this subject.

Keywords: traditional knowledge, coastal resource education, coastal resource management, India

INTRODUCTION

The coastal stretch of India is made up of diverse ecosystem, which includes a wide range of mangroves, coral reefs, sea grasses, salt marshes, mud flats, estuaries, lagoons, and unique flora and fauna.In India, nearly ten million fishermen depend on coastal resources and seas for their survival. Increasing stress due to development of industries, trade and commerce, tourism and resultant human population growth and migration towards coastal cities and urban centers pose a serious threat to the health of these coastal ecosystems and to lives and livelihoods of coastal communities. Thus, protection, conservation, and rejuvenation of coastal natural resource have become a need of thehour. This paper focuses on the use of traditional fisheries knowledge and indigenous fisheries knowledge for sustainable fisheries,which carry special relevance in the context of resource conservation, reduction of environmental pollution, maximum utilization of locally available resources, and cost effectiveness.

RESOURCE POTENTIAL OF INDIA

India has a vast coastline of about 8,129 km encompassing nine maritime states and four union territories with an Exclusive Economic Zone (EEZ) of 2.02 million km^2, which is home to a diversity of coastal and marine ecosystems, comprising nationally and globally significant biodiversity rich areas. Until today marine diversity is less known than terrestrial biodiversity due to the logistic difficulties of explorations, underwater surveys, and collections. The coastline of Bay of Bengal and Arabian Sea continues to be a rich fishing ground in the South Asian region, and India is one of the world's largest fish producing countries. Indian marine ecosystems are all known for their high biological productivity, thus providing a wide range of habitats for aquatic flora and fauna. They also provide important food resources and other fishery relatedactivity to people.

FISH PRODUCTION IN INDIA

With continuous and sustained increments in fish production since independence, India is considered to be the third largest fish producer in the world (first and second being China and Peru, respectively) and

second largest producer through aquaculture. In the overall production of shrimps, India stands in fifth in the world. India constitutes about 6.3% of the global fish production; the sector contributes to 1.1% of the GDP and 5.15% of the agricultural GDP. Per capita fish consumption in India is 9kg (NFDB, 2016).

CURRENT STATUS OF INDIAN SEAFOOD EXPORT

During the financial year 2014-15, exports of marine products from India reached an all-time high. Exports aggregated to 10,51,243 MT valued at Rs. 33,441.61 crores and USD 5511.12 million. Compared to the previous year, seafood exports recorded a growth of 6.86 % in quantity, 10.69% in rupees and 10.05 % growth in USD earnings.Frozen shrimp continued to be the major export item in terms of quantity and value, accounting for a share of 34.01% in quantity and 67.19% of the total dollar earnings. Fish was the second largest export item, accounting to a share of about 29.44% in quantity and 11.24% in dollar earnings. The US wass the largest market for Indian seafood products with a share of 26.46% followed by South East Asia (25.71%), European Union (20.08%), Japan (9.11%), Middle East (6.04%), China (4.02%) andother countries (8.58%) (MPEDA, 2016).

COASTAL BIODIVERSITY

India's coastline holds many biological treasures.The rich mangrove forests of Sundarbans (Plate 1a), the world's largest congregations of nesting turtles in Odisha, beautiful seagrass beds in Palk Bay, enigmatic sea cows in the Gulf of Mannar, majestic yet gentle whale sharks in the Gulf of Kutch and some of the world's most beautiful and striking coral reefs (Plate 1b) are examples of some of the biological treasures of India's coastal and marine biodiversity. Besides being store houses of biological diversity, coastal regions are also home to a large human population. Indian coastal ecosystems consist of sandy and rocky beaches (Plate 1c&d),backwaters (Plate 1e), estuaries, creeks, mangroves, coral reefs, Mudflats (Plate 1f) marshes, lagoon, and seagrass.

IMPACT OF NATURAL CALAMITY ON FISHERIES AND COASTAL COMMUNITIES – POST TSUNAMI

The tsunami, which also attacked Indian Ocean on the 26th December 2004, caused considerable destruction and casualties in the coastal regions of the states including Tamil Nadu, Pondicherry, Kerala, Andhra Pradesh, and Andaman and Nicobar Islands. There was a considerable reduction in the fishing trips and decline in catch rates, which was mainly due to loss of fishing equipment, fear of recurrence of tsunami, and displacement from their original place of inhabitance to relief camps. Fishermen restricted their activities near the shore. Hence, there was drastic reduction in the per capita landings of all types of fishing units. The prices of marine fish also faced great setback immediately after the tsunami. This was mainly due to low demand for fishes in the market, as result of people's apprehension, that fishes might have consumed carcasses of humans and animals floating in the sea after the tsunami.

The income levels of owners of mechanized and non-mechanized boats as well as the crew members showed a steep decline. Fishing labourers, who share one third of the total revenue of the catch, suffered heavily with substantial wage losses due to decrease in catch after tsunami. The tsunami also caused widespread damage to houses that were either completely destroyed or damaged (Plate 2 a b c & d).

Employment opportunities apart from capture fisheries, which includes net mending and weaving, supply and repair of fishing equipment and gear, boat building, ice plants, marketing, processing and transporting of fish, and fish exports, among others seem to have been affected very badly (Sathiadas & Prathap, 2008).

THREATS TO MARINE BIODIVERSITY

India's rapid population, economic, and industrial growth had created pressures on the coastal resources. Some coastal stretches in India were highly polluted with municipal waste deriving from urbanization and tourism, waste generated from industry, and toxic chemicals from fertilizers and pesticide application. Untreated sewage and other non-industrial waste accounted for more pollution than industrial effluents. Mining of sand from the sea-bed resulted in an increase in turbidity in the ambient water, which affects benthic organisms and primary productivity by limiting the availability of

light. Aquaculture activity in some parts of India had also placed considerable pressure on coastal resources. Construction of breakwaters (Plate 3a), which forms part of the port development, alters the sediment transport mechanisms in the coastal areas, thereby causing erosion (Plate 3b) or accretion.

Major anthropogenic activities that cause ecosystem degradation and destruction include habitat conversion into the other forms of land use, overexploitation of species, associated destructive fishing practices, spread of invasive alien species, and the impacts of pollution from agricultural, domestic, and industrial effluents.The marine biodiversity has to counter a wide range of challenges that threaten their very existence. These challenges include the impact of climate change, overexploitation of fishery, habitat damage, urbanization, and pollution.

The rise in sea level, due to the melting of the glaciers, inundates coastal areas and in some cases would drown an island completely. The overexploitation of fishery resource through commercial fishing, recreational fishing, illegal unregulated or unreported fishing (IUU) causes a decline in the fishery resource of the sea (Plate 3c). The increase in oceanic temperature due to global warming results in coral bleaching (Plate 3d).The unsteady water cycle increases the rainfall causing floods and changes the patterns of water movement, displacing the usual path of biodiversity.

Destructive fishing gear, especially bottom trawling, damages the habitat to a large extent. The coral reefs are ripped off when the nets that entangle them are removed. The dredgers have a drastic effect on the benthic organisms as they disturb or in most cases remove the soil, which is the habitat of a variety of encrusting organisms, biofoulers and epibenthic organisms. The marine environment is being polluted by an array of pollutants that include, sediments from mining or rigging, plastic litter (Plate 3e) usually from the navigating ships, discharge of effluents (Plate 3f), hazardous and radioactive substances from industries along the coast, discarded fishing gear in the sea (Plate 3g) that accounts for ghost fishing, microbial pollution and trace chemicals which become carcinogens, endocrine-disruptors, etc.They cause a serious threat to the life of many aquatic organisms.

