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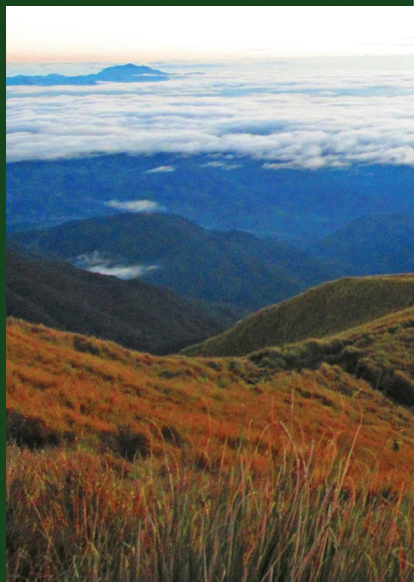
Special Issue
Proceedings of the 25th Annual Philippine Biodiversity Symposium



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Cover Photo: *Pteropus pumilus*, *Lamprolepis smaragdina*, *Dasycrotapha speciosa*, and Mt. Pulag, (Left to right)

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Message from the Executive Adviser, Sylvatrop

On its 40th anniversary, Sylvatrop is proud to present a special issue with the Biodiversity Conservation of the Philippines (BCSP). On our seventh year of working with the BCSP, we hope to continue to serve as a viable medium for exchanging scientific information about the Philippine biodiversity.

Sylvatrop Vol. 26 contains eight full papers presented during the BCSP's 25th Annual Philippine Biodiversity Symposium with the theme "25 Years of Biodiversity Conservation in the Philippines: Global Relevance, Local Realities" held on April 5-9, 2016 in Calapan City, Mindoro Oriental. Publishing these new research results on the rich biodiversity of the Philippines is our way of recognizing the efforts of different individuals who work hard in ensuring that science-based information still remains to be accessible to everyone.

We, in the Ecosystems Research and Development Bureau (ERDB), and in the Sylvatrop Editorial Board (SEB), would like to commend the BCSP for its continued commitment and dedication in promoting the biodiversity research and conservation in the Philippines. BCSP has remained persistent in increasing public awareness, appreciation, and understanding of the Philippine biodiversity. These efforts remain to be aligned with DENR's mission to work hard for the betterment of our environment.

Thus, in behalf of the SEB, we look forward to a continuous partnership among different organizations in bringing scientific outputs available to our dear readers and subscribers. May the information found in this issue inspire more individuals to work hard for the protection and conservation of our rich flora and fauna.

We congratulate the BCSP for another fruitful undertaking!

Dr. Henry A. Adornado
Executive Adviser, Sylvatrop Editorial Board and Director, ERDB

Message from the BCSP President

The Biodiversity Conservation Society of the Philippines (BCSP), formerly the Wildlife Conservation Society of the Philippines (WCSP), aims to facilitate the exchange of knowledge and contribute to the improved research and conservation capabilities of those working on Philippine biodiversity. Towards this goal, the BCSP organizes the annual Philippine Biodiversity Symposium, a gathering of national and international researchers, conservationists, managers, and students working on Philippine biodiversity. It is also one of the major events on biodiversity research and conservation in the country.

The 25th Annual Philippine Biodiversity Symposium was held in Calapan City, Oriental Mindoro on 5-9 April 2016 with the theme "25 Years of Biodiversity Conservation in the Philippines: Global Relevance, Local Realities." The meeting was attended by over 280 participants from various sectors, many of whom contributed important work in various fields related to Philippine biodiversity through the different events at the symposium. On the 25th anniversary of the symposium, we are pleased to continue with the tradition of publishing symposium proceedings to encourage research, collaboration, and the exchange of knowledge that will benefit Philippine biodiversity in general. This Special Issue of Sylvatrop, which covers different taxa and topics of interests – from plants to marine mammals, species distributions to invasive species, contains full papers of some of the presentations delivered during 25th Philippine Biodiversity Symposium by professionals and students alike.

We are very grateful to the authors who submitted their manuscripts to BCSP and to the Sylvatrop Editorial Board (SEB) for working with BCSP in publishing this special issue. Special thanks also go to the BCSP Publications Committee, reviewers, and editors for their tireless commitment in making the anniversary proceedings possible.

We wish to thank the City Government of Calapan, Oriental Mindoro and the Mindoro Biodiversity Conservation Foundation, Inc. (MBCFI) for graciously co-hosting the 25th Philippine Biodiversity Symposium. We also wish to acknowledge the partners and sponsors of the symposium for without their support, the symposium would not have been successful: the Department of Environment and Natural Resources' Biodiversity Management Bureau, the Provincial Environment and Natural Resources Office of Oriental Mindoro,

the Provincial Government of Oriental Mindoro, TeaM Energy Foundation, Inc. UNEP-GEF FORIS Project-Philippines, USAID B+Wiser Program, Philippine Tropical Forest Conservation Foundation, Inc., Crocodylus Porosus Philippines, Inc., Bat Conservation International, Center for Conservation Initiatives, Primer-CORE, Fauna & Flora International-UK, Department of Education-Calapan City District, Divine Word College-Calapan City, Globe Telecom, Anvil Publications, and the Malampaya Joint Venture.

We hope you enjoy this issue and we look forward to future BCSP publications to help advance the research and conservation of Philippine biodiversity.

Cynthia Adeline A. Layusa-Oliveros
President, BCSP

Biodiversity Conservation Society of the Philippines

MBCFI
Mindoro Biodiversity Conservation Foundation, Inc.

The *25th* Philippine Biodiversity Symposium
25 Years of Collaborative Biodiversity Conservation in the Philippines: Global Relevance, Local Realities
5-9 April 2016
Filipiniana Hotel, Calapan City, Oriental Mindoro

About the 25th Annual Philippine Biodiversity Symposium

25 Years of Biodiversity Conservation in the Philippines: Global Relevance, Local Realities

Biodiversity Conservation Society of the Philippines

The Biodiversity Conservation Society of the Philippines (BCSP), formerly called the Wildlife Conservation Society of the Philippines (WCSP), is a professional organization of wildlife researchers, managers, scientists, and conservationists. It aims to advance biodiversity research and conservation in the Philippines by facilitating communication and contributing to improved research and conservation capabilities of those working on Philippine biodiversity, particularly the members of the association, and to increase public awareness, appreciation, and understanding of Philippine biodiversity.

The 25th Annual Philippine Biodiversity Symposium was organized by the Biodiversity Conservation Society of the Philippines (BCSP) co-hosted by the City Government of Calapan, Oriental Mindoro and the Mindoro Biodiversity Conservation Foundation, Inc. (MBCFI) in partnership with the Department of Environment and Natural Resources-Biodiversity Management Bureau (DENR-BMB), the Provincial Environment and Natural Resources Office of Oriental Mindoro, and the Provincial Government of Oriental Mindoro.

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Distribution, abundance, and habitat requirements of endangered babblers in Mt. Kanlaon Natural Park, Negros Island, Philippines

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A study on the distribution, abundance, and habitat requirements of flame-templed babbler ***(Dasycrotapha speciosa)*** *and Negros-striped babbler* ***(Stachyris nigrorum)*** *in Mt. Kanlaon Natural Park was conducted from 18 May to 2 June 2015. A total of 44.5 km of transects were surveyed using a combination of line transect and point count methods while 567 circular plots measuring 30mx30m were established for habitat assessment. A total of 27 individuals of the flame-templed babbler were recorded in habitat types occurring from 604–1,078 masl while 14 individuals of the Negros striped-babbler was encountered in primary forest and secondary montane forest from 1,105–1,927 masl.* ***D. speciosa*** *was abundant in secondary lowland forest (n = 16) while* ***S. nigrorum*** *was abundant in secondary montane forest (n = 8). The presence of* ***D. speciosa*** *in plantation denotes that this forest serves as temporary habitat for this babbler. Both logistic regression analysis and Poisson distributions showed that increased percentage of climbing bamboos and trees with 16–20 m height and decreased elevation implied increased likelihood of the occurrence and abundance of* ***D. speciosa****.*

Keywords: Flame-templed babbler, Negros-striped babbler, abundance, species, elevation

Subsequently, decreased tree density was associated with increased occurrence and abundance of ***S. nigrorum****. Existing local threats include bird hunting, illegal tree cutting for timber, and firewood and charcoal production. This study recommends regular forest monitoring and strengthening of forest protection and enforcement.*

PHILIPPINE BIRDS HAVE RICH DIVERSITY AND ENDEMISM BUT ARE ALSO ONE of the most highly threatened fauna. Of the 678 recorded species in the country, 206 are endemic and about 84 species are either extinct or critically endangered (Haribon Foundation 2014). Most of these endemic bird species are in danger of extinction. As birds are being used as indicators of the status of an area's fauna, the threatened extinction of bird species implies comparable losses in other groups, and hence a major reduction in biodiversity (Brooks et al. 1992). Activities that threaten the survival of endemic Philippine birds include illegal bird hunting, illegal logging, deforestation, and conversion of forest to agricultural commodities.