The introduction of alien species into an ecosystem can alter the entire composition of the biodiversity in that biome. The absence of natural predators, conducive environment, and easy prey can help establish the population of the alien species causing huge damage to the ecosystem as the native species are pushed to a state of mere survival.

Marine debris, mineral exploration, oil rigging, and laying of pipelines and cables in the sea cause habitat destruction and biodiversity loss. The fine silt that is inevitable during mineral exploration alters the turbidity of the water column forcing the fishery to move away from the place. The silt that settle down would bury the encrusting and the epibenthic organisms, which form the major attractants of biodiversity. The oil pipelines that are in deep sea also threatens the life of many organisms. Leakage in the pipeline would wipe out the biodiversity in a very short span of time (Tewari & Bisht, 2010).

ENDANGERED MARINE SPECIES

International Union for the Conservation of Nature(IUCN) has listed approximately 342 marine species in India (Table 1, Plate 4),that fall under different categories, viz.Critically Endangered, Endangered, Near Threatened and Vulnerable (IUCN, 2016). Steps have to be taken for the conservation of these species.

CONSERVATION

In situ conservation of species is the process of protecting an endangered or threatened marine animals in its natural habitat by protecting them from predators and anthropogenic activities.

Sea Ranching: It is a culture method whereby juvenile animals, generally produced in hatcheries but could also be wild-caught, are introduced into the natural environment and allowed to grow without containment structures.

Marine Reserve/protected areas: A marine reserve is a defined space within the sea in which fishing is banned or restricted to protect the habitat and ultimately conserve the associated biodiversity. Marine reserves are also very similar to marine protected areas, fishery reserves, sanctuaries, and parks (Table 2). Declaration of certain protected areas/biosphere reserves for *in situ* conservation of resources appears to be a pragmatic approach. The important biosphere reserves in India (Table 3) are Gulf of Mannar Biosphere Reserve (Tamil Nadu): Sunderbans Biosphere Reserve (West Bengal), Great Nicobar Biosphere Reserve (Andaman and Nicobar Islands), North Andaman Biosphere Reserve (Andaman and Nicobar Islands) (Plate 5a) and Little Rann of Kutch Biosphere Reserve (Gujarat).

Bioregional management: It is the total ecosystem strategy, which regulates factors affecting aquatic biodiversity by balancing conservation, economic, and social needs within an area. In these bio-conservation units, activities such as fishing, hunting, harvesting, and development activities are strictly limited.

Threatened or endangered species designations: Threatened species include organisms likely to become endangered if not properly protected. Endangered species are plants and animals that need protection in order to survive as they are in immediate danger of becoming extinct. Once species are listed, they become subject to national recovery programs and will be placed under international protection.

Restoration/Mitigation efforts: Aquatic areas that have been damaged or suffered habitat loss or degradation can be restored. Even species populations that have suffered a decline can be included for restoration.

Ex situ conservation is "off-site" protection of species by removing the threatened species from their existing habitat and placing them in protected environments. This includes live gene bank, where the endangered species are reared in captivity, bred, and genetically managed avoiding inbreeding, domestication, and unintended selection. Cryopreservation of gametes in liquid nitrogen and gene banks can help in long-term conservation.

Increasing public awareness is one of the most important ways to conserve aquatic biodiversity. This can be accomplished through educational programs, incentive programs, and volunteer monitoring programs. Several initiatives were taken by the Government of India focusing on the conservation and management through implementation of laws and continuous monitoring. The Wildlife Protection Act of India (1972) provides legal protection to many marine animals. The Environment Protection Act, 1986 declare mangrove and coral reef areas as ecologically sensitive areas. The Coastal Regulation Zone (CRZ) prohibit the developmental activities and disposal of wastes in the fragile coastal ecosystems that facilitates the mass nesting of sea turtles at Gahirmatha, Odhisa (Plate 5b). The National Biodiversity Authority also focuses on matters related to the protection and conservation of biodiversity.

INDIGENOUS FISHERIESKNOWLEDGE/ TRADITIONAL FISHERIES KNOWLEDGE – PULICAT PERSPECTIVE

The normal practices of the fisherfolk always had concern for the environment or more so conformed to the norms of the ecosystem. Due to factors like over population, export demand, technological advancement, ecosystems slowly

withered and are now facing the after effects of negligence. It is now pertinent that academicians promote to the current generation of fishermen these, an indigenous fishing practice, which isin tune with nature. By highlighting what the yesteryear fishermen practiced to maintain sustainability, negligence would not grow to ignorance.

Fishing in Pulicat is an example of sustainable fishing. The regulation on the fishing rights and fishing grounds, which is monitored and implemented strictly through a system called "P*aadu* system," is an example of sustainable fishing. According to this system, a village is allotted a particular fishing ground to fish only on certain days using only certain craft and gears. This prevents overcrowding, allows equal distribution of productive fishing grounds, and reduces fishing pressure in the lake by providing fishing rights in the sea. The use of non-mechanized boats helps prevent oil pollution and noise pollution, and reduces damage to the nets.

The fishermen had a unique knowledge on fish aggregation through the onset of wind direction. They were able to project the aggregation or movement of shoals of specific fishes at the advent of a specific wind from a specific direction. By this, they were able to forecast fish catch, thereby increasing their catch per unit effort (CPUE) and income per unit effort (IPUE). They were able to take specific nets for specific shoals of fishes having specific mesh size, thereby, reducing the quantum of trash fish or bycatch.

The complexity in the pattern of installation of shrimp nets in the lake was done in full knowledge of the movement of the shrimp based on the impact of any obstruction. The use of specific baits for the hook and line fishing was also based on the behavior of the fishes. Live prawn was used as bait for fishing seabass not because of visual stimulus of the twitching of the prawn but because of the olfactory stimulus of the body fluids that ooze out of the prawn while twitching. Another traditional practice was the crab fattening where the unproductive crab, after a moult was transformed into commercially potent crab. This type of culture was more prevalent in small fishing hamlets.

Jamilabad, a village in Pulicat, maintained their traditional knowledge of building boats (Plate 6 a & b) for the entire fishing community in and around Pulicat. The boat builders never went to any institute to learn the art, but the indigenous knowledge was transferred from one generation to the other for so many years till recently when fibre boats came into play. The choice of wood, adhesive, nails, paint, and sail are all custom-made

from locally available indigenous products. The introduction of the fiber boats had distorted their livelihood and their art was in the verge of a mere memory.

Neelankarai, a fishing village in the east coast of India near Mamallapuram, practiced a unique method to attract fish to their area. The bark of a tree, *Delonixelata,* was cut and anchored in the sea. The bark would start to purify slowly and the smell from the bark would attract many fishes to the vicinity. This was used as a fish aggregating device. Fishermen could easily forecast the weather and help in effective fishing. With the help of the colour and proximity of the cloud and the direction of the wind, they were able to predict the presence of the shoals in the vicinity.

In a shallow water body like Pulicat Lake, the depth of the lake was not uniform and this could result in the boats getting grounded. The colour of the water gave a clue to the fishermen whether the depth was adequate to wade through.

INDIGENOUS FISHERIES KNOWLEDGE/ TRADITIONAL FISHERIES KNOWLEDGE – KERALAPERSPECTIVE

Traditional knowledge on selection of wood for making crafts helped them to have better quality boats with strong and long durability in salt water. The use of sardine oil was the most common practice to safe guard the wooden boats. Cotton and jute threads were used for making gears with the mesh size suitable for catching only the targeted size and for reducing juvenile fishing. Traditional knowledge of boiling the nets in cow dung slurry and drying it in the sun helped them to maintain the nets.The other method of boiling the nets with dried seeds of tamarind gave strength and colour to the gears.A mixture of powdered ghee and charcoal were used as an antifouling agent in their traditional crafts. Hence, a wide variety of materials and indigenous techniques were used in making crafts and gears and also for their maintenance.

Based on the water movement and colouration, fishers were able to tell the availability of fish. The appearance of seagulls would indicate the presence of fish. Sardine shoals was characterized by the presence of small bubbles and oily appearance on the top of water. The presence of silver bellies was indicated by a white colouration of water. Muddy water in some

seasons indicated good shoals on the next day.The traditionally practiced shoal identification techniques showed the sound knowledge and close association of the older generation with the nature.

Traditional knowledge was used even for the post-harvest techniques. Fresh fish sprinkled with wet sand was believed to preserve the fish, day long.The fishes like sharks and rays were kept in pits dug on beach helped prevent easy decay.The common practice of salting fish in earthenvessels and keeping them for two days and drying them for 3-4 days in the hot sun was practiced as a common preservation technique.Many of the indigenous preservation methods were cheaper and free from harmful chemicals (Ashaleetha & Immanuel, 2008).

COASTAL RESOURCE EDUCATION

India has a vast coastline and a wealth of coastal resources; thus,its fishing potential and the need for its coastal management have to be made known to all people through proper education. Like Environmental Studies which was introduced into the curriculum after the government deemed it important for people to know their part in the degradation of the environment, Coastal Resource Management should also be part of the curriculum for the people to know the need for proper management of the coastal resource. This education can be started even from school as a chapter in Biology and in under graduation as a paper and in post-graduation as an interdisciplinary optional paper.

Fishing holidays (61 days in east and west coasts) introduced by the government is a step towards conservation. The overexploitation following the fishing holidays has to be checked to taste the fruits of such endeavor. This can be done with the cooperation of NGOs, self-help groups, and entrepreneurs. The fishing pressure should be neutralized with aquaculture.

Workshops and training programs can be organized to highlight the importance of coastal resource and its management through schools, colleges, and NGOs, to make people aware of the latest research and potential in fisheries. Awareness campaigns on conservation and management is the need of the hour.

Extension education in the form of out of school education can target specific groups based on their understanding. Different methodologies can be adopted for different target groups like pamphlets, street plays, movies, short plays, meetings, demonstrations, onsite programs, newsletter; participatory rural appraisal techniques can be used for effective transfer of information.

Lab to land programs should be quick, transparent, and replicable. The successful techniques from the institutes should be brought to the people and educate them to maximize the potential utilization of research findings.

Joint efforts from all units related to the coastal resource like the state fishery departments, forest department, coast guard, fisher folk, boat builders, entrepreneurs, businessmen, NGOs, scientists, researchers, and academicians should join hands in coastal resource education and management. Central fisheries institutes in India like, CMFRI, CIBA, CIFT, CIFRI, CIFE and others play a very important role in educating the farmers/communities by providing technical support and consultancies as well as monetary help in the form of loans, credits, and subsidies.People's awareness, participation, and support are pivotal to the implementation of any project concerning the resource management. More than management and conservation, it is the concern that is very important.

The population of India has grown exponentially and is likely to touch 1.6 billion in 2050. Conservation of coastal resource is pivotal to sustenance in meeting the growing need for food and nutritional requirements of the country. Innovation in hatchery technology and farming, feed technology, diversification, and introduction of more cultivable organisms in aquaculture could help reduce the fishing pressure on capture fisheries.

The indigenous fisheries knowledge and traditional knowledge of the fishermen cannot be ignored these days as they could stabilize the balance between need and greed. Coastal resource management / education will surely transform the coastal resource into an unending resource for the future. The coastal resource concern is more important than coastal resource conservation.

ACKNOWLEDGEMENT

Sincere thanks go to the Department of Zoology, Madras Christian College for providing the necessary facilities and the Google images for the pictures.

REFERENCES

Ashaleetha, S., & Immanuel, S. (2008). Scope of ethno-fisheries and sustainable marine fisheries management in India. *Ind.J. Traditional Knowledge*, *7*(2), 226-232.

IUCN, International Union for Conservation of the Nature. (2016). Retrieved from https://www.iucn.org

National Fisheries Development Board. (2016). Accessed from nfdb.gov.in

Tewari, G., & Bisht, A. (2010). Aquatic biodiversity: Threats and conservation. *Aquafind*, 241-246.

The Marine Products Export Development Authority (Ministry of Commerce and Industry, Government of India). (2016). Accessed from mpeda.gov.in/MPEDA/marine_products_exports.php#

Sathiadas, R. & Prathap, S.K. (2008). Socio-economic impact of tsunami on fisheries and coastal communities in Kerala. *Proc. on The Seventh Indian Fisheries Forum*(pp. 338-347),K.Vasudevappa, Y.Basavaraju, D.Seenappa, S.Ayyappan&S.Ravichandra Reddy (Eds.)Mangalore, ICAR, India: AFSIB.

Plate – 1. Few Coastal Ecosystems in India

(a) Mangroves in Sunderbans, West Bengal; (b) Coral Reefs of Andaman Islands;
(c) Sandy Beaches of Goa; (d) Rocky Shores of Mammallapuram;
(e) Backwater of Kerala; (f) Mudflats of Muthupet, Tamilnadu