The Negros babblers, flame-templed babbler (*Dasycrotapha speciosa)* and Negros-striped babbler *(Stachyris nigrorum)* were the focus of this study. *Dasycrotapha speciosa* is endemic to the islands of Negros and Panay while *S. nigrorum* is endemic to the island of Negros. The abovementioned resident species have an IUCN conservation status of endangered (BirdLife International 2015). Previous studies on the Negros babblers date back to as early as 1990s for *D. speciosa* and 1980s for *S. nigrorum* (Mallari et al. 2001). Since then, no in-depth study on the habitat requirements of the Negros babblers has been conducted to easily conserve the species and their habitat. Much work needs to be done for the protection and preservation of these species.

Thus, this study aims to determine the distribution, abundance, and habitat requirements of *D. speciosa* and *S. nigrorum*. Also, it aims to identify existing and potential threats to babblers to serve as basis in crafting recommendation for conservation. Results of the study will also be used to improve the guidelines and policies that would help in developing the conservation management plan of Mt. Kanlaon Natural Park.

Materials and methods

Study area

The study was conducted at Mt. Kanlaon Natural Park (MKNP) (Fig. 1) located in Negros Island, Philippines. It has a land area of 24,577 ha with a peak rising up

to 2,454 meters above sea level (masl). On the eastern foot plain of Mt. Kanlaon lies Canlaon City which is located at the boundary dividing the two provinces of Negros Island. The park is bounded by the municipalities and cities of La Carlota, San Carlos, La Castellana, and Murcia in Negros Occidental and Canlaon and Vallehermoso in Negros Oriental.

Sampling was conducted from 18 May 2015 to 2 June 2015 in three sites on Mt. Kanlaon: Camp Shelter, Barangay Mailum, Bago City; Sitio Wasay, Barangay Minoyan, Murcia; and Gintubdan, Barangay Ara-al, La Carlota City. Five habitat types were sampled – primary forest, secondary montane forest, secondary lowland forest, mixed forest, and plantation.

Figure 1 Map of Mt. Kanlaon Natural Park surrounded by cities and municipalities of Negros Occidental and Oriental (Photo from www. geocites.ws dated May 9, 2015)

Primary montane forest

This is located in the sampling site in Camp Shelter, Bago City. A 24-km transect was established in this habitat type (Fig. 2). It is located within the elevation of 1,300 masl to 1,580 masl within the coordinates of N 10°28′50″ E 123°07′12″ and N 10°28.45'E 123°07.69' with thick understory vegetation and significant abundance of epiphytes and fruiting trees.

Figure 2 Primary montane forest in Bago City at an elevation of 1300 masl to 1577 masl (Photos taken by Catrina Nicole Adorable on July 13, 2015)

Secondary montane forest

This habitat type (Fig. 3) is found throughout the sampling site in Gintubdan, La Carlota City. It is situated at an elevation of approximately 1,070 masl to 1,815 masl with the coordinates of N 10°25′40″ E 123°05′32″ and N 10°25′45″ E 123°07′23″. A total of 15 km transect was established. In this site, trees were much shorter which allowed clearer views of birds. Tree growth is also influenced by environmental

conditions at higher elevation. The area has undergone extensive logging resulting in a younger forest structure compared to the forest at sampling site in Bago City. Abundance of pandan and bamboo was observed in the area.

Figure 3 Secondary montane forest in Gintubdan, La Carlota City at an elevation of 1072 masl to 1816 masl (Photos taken by Trexie Alimpoos and Catrina Nicole Adorable on July 13, 2015)

Secondary lowland forest

This habitat type (Fig. 4) occurs at the sampling sites in Bago City and Wasay, Murcia, Ranger Station. A total of 7.4 km transect was established in this habitat. It is situated at an elevation of approximately 670 masl up to 1,192 masl within the coordinates of N 10°28′50.2″ E 123°07′11.7″ and N 10°29.59′ E 123°06.47′. Local residential areas were observed in the vicinity. This site is predominated by large trees with moderate presence of pandan and bamboo. Gmelina trees are also found in the area. The habitat type is also defined by the slightly open to close canopy cover.

Mixed forest plantation

Mixed forest plantation (Fig. 5) is primarily found at the sampling site in Wasay, Murcia Ranger Station. A total of 4 km transect was established between the elevations of approximately 575 masl to 670 masl within the coordinates of N 10°30.02′ E 123°05.74′. This habitat type is defined as being dominated by cultivated big trees, mostly by mahogany, narra, and gmelina. Local residential areas can also be observed in this habitat.

Figure 4 Secondary lowland forest in Bago City and Wasay, Murcia with an elevation of approximately between 670.3 masl to 1192 masl (Photos by Trexie Alimpoos and Catrina Nicole Adorable on July 14, 2015)

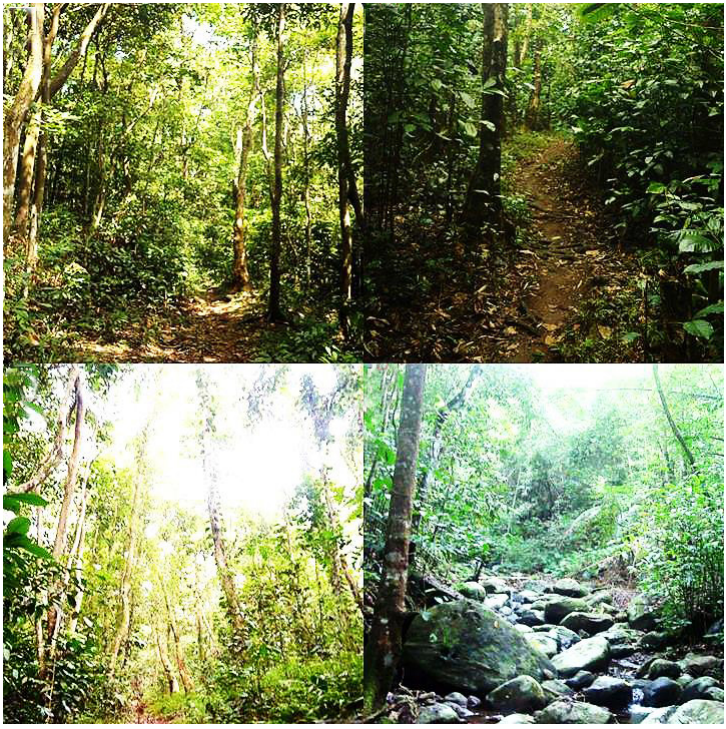

Figure 5 Mixed forest in Wasay, Murcia at an elevation of approximately between 574.3 masl and 668.8 masl (Photos by Catrina Nicole Adorable and Rafael Ryno Sanchez on July 13, 2015)

Plantation

A plantation (Fig. 6) is found on the second sampling site in Wasay, Murcia Ranger Station. A total of 4 km transect was established in the area. It is situated between the elevations of approximately 520 masl to 645 masl. This habitat type is defined mostly of flocks being around coffee and climbing pandan. Residential areas can be found nearby which accounts for cultivation at the site.

For babbler survey, Line Transect and Point Count Method were used. A total of 44.5 km transect was established. Monitoring stations were established at every 250 m point of every transect with a 10-minute babbler search using binoculars. Babbler survey was conducted just before sunrise when birds are more active. Birds encountered were identified with the aid of a bird expert. Neon orange ribbons were used to mark areas where the target bird species were found.

Figure 6 Plantations in Wasay, Murcia at an elevation between 518.9 masl and 646.1 masl (Photos by Catrina Nicole Adorable and Christine Adlaon on July 14, 2015)

The sampling was conducted under gratuitous permit number R6-2014-001 issued by the Department of Environment and Natural Resources (DENR).