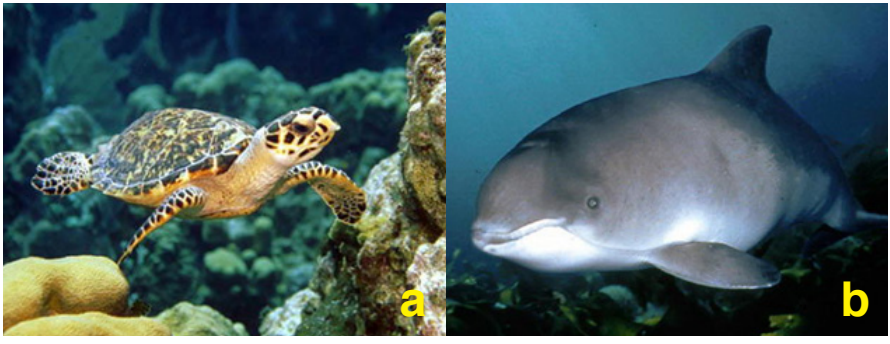
Plate – 2. Effects of Tsunami

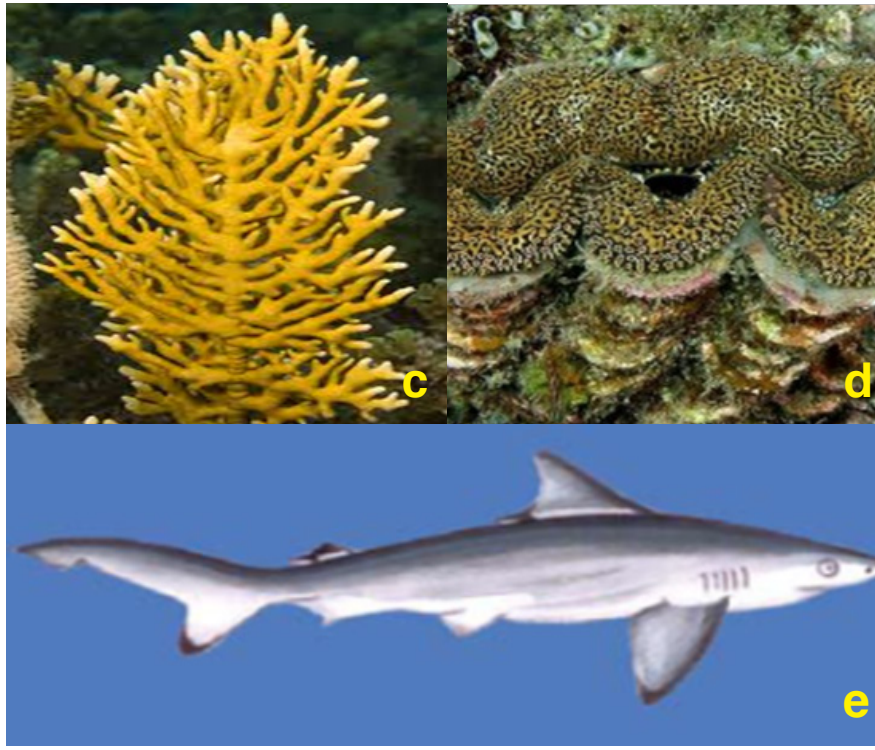
(a) Tsunami damages in Cudalore; (b) Erosion in Pondicherry;
(c)Houses damaged in Nagapatinam; (d) Boats damaged in Cudalore

Plate – 3. Threats to Marine Biodiversity

(a) Construction of Breakwater; (b) Beach Erosion;
(c) Overexploitation of Fishery Resource; (d) Coral Bleaching;
(e) Plastic litter; (f) E**ffl**uent discharge; (g) Discarded nets

Plate - 4. Endangered Marine Species of India





(a) Hawksbill Sea Turtle; (b) Sei Whale; (c) Fire Coral;
(d) Giant Clam; (e)Pondicherry Shark

Plate - 5. Marine Protected Areas in India

(a) National Park in Andaman Islands; (b) Turtle nesting at Gahirmatha, Odisha

Plate - 6. Boat-building in Jamilabad, Pulicat

(a) Choice of wood; (b) Boat-building in Jamilabad, Pulicat

Table 1. Endangered Marine Species in India

S.No.	Group	No.of species
1	Anthozoa	28
2	Hydrozoa	182
3	Bivalvia	25
4	Holothuroidea	2
5	Chondrichthyes	70
6	Actinopterygii	9
7	Reptilia	3
8	Aves	10
9	Mammalia	4
10	Liliopsida (seaweed)	2
11	Magnoliopsida (seaweed)	5

Table 2. Marine Sanctuaries and Marine National Parks in India

S.No.	Name of Marine Sanctuaries and Marine National Parks	State of India
1.	Gulf of Kutch Marine National Park	Gujarat
2.	Mahatma Gandhi Marine National Park	Andaman Islands
3.	Gulf of Mannar Marine National Park.	Tamil Nadu
4.	Rani Jhansi Marine National Park	Andaman and Nicobar Islands

5.	Gahirmatha Marine Wildlife Sanctuary	Odisha
6.	Malvan Marine Wildlife Sanctuary	Maharashtra

Table 3. Marine Biosphere Reserves in India

S.No.	Name of the Marine Biosphere Reserve	State of India
1.	Gulf of MannarBiosphere Reserve	Tamil Nadu
2.	Sunderbans Biosphere Reserve	West Bengal
3.	Great Nicobar Biosphere Reserve	Andaman and Nicobar islands
4.	North Andaman Biosphere Reserve	Andaman and Nicobar islands
5.	Little Rann of Kutch Biosphere Reserve	Gujarat


GILLMAN

REVIEW SECTION

A Review of Leoncio Deriada's "People on Guerrero Street"

Jossaine Galenzoga

Jean-Paul Sartre, in his essay "François Mauriac and Freedom," wrote, "The novel does not present things, but rather their signs." The novelist, in whose hands these signs are manipulated in the crafting of a story, creates a parallel world where a reader is suspended and is made unaware of the time, which s/he spends immersed in the then more real world of the novel.

The novel itself is one whole unit of signs. And so the reader, in the process of reading, is subconsciously trying to decipher the signified behind the characters' actions, the decisions they make, the events that occur in their lives. This mental exercise behind the act of reading can only be sustained if the characters in the novel are, as Sartre said, free. The moment the characters become predictable, the reader is transported back to the world where s/he finds him/herself reading a novel, and the novelist loses him/her.

Is Leoncio of *People on Guerrero Street* free? Yes. As Dr. Leoncio Deriada does not seem to hide the novel being based on his life, I immediately read the novel's Leoncio as a fictionalized version of himself. This Leoncio is still Leoncio Deriada. They are different but essentially similar. And the truthfulness—I assumed this truthfulness as well, because the novelist claims this is an autobiographical novel—with which Leoncio the novelist wields the Leoncio of the novel to re-construct the Davao of his youth frees him from forcing the novel to take the shape of whatever it signifies.

Therefore, Leoncio of *Guerrero Street* is free, as you and I are free, to live as he will. And it is not until he himself discovers the significance of his life experiences that we are enlightened about what the novel means.

People on Guerrero Street is a chronicle of Leoncio's transition from boyhood to maturity and spiritual enlightenment. This internal shift in Leoncio is ushered in by the death of Pepe. His closest friend gone, Leoncio begins to sense a longing that he does not know how to satisfy. He feels hungry but not for food, thirsty but not for water ("Again, as during the night in Ventura, I was gripped by a terrible loneliness. There was something I badly needed but I did not know what it was. I felt like screaming. Yet, it was not food. It was not water. Or was it someone I needed?").

As in real life, Leoncio is not prepared for the death of Pepe. We who are reading his story are more prepared than he but are as surprised at the revelation of Pepe's imminent death. When Leoncio says in Chapter 54, "And cancer had no cure. Pepe would die," it is also only then that the gravity of the situation sinks into our consciousness. Leoncio tries to cope with Pepe's death by removing himself from the environment where he had to come face to face with the reality of his friend's death. He busies himself with school work. But he has eventually to come home, where he has no escape from Pepe's wake. There he cries about his friend's death but at the same time realizes that there must be something aside from Pepe's death that he is grieving for ("I cried aloud as I had never cried before. But deep inside me, I was not grieving for Pepe. I was probably weeping for myself, for a terrible inadequacy, for something I was hankering for but was afraid to pursue because I did not trust myself.").

In Chapter 45, about the first night of Christmas vacation that Leoncio spent in his home in Ventura, Dr. Deriada wrote, "I looked at the sky and held my face steady for a few minutes until the cold became unbearable. Below, the Tamugan River was overpoweringly intimate in its muffled roar….Suddenly, I was gripped by a certain loneliness. I thirsted for some terrible need. I felt like screaming for something but I did not know what it was. I wanted to speak to somebody. No, not Pepe. Not Sol. Not Ador. Not Tony. Not Tanny, Mike, Mario, Primo. Not Glo, Flo, Necita, Nellie. Not even Terry…" We sense that what is going on is spiritual contemplation, a searching for something that is not found in Leoncio's immediate surroundings, not even in himself. What he goes away taking from this spiritual pondering is only the knowledge that there is something

amiss within himself. Even here, Leoncio is still very much a free character. Although spiritually tormented, he is free to search or not to search for that which he feels he is lacking.