Habitat assessment

Habitat assessment was performed using a total of 567 30 m x 30 m circular plots. Plots were located at the start and at 50 m intervals along each transect line. Habitat variables assessed were elevation, tree height, woody vine, canopy cover, understory cover, understory layer height, tree density, diameter at breast height (DBH), distance to bodies of water, abundance of climbing pandan, climbing bamboo, mosses, and anthropogenic disturbances. The tree height was categorized into different ranges of height within a 30 m x 30 m circular plot. These ranges were number of trees less than 10 m; number of trees from 10 – 15 m; number

of trees from 16 – 20 m; and number of trees greater than or equal to 21 m. The canopy cover was taken with the aid of an improvised densiometer. The understory, tree density, distance to bodies of water, climbing pandan, climbing bamboo, and mosses were identified through visual estimate. Trees that were in the range of 16 m and up were measured using a measuring tape and were tallied under the DBH. In determining accurate locations, elevation and coordinates were determined using a Global Positioning System (GPS). These habitat variables are important in the overall assessment of the study since a change in one of the variables would entail a change or alteration in the habitat population.

Data analysis

Kruskal–Wallis Test was used to test if there were any significant difference between the habitat variables of different habitat types (Laerd Statistics 2013). Mann-Whitney U Test was used to test if there are any significant differences among the habitat variables between plots with and without babblers (Laerd Statistics 2013). Poisson Distribution was used to show a discrete frequency of distribution predicting the probability of the number of success an independent event has in showing the relationship between the species abundance and its habitat variables (Lane ud). Logistic Regression Analysis correlates the occurrence of the species to the habitat variables and to test a hypothesis between the relationship of a predictor variable to a categorical variable (Peng et al. 2002).

Results and discussion

Distribution of endangered babblers

The distribution of the endangered babblers is summarized in Table 1. *D. speciosa* mostly inhabited habitat types at lower elevations within the range of 400 masl to 900 masl. *S. nigrorum* inhabits habitat types at higher elevations within the range of 1,000 masl to 1,800 masl. *D. speciosa* was also specifically observed in the secondary lowland forest, mixed forest plantation, and plantation. On the other hand, *S. nigrorum* was recorded in the primary montane forest, secondary montane forest, and secondary lowland forest. This is because *D. speciosa* is a lowland forest specialist, of which they were also observed in forest edges and lowland secondary growth forest. On the other hand, *S. nigrorum* inhabits montane forest habitat type (BirdLife International 2015).

Table 1 Distribution of endangered babblers across habitat types in Mt. Kanlaon Natural Park

Species name	Primary forest	Secondary montane forest	Secondary lowland forest	Mixed forest	Plantation
Dasycrotapha speciosa	-	-	+	+	+
Stachyris nigrorum	+	+	+	-	-
Total number of species	1	1	2	1	1

+ present, - absent

D. speciosa was recorded from 603.8 masl to 1,078 masl and *S. nigrorum* from 1,105 masl to 1,927 masl. *D. speciosa* is a lowland specialist inhabiting lower storey and forest edge while *S. nigrorum* inhabits primary montane forest, mostly of higher elevations (BirdLife International 2015) (Fig. 7).

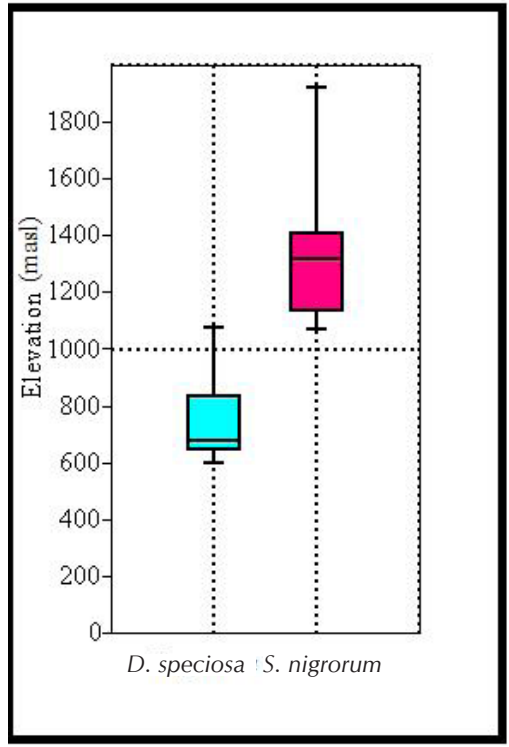

Figure 7 Species limit of endangered babblers in Mt. Kanlaon Natural Park

A total of 22 individuals of *D. speciosa* and none for *S. nigrorum* were recorded in the lower elevation within the range of 400 masl to 800 masl. For the middle elevation (850 – 1,400 masl), 5 individuals of *D. speciosa* and 10 individuals of *S. nigrorum* were observed. Lastly, for the high elevation (1,450 – 1,800 masl), 4 *S. nigrorum* were observed while none for *D. speciosa*. This is because these babblers have a certain altitudinal limit which means that the species can only thrive at a certain elevation. This can be observed in the data as shown in Figure 8. *D. speciosa* inhabits lower and mid elevations specifically between the elevations of 300 – 900 masl because this species thrives on lower elevations of forest edges and secondary growth forest. This also explains why there are no *D. speciosa* recorded in higher elevations. *S. nigrorum* mostly inhabited the area that grows in montane forest with 1,000 masl up, chiefly occurring between 1,050 m and 1,400 m generally favoring the lower story. Most of the babblers were only heard and only few individuals were seen. One reason which accounts for this is the unobtrusive nature of the bird except when feeding and singing (BirdLife International 2015).

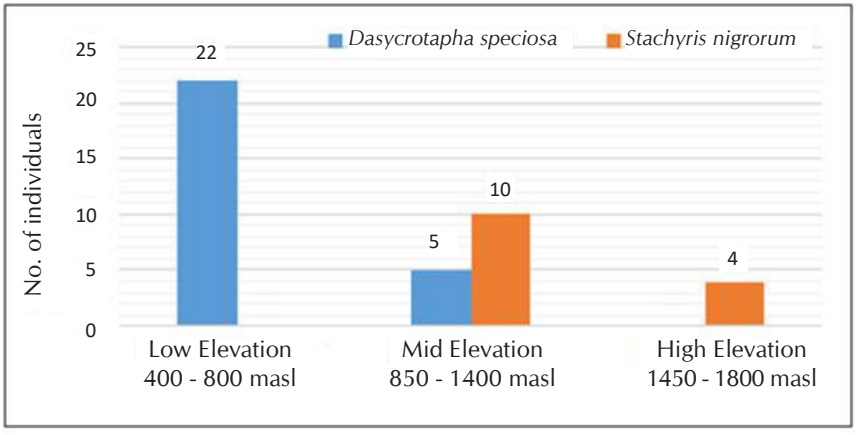

Figure 8 Number of individuals of *D. speciosa* and *S. nigrorum* per elevation type in Mt. Kanlaon Natural Park

Abundance of babblers

A total of 27 individuals of *D. speciosa* were recorded in this study. It was observed to be most common in lowland secondary forest where 16 individuals were recorded. As for mixed forest, a total of 9 individuals were recorded in plantation. *D. speciosa* was also found to have a larger population because there is more lowland forest habitat for the species compared to *S. nigrorum*. According to BirdLife International (2015), the population size of *D. speciosa* ranges between 2,500 and

9,999 mature individuals which is greater than *S. nigrorum* with a population size of 600–1,700 mature individuals remaining. However, though *D. speciosa* is endemic to the island, it must also be considered that only Mt. Kanlaon was surveyed and not the entire provinces of Negros and Panay.

As for *S. nigrorum*, a total of 14 individuals were recorded. It was most abundant in secondary montane forest with 8 individuals recorded, 5 individuals in the primary forest and one in the secondary lowland forest (Fig. 9). BirdLife International (2015) stated that the species population size ranges from 600 to 1,700 mature individuals. Although the observed number of individuals did not halve the population of this babbler, it should be considered that aside from Mt. Kanlaon, this babbler was mostly observed in Mt. Talinis (Kennedy et al. 2000).