In the great scheme of things, the death of Pepe acts merely as a pointer to a more significant issue in Leoncio's life. This something else that Leoncio desperately tries to figure out is made more important because it is placed in contrast to the deep and firmly established friendship that Leoncio shared with Pepe. We expect the death of his beloved friend to be a blow, but it turns out that although it is, it is not the only one, nor is it the biggest. He recognizes this finally when he attends Pepe's wake, listening to prayers for the dead. He realizes that while something has been taken away from him, there is something greater than Pepe that he has been missing all along. This realization is coupled with a deep and terrible loneliness, because it is as if he has only begun to grieve the loss of something he has lost a very long time ago.

"I was hungry for something. I was thirsty for something. Yet it was not food. It was not water" is an allusion to John chapter 4 verses 13 and 14 of the Bible that say, "Jesus answered, 'Everyone who drinks this water will be thirsty again, but whoever drinks the water I give them will never thirst. Indeed, the water I give them will become in them a spring of water welling up in eternal life'" as well as John chapter 6 verse 35 that says, "Then Jesus declared, 'I am the bread of life. Whoever comes to me will never go hungry, and whoever believes in me will never be thirsty." This suggests, then, that what Leoncio is longing for is salvation of the human soul. This explains why the death of Pepe, forcing him to come to terms with death and the brevity of life, heightened his spiritual turmoil.

He cries, "Jesus, Jesus, Jesus!" at Pepe's wake, signifying that he has decided that the answer to this spiritual dilemma is Jesus Christ who was hung on a cross. Upon whispering the name to himself, Leoncio hears Terry's voice over the radio. His hope for Terry is rekindled. He decides he will no longer mourn for Pepe. Leoncio is changed from the crying school boy who lost his best friend to the young man who is looking forward to life and who will go on living. Until the time he goes the way Pepe has gone before him. And even after that.


GILLMAN

REVIEW SECTION

Making a Shadow Fit a Figure of Which it is Not the Shadow, Or: The Word Made Sawi

Ivane R. Mahinay

Chronicles of Suspicion is a collection of short stories and essays by Cesar Ruiz Aquino, and his only to date. It was published in 1990 by Kalikasan Press. The book spans almost three decades of writing and gives a record of the places the author has lived in. The earliest story dates back to 1962 and the latest 1990, and the stories are indicated to have been written in Manila, Baguio, Dumaguete, and Zamboanga—virtually all over the country.

Checkmeta: The Cesar Ruiz Aquino Reader is a collection of narratives, poems, and excerpts from works-in-progress published in 2003 by Midtown Printing Company. Most of the pieces in this book, primarily the narratives and poems, have been published in Aquino's earlier collections. The narratives are pieces taken from *Chronicles of Suspicion* which were reworked and in some cases combined into single short stories, and the poems are taken from *Word Without End*, published by Anvil Publishing in 1993. Checkmeta won the National Book Award for Personal Anthology in 2003 (National Book Development Board, n.d.).

Cesar Ruiz Aquino was born in Iligan, Lanao del Norte and grew up in Zamboanga City. (Cha, n.d.) He has lived most of his life a decorated man of letters: special auditor then fellow in the Silliman Writers Workshop in the years 1962 and 1967, Carlos Palanca Memorial awardee in the years 1978 and 1997 for poetry and in 1979 and 1989 for fiction, *Gawad Pambansang*

Alagad ni Balagtas Lifetime Achievement awardee in 1997, National Fellow for Poetry in 2003, and S.E.A. Write Awardee in 2004 (World Heritage Encyclopedia, as cited in Project Gutenberg Self-Publishing Press, n.d.). He currently resides in Dumaguete City where he teaches creative writing and literature at Silliman University and is a regular panelist for the Silliman University National Writers Workshop.

In the world of Philippine letters Cesar Ruiz Aquino is known primarily as a poet. His poetry books outnumber his fiction five to one, and his poetic tendencies often seep into his fiction. In both fiction and poetry he is equally experimental, earning the following praise from Juaniyo Arcellana (2007): "But how he succeeds, proving that poetry is the art of the possible, or turning the post-structuralists inside out, the poet's mission impossible is to turn chaos into art."

This experimentation is most pronounced in his fiction, where he makes use of all available resources—his extensive knowledge of Western literary history and conventions and his encyclopedic knowledge of Western "high" and "low" culture—infusing the form with a distinct spirit that is an amalgam of Philippine history and culture, especially, a fundamental madness that in some stories he ascribes to the divine madness of poets, in some to a madness found at the heart of the Filipino experience. *Chronicles of Suspicion* and *Checkmeta: The Cesar Ruiz Aquino Reader*, Aquino's only fiction collections to date, demonstrate in the span of thirty-nine stories the various ways in which he takes the fiction form, exposes and dismantles its conventions, and, finally, bends it to the specific wills of his person and circumstance.

This practice of taking the short-story form and deconstructing it is called "metafiction." Simply put, it is, according to Nicol (2009), "fiction about fiction" (p. 35). It is fiction that rejects the illusion of "offering the reader an insight into the real world," and instead embraces its status as a creation, an artifact, by revealing the "frame" of literary conventions that perpetuate the illusion of a story being objectively 'real' (Nicol, 2009, p. 35).

The notion seems easy enough to understand on paper, but is harder to pin down in practice, not least because, as Patricia Waugh (as cited in Nicol, 2009) argues, metafiction as a technique antedates the novel and is even present in all fiction. There, too, is the simple fact that just as there are many conventions and frames that could be used to give a semblance of reality in fiction, so are the ways to break them.

Chronicles of Suspicion begins with notes, first indicating where these pieces have been published before, only calling them 'prose pieces,' after which follows a note from the author telling the reader that the stories, "taken individually, are acutely autobiographical," but taken together as one volume "take on an oddly fictional character" (Aquino, 1990). Meanwhile, in *Checkmeta,* these stories are only referred to as 'narratives.'

Most sites classify the book as a short story collection, and yet some of the pieces read like creative non-fiction. These include the pieces "The Great Filipina Navel," a rumination on sexy dancing and the place of the Filipina woman in society, "Lapus Lazuli," "Alihs in Wonderland," and "A Fine Madness Named Pepito Bosch," which are all profiles written in the style of New Journalism, a style made popular in the 1960s and 1970s in America by the writers Tom Wolfe, Truman Capote, and Gay Talese, and in the Philippines by Nick Joaquin[1]. To add to that is the tricky framing of these pieces as both autobiographical and fictional at the same time, even before the reader has begun reading. This combined blurring of the boundaries between fiction and non, autobiographical and non, have the effect of throwing into suspicion the realism in these pieces. The reader, so to speak, is kept on his/her toes, and thus, always reminded of the artifice of the whole enterprise.

There, too, is the business of the sequence of stories in *Chronicles of Suspicion*. The first story, "Proheme," indeed serves as a preface to the rest of the stories in the book, almost like a statement, in story form, of the author's aesthetics. The story is simply about a group of characters, Mita and Rey, Nano the midget, Mierkoles the strange, Mama Vicenta, Mama Nena, and a couple of aunts, and their friends. There is no recognizable plot, and the story is ruled by the logic of free association. What begins as a story of Mita, Rey, and their friends, turns into an anecdote about Nano's crush on an aunt's friend, which then turns into an anecdote about Rey and his mother, then Mierkoles and his genealogy, to finally an account of the seemingly arbitrary creation of this world by God ("He just came along"). The story is wrapped up with a paragraph that best summarizes it and the rest of the stories' logic:

> Things connected in magic combinations in his mind though they did not make sense when he repeated them to others. It was a game played alone. (p. 14)

1 who, in his 1996 Magsaysay Awardees' Lecture "Journalism Versus Literature?", claims to have pioneered the movement.

It is a fragmented, meandering, non-linear, and, dare I say it, non-rational narrative—this last one I say in light of the primarily Western convention of linear plot progression and determinism in realist fiction[2]. This non-linear logic, one that does not follow the "rationalism" of literary realism is what governs the other stories in the book.

Another way in which the sequence of the pieces affects the reading of the book is the technique of inter-story references the author uses. Characters like Willie Arseño and Darnay Demetillo, once introduced, regularly weave in and out of stories. "All fish below the thighs," a reference to a Robert Graves poem, is introduced in "Crazy in Ermita," and reappears twenty pages later in the story "Assault in Dumaguete," in the phrase "reaching down to where she was all fish." (p. 63) "Jerahmeel," one story in this collection, is acknowledged in another piece as a story written by the narrator. This constant cross-referencing, these rhizomatic connections, have the effect of making palpable the artificiality of storytelling; furthermore, these connections remind the reader that each story is not a separate window to an objective reality, but rather distillations of a single consciousness—Aquino's.

But what has been mentioned does not even directly involve the stories themselves yet. It is more appropriate to say that what has been mentioned so far more aptly belongs to the realm of *paratext*[3] than to the actual stories themselves.

Within the stories, Aquino employs a wide array of metafictional techniques which, in this paper, I classify into [1] intertextuality, [2] experiments in narrative structure and technique, and [3] self-reflexivity.

As mentioned previously, Aquino uses intertextuality, particularly inter-story references, to break the illusion of reality in fiction. But besides references within this particular collection, Aquino, with his encyclopedic knowledge of the Western canon and culture, also references works outside the book. This is best demonstrated in the story "Proheme to Zamboanga."

"Proheme to Zamboanga" is, simply, fictionalized account of Aquino's childhood in Zamboanga. It is, however, peppered with references to other works of literature, movies, trivia, the Bible, and local lore. These references not only point to the fact that fiction is constructed out of the collection of conventions that constitute what literature is and what a story is, but Aquino rather runs away with the idea and further argues that life itself is a

2 This determinateness of meaning is the charge leveled against literary realism by the practitioners of nouveau roman (Keep, McLaughlin & Parmar, 2000) and magic realism (Moore, 1998).

3 That is to say, "the various kinds of texts which supplement a 'main' text." (Genette, as cited in Nicol, 2009)

product of literary history and convention. When he begins the story with "Zamboanga is the word of my life," (p.32) he is introducing the idea not only that language and literature may be used as a metaphor for life, but that life itself is language and literature, is fiction, is story. In his account of his birth, he references Zoroaster. In Pagadian, where he lives as a child, an intersection can be found—a symbol, he says. In adulthood he turns out to be a Hamlet, more Hamlet than Shakespeare's Hamlet could ever be. In a catalogue of firsts, among them are the items "my first experience of formal rhythm" and "my first experience of narrative." We are made to understand that experience is not lived first, then referred to and made material through language and storytelling. Experience itself is a narrative, a fiction lived out, and as such is subject to the very same construction involved in fiction. This theme is reiterated later on in the story "The Reader," in which the writer is the titular character, his life the book he is reading.

Elsewhere Aquino plays with narrative. The possible ways in which narrative may be dismantled to reveal its artificiality is just as myriad as the ways in which narrative may establish the realist illusion. In Cesar Ruiz Aquino's fiction, this takes several forms.

First is his restructuring of the traditional progression of the narrative. In "Two" the story is structured in two halves titled "The Wound" and "The Scar." There is no visible tie between these two halves plot-wise—the first half is about a fifteen-year-old girl with whom the narrator has an unnamed relationship with, who turns out to be pregnant with F's child; the second half about a "dead" person with a scar on the elbow, who thinks that maybe if the scar is removed he/she can pretend to be someone else and go home. The second half ends with the narrator crying over the scar in a dream once, and waking up with the pain still there. Clearly, these two halves are separate stories, fragments, but they may be said to be thematically connected, both being about pain, no matter how different the circumstances.

"And Sunday Morning" is another piece that proceeds in the same fragmented manner. It begins with the narrator on his way to the police station and, in the manner common to all realist fiction, with a description of setting and an introduction of a character we expect to play an important role in the story. The narrator recounts what has happened from Saturday afternoon until the present time of telling, Sunday morning. It is rather long-winded, but we learn that he is friends with a Noel, has been since adolescence, but they are now beginning to drift apart. After that we find

him in the police station where it is revealed that he knew another man now dead and that he wants to give his statement. The two policemen—one old, one young—play chess as he writes, the old man explaining to the narrator that his king is not in danger when very clearly he is losing. The case is brought up and talked about, the narrator ruminates some more, then the narrator submits his written statement to the policemen. He concludes that the old man is indeed losing, that they will probably keep on playing, but that it doesn't mean anything to him. The story proceeds in stops and starts, almost in a stream of consciousness manner, except this random progression of things isn't in the mind, but life as it happens to the narrator.

In "Kalisud a la Dante Varona" the narrator, a chess coach, accompanies chess player Roy Mercado for a tournament in Tacloban. They run through their first difficulty on the boat, where they struggle to find space to sleep. Arriving in Tacloban, they run into a different set of difficulties, having to do this time with girls [4]. After a spate of references, from E.T. to Descartes to Pollock, and more stories about the chess players, the story abruptly shifts to a conversational tone, the narrator talking to an unnamed 'you' and ends thus:

> Wish I could have stayed on. But then again thank goodness I couldn't have. I couldn't have endured very long your sudden aloofness. When you spoke the dialect I wish you didn't. I was sad beyond measure and it made me sadder. I guess it was knowing I'd never, for all the wildness of my life, see you again. That, and the bruise-like, pleasing perfection of your pout. (p. 183)

There is absolutely nothing in the previous paragraphs to connect this last paragraph to. There is mention of a girl, but it was Roy who saw and subsequently fell for her, not the narrator. Still, the story stands—what started out as a straightforward story about a chess coach and his player, has now turned into a heartfelt confession for an unknown 'you,' perhaps known only to the author[5] himself.

What all these three stories have in common is the refusal to follow the determinate logic of traditional realist fiction. In this Aquino mirrors the French *nouveau roman* writers, precursors of postmodern fiction. In the

4 A recurring motif throughout his fiction, I have to say.

5 Or the narrator, or the author's second self as seen on paper—whatever your belief about narrative voice and authorial presence may be.

words of its most famous practitioner, Alain Robbe-Grillet, "The task of the new novel […] is to foster change by dispensing with any technique which imposes a particular interpretation on events, or which organizes events in such a way as to endow them with a determinate meaning." For him, the illusion of order, which may take the form of a linear plot hurtling towards a determinate and conclusive ending, is "inconsistent with the radically discontinuous and aleatory nature of modern experience" (Grillet, as cited in Keep, *et al*., 2000). What results then, as is the case in these three stories, is a narrative that is as seemingly discontinuous and random as real life: a story about a pregnant fifteen-year-old who is leaving turns into a story of a person with a scar who can't go back home; the story of a narrator who goes drinking with a friend from his adolescent years turns out to be a story about a dead man he knew; the old policeman and his impending defeat at a chess game, which turns out, in the end, to hold absolutely no meaning for the narrator; a story of a chess tournament which ends with an out-of-the-blue confession to a person not named.

But besides making the reader feel the randomness and chaos inherent in the world, what these fragmented stories further do is make obvious the god-like figure lurking behind all of fiction, choosing and deciding what goes into a story, what doesn't, and for what effect. Paradoxically, this kind of aleatory writing also makes the reader a more active participant in the writing of the story (Keep, *et al*., 2000). When an author presents seemingly unrelated fragments and refuses to make explicit the ties that bind these fragments, the reader is made conscious of the writer's decision to present it as such, but at the same time takes away the writer's previous privilege of imposing a definite interpretation on the reader. It draws the reader's attention to the process of meaning-making in fiction, not only on the author's part, but on the reader's as well.

Aquino uses even more radical techniques in some stories, producing pieces that do not look like traditional prose at all. For example, in "The Bulbiferous Blurbs" the narrative is made up entirely of fictional blurbs from actual writers, some of whom show up elsewhere in the collection. This draws parallels to B.S. Johnson's "A Few Selected Sentences," which is likewise a story made up entirely of sentences taken from various sources. In both stories, the metafictional techniques used by the authors show how "reality," both in fiction and in the real world, are constructed "through the arbitrary system of language" (Waugh, 1984). There too is the story

"Writers,"[6] in which Aquino uses footnotes to provide commentary as the story progresses, preventing the reader from ever getting "lost" in the story, constantly reminding the reader of the ever-intrusive persona of the writer, which in turn reminds the reader that this is, after all, only a work of literature made by Aquino.

In other pieces, a certain self-reflexivity seizes the story before it even begins. In "Crazy in Ermita," Aquino begins with a rumination on various, as the author puts it, "mediums of perception"—beginning with the airplane, the automobile, certain narcotic substances, and the boat. All vehicles, all involving "trips," whether on air, on land, on water, or as the author puts it, into the "inner space" of the self. What follows are fragments: the narrator's time in Baguio, where he "chased [his] life in crazy circles," haunted by a 'recurrent'[7] dream, the vessel for all his unspoken frustration in which he sees all countries and cities, which dream facilitates an epiphany that he may not see these places in real life although he insists he has; then his beginnings as a poet in high school, when he was touched by the power of literature and driven to "divine lunacy" and eating, breathing, living literature even when he wasn't reading; then his time in Zamboanga with a certain Willie Arseña and their group of crazy, bohemian friends, their discovery of Henry Miller's *Tropic of Cancer*, which helps them see the neuroticism of their town; then descriptions of the real town loonies; after which the story breaks out into a monologue that is more euphonic beauty than intelligible speech, spoken, presumably, by Willie to the narrator ten years later. Willie tells him about a girl called Masarap who is "touched in the head," with whom Willie made love to all those years ago, which scene is then imagined by the narrator, which leads to him declaring and defending, in high-romantic fashion, the preciousness of the memory even when the girl has gone mad. What is most notable in all these fragments is the presence of 'vehicles of perception': in the first fragment, the dream; in the second, literature; in the third and fourth fragments, *Tropic of Cancer*; and finally, in the last, the imagined scene of copulation. All these devices were previously hinted at in that first section discussing those literal vehicles of perception.

6 The story appears in Checkmeta as the revised and combined version of the footnotes-less "Anak Bulan" and "The Browser," which originally were separate stories in Chronicles of Suspicion.

7 In quotation marks because the narrator is unsure about it being recurrent—the author provides a couple of possibilities for this, a) it may very well be a dream repeated or b) it is only the original dream remembered in succeeding dreams. The last such dream is a "resolution of the dream in the new dream." Let me add that this too smacks heavily of metafiction.

This same reflexivity is displayed as well in "Stories," a story about telling three stories. It begins with the narrator admitting to some difficulty in telling two separate stories for some twenty years now. One day he gets the idea to tell both stories together, and so "Stories," the story that houses these two sub-stories, is born. Story #1 is about a madwoman, pregnant with an unknown man's baby; the baby upon being born is promptly devoured by a dog. Story #2 is about a young married couple, both of them still teenagers. The boy, Kip, is sick, and the narrator hints, possibly dying. He is confined at the hospital where young Sillimanian girls make friends with him. The girl, his wife, sees this and disappears for three days. When she comes back, the boy weeps and calmly reproaches her for what she has done. The narrator ponders the two stories and their underlying themes and makes this connection: if Kip died, he would be the baby in the first story; if he lived, then the stories would "annihilate" each other. He then decides that it needs one more story, and this last one has, yet again, two more separate stories within. The first is about a man, William, who once lived in the narrator's house doing odd chores and borrowing small amounts of money every now and then. The second story is about a woman, Ester Lim, suspected to be mad, who claims to know the narrator and meets him one day. What ties the two sub-sub-stories is, yet again, the narrator—he owns a portentous black jacket which he gives to Ester when she tells him she feels cold and wants to be held, and which he leaves around the house afterwards, and which William takes hold of and uses. William is gunned down one day wearing the said jacket. The narrator then discusses all stories and connects them this way: William is the unknown father in Story #1, but when he was murdered he was made both the baby in Story #1 and Kip in Story #2. Ester Lim is both her own mad self and the madwoman in Story #1. He further argues that all of these stories, they were told to him and they happened to him so that the narrator could be himself—that is, so he could be a writer ("To me, who haven't cared, is allotted the notion that the madwoman's child had been engendered and obliterated so I could be forty-three, so I could use the word 'resplendent,' so I could love Emy [8]."). The writer then lets William back into the narrative, admitting that they do have similarities. William, now dead, delivers a monologue to end the story. He argues that the writer is Kip, that all the characters and details

8 The insertion of a fact otherwise not mentioned in the story and really quite irrelevant, a fact we can only surmise is derived from the writer/narrator's life outside the story, is also metafictional.

that has inspired and were employed to tell this story has served the writer well, and that finally, perhaps, it is the writer who is the father of the baby in the first story, not William.

There are several ways this story makes use of metafictional elements—from the narrator's outright admission that he is indeed writing a story about several discrete stories, to his explaining his narrative choices to the reader, to the last monologue which imputes, basically, the writer as being the essence of all the characters in the story, if only because he is the source of the whole story. But more importantly, the piece displays quite explicitly the author's hand in picking details and making connections between otherwise separate and unrelated fragments. It shows a universe that is not the real world, rather a creation of the author's that does not correspond to anything outside itself, even when the source is from someone else's life or even if the material is the author's own life and experiences.

In "Assault on Dumaguete" Aquino begins with two epigraphs—one fictional, a declaration of love from one Julius the Fourth to a certain Josie, the other a real quote from Jacob Burckhardt taken from his book *Reflections on History*, about "[safeguarding] our impartiality against the invasion of history by desire." What follows is a preface of sorts, in which we come to understand that this second quote is used ironically, for we find the author talking directly to us readers and owing up to his partiality throughout the rest of the story. He tells us he will use the split-person point of view—and he does, in certain sections using the third person limited viewpoint of Julius the Fourth, in others, including this 'preface,' using the first person viewpoint, still of Julius—and admitting that both Juliuses are essentially him, the author. We are then presented with the split-story of Julius, who came to Silliman in 1972 to teach, who was confined in the hospital due to a nervous breakdown, who was then visited by Faye, the object of his affections. In the last section, the story takes a different route when the narrator directly addresses a 'you,' later named Weng. Here, in between rhapsodies to Weng, Julius talks about writing a novel in which the central character is named Cesar Ruiz Aquino, who ardently wants to kiss the addressee and expresses this desire in behalf of all his conceptions, be it Cesar Ruiz Aquino, the author of *Chronicles of Suspicion*; Julius the Fourth, the on-paper alter-ego; and Cesar Ruiz Aquino, the central character of the novel-in-development. Here he also admits that the Josie mentioned in the first quote was only a figment of his imagination, born of his sorrow of him and Weng "[parting] ways forever." He ends by

saying that he suffers from the ailment called memory, that all that has transpired in the story has been a "tentative exorcism," and that he hopes to pull the memory out of himself someday.

This story is metafiction through and through, from the self-referential opening section which discusses beforehand the story's main literary device; to the device itself which presents the reader with two perspectives from the same person, showing how the same set of events can be framed differently even when viewed through the eyes of the very same person; with the metafiction reaching its climax in that beautiful, complicated ending. By the end we are made to understand that everything we have read so far is only one big construct, by this consciousness who is Cesar Ruiz Aquino the writer, who also happens to be Julius the narrator, who is constructing, in return, Cesar Ruiz Aquino, a fictional character. Here we are shown the self-generating features of fiction: that a writer conceives a second self on paper, who in turn, contributes to the impression readers build of the writer in their heads, which impression is of the writer but not the writer himself, for it has been tampered by, ironically, the writer's own fiction. In a sense, the writer begets a story that begets the writer. The wider and more far-reaching implication is that in every story there are two parallel fictions: one its plot, and the other a commentary on the creative process in fiction. Lastly, as regards the Burckhardt quote in the beginning, it shows us the impossibility of impartiality in any narrative because of the impossibility of eliminating desire. In the concluding section, the narrator says, "I'm still there," referring to his and Weng's past, and this memory, this longing, this desire for her, colors his telling of the story. This implies that the author's aims in each story forces him/her to frame it according to these aims, to the exclusion of everything else, and this is true for every story.

But the most important implication for all this experimentation and playing around with forms is that it lays bare the complex relationship between author, reader, fiction, and reality. "The author is dead," says Barthes, or rather, his authority over meaning is (White, n.d.). Ironically, the way Aquino's metafiction steers towards this conclusion is through the assertion of authorial presence in his work. He reveals, and then pulls away, for example, from the traditional idea of narrative progression, not only to undermine that convention, but to make fiction that is more personal. He tells three separate stories and holds it together with his own associative logic. He refers the reader to characters and turns of phrase introduced in previous

stories to iterate that it is his imaginative world that the reader immerses in when reading his stories. He tells us something then corrects himself. He is unsure and tells the reader that he is. He cites the whole of the Western canon, but does so in the service of autobiography. One would think these techniques would make him a god of sorts, but it doesn't. He picks the details to incorporate in his fiction and he points out the conventions he wants to subvert, but these conventions are not, in any way, made by him. In fact, it is these conventions that make him exist on paper. By questioning, then, the conventions of fiction, he is questioning the very thing that not only makes his plots possible, but also makes possible Aquino the writer. By challenging the way realist fiction creates reality in a text, he is also challenging his on-paper persona—if everything in this book is indeed not reality but only a product of his imagination and literary convention, then the narrator or the intrusive voice that tells us this must be himself a figment of imagination and convention too. And all of these are contingent, first and foremost, on the reader recognizing these conventions and this breaking of conventions.

It is all very complicated, but it may be summarized thus: The author does not present "reality," but rather a fictional universe born out of literary history and convention. The reader is inducted to this universe by his recognition of these conventions. When an author says in a story, "this is an illusion" or "this is a convention," he still does so by way of conventions, because this is precisely what makes a story. The voice saying "this is only a story, a construction," cannot be the authority of a story, and does not qualify as the only thing in the story that is real, for the simple reason that the whole story *isn't*. Meaning then, still resides with the reader, as he is left to figure out what is real and unreal. Though the point is, merely, to question the boundary, and not to determine which is which, the latter being infinitely debatable.

A similar idea is found in "The Reader," a treatise in story form on the writer as reader. Aquino begins the concluding section with a delicious paradox:

> The story he is reading is the one he exists in. But if that story existed, the reader cannot possibly read it. Because then he'd be imaginary—resemblance to anyone is purely coincidental. And therefore the story does not exist. Nevertheless it does. And nevertheless he's reading it. (p. 102)

Some paragraphs later the narrator gives us a fictional encounter of Leon Kilat and his equally fictional daughter Aya, and the narrator comments:

> The story, of course, is fantasy. But the reader is not. He is, as he has always been and ever will be, real. Or rather as long as he lives—and as long as he reads. For he is the man who'd read all, if only he had the time—including his, if only it existed. Let Aya sing in the bathroom when his time comes! That shall be another story. Or perhaps the same. (p. 103)

What we take to be experience, or life itself, really is narrative. It is not objective reality or the objective event itself, but our subjective interpretation of it. When we narrate, we really are only saying "*I* experienced it, and I experienced it *this way*." Even the 'I' is a fiction—it exists, yes, but as part of narrative. It is fiction, an interpretation of what the self is. So it both exists and not. If experience were a word and Aquino the reader, his metafiction has allowed him to make the word his own. The word made Sawi. But then, through reading, Sawi's word is made by the readerws. Somewhere, life exists unaltered by human gaze. But not here.

REFERENCES

Aquino, C. R. (1990). *Chronicles of suspicion*. Manila: Kalikasan Press.

Arcellana, J. (2007, December 17). The poet from Dumas Goethe. *The Philippine Star.* Retrieved from http://www.philstar.com/arts-and-culture/33806/poet-dumas-goethe

Cha: An Asian Literary Journal. (n.d.) *Cesar Ruiz Aquino*. Retrieved from http://www.asiancha.com/content/view/2083/506/

Keep, C., McLaughlin T., & Parmar, R. (2000). *The new novel.* Retrieved from http://www2.iath.virginia.edu/elab/hfl0260.html

Moore, L. (1998). *Magical realism.* Retrieved from https://scholarblogs.emory.edu/postcolonialstudies/2014/06/21/magical-realism/

National Book Development Board. (n.d.). *Checkmeta: The Cesar Ruiz Aquino reader.* Retrieved from http://nbdb.xeozone.net/national-book-award/checkmeta-the-cesar-ruiz-aquino-reader/

Nicol, B. (2009). *The Cambridge introduction to postmodern fiction*. Cambridge, UK: Cambridge University Press.

Project Gutenberg Self-Publishing Press. (n.d.). *Cesar Ruiz Aquino*. Retrieved from http://self.gutenberg.org/Article.aspx?ArticleId=0005560233&Title=c%C3%A9sar%20ruiz%20aquino

Waugh, P. (1984). *Metafiction: The theory and practice of self-conscious fiction*. London: Methuen.

White, C. (n.d.). *The death of the author.* Retrieved from http://coursesite.uhcl.edu/HSH/ Whitec/terms/D/deathauthor.htm

REVIEW SECTION

Cover Photo "Zanzibar Shrimp | Dasycaris zanzibarica" by ***Luigi Borromeo***