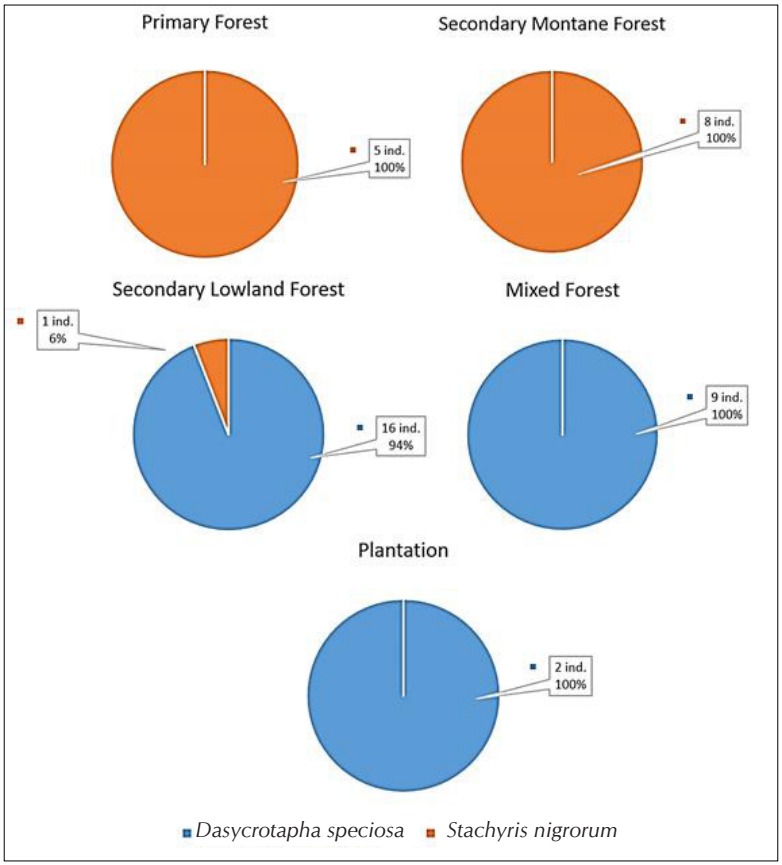

Figure 9 Relative abundance of endangered babblers across habitat types in Mt. Kanlaon Natural Park

Although a number of these individuals were found, they are still under the conservation status of endangered because there are still activities that threaten their survival.

Correlation between abundance of babblers and habitat variables

At p = 0.05 significance, Table 2 shows the correlation between the abundance of species with its habitat variables. For *D. speciosa*, climbing bamboo and tree density were found to be significant with the abundance of the species. An increase in the percentage of climbing bamboo and tree density would increase the abundance of *D. speciosa*. Also, a decrease in elevation would entail an abundance of the species. This also claims to be true since this species forage in the undergrowth, understory bushes, and trees, and dense growths of vines and ferns on larger trees. These babblers are said to be unobtrusive except when singing, thus, they most likely stay in places where they can find deep cover (Brooks *et al*. 1992).

Table 2 A summary of significant variables related to the abundance of species within p = 0.05

Species	Habitat variable	B	Wald chi-square	P	Odds ratio	Remarks
Dasycrotapha speciosa	Elevation	-0.006	7.877	0.005	0.995	Significant
	Tree height >16 – 20 m	0.076	5.904	0.015	1.079	Significant
	% of climbing bamboo	0.196	3.879	0.049	1.217	Significant
Stachyris nigrorum	Tree density	-0.039	6.827	0.009	0.962	Significant

Tree density was found to be significant in the abundance of *S. nigrorum*; a decrease in tree density would mean an increase in the abundance of *S. nigrorum*. This result strongly presses the fact that the species prefers mid-montane and mossy forest (Brooks et al. 1992).

Table 3 shows that variables such as elevation, trees less than 10 m, trees 10–15 m, trees 16–20 m, trees greater than 21 m, percentage of woody vines, percentage of understory, understory layer height, tree density, mean of DBH, DBH of trees from 15–50 cm, DBH of trees from 51–100 cm, DBH of trees from 101–200 cm, DBH of trees above 200 cm, percentage of climbing pandan, percentage of climbing bamboo, and percentage of mosses were all significant.

Table 3 Kruskal – Wallis test

Variables	Asymp. sig.	Remarks
Elevation	0.000	Significant
Trees < 10m	0.000	Significant
Trees > 10 - 15m	0.000	Significant
Trees > 16 - 20 m	0.000	Significant
Trees > 21 up	0.000	Significant
Woody vines	0.000	Significant
Understory %	0.000	Significant
Understory layer height	0.000	Significant
Tree Density	0.000	Significant
DBH Mean	0.000	Significant
DBH 15 - 50 cm	0.000	Significant
DBH 51 - 100 cm	0.000	Significant
DBH 101 - 200 cm	0.000	Significant
DBH 200 cm above	0.000	Significant
% of C. Pandan	0.000	Significant
% of C. Bamboo	0.000	Significant
% of C. Mosses	0.000	Significant

Correlation between occurrence of babblers and the habitat variables

At p = 0.05 significance, Table 4 showed that the occurrence of *D. speciosa* is high when there is a decrease in elevation and an increase in the percentage of bamboos and trees with 16–20 m height. From this, it can be implied that elevation is a prime indicator of the presence of *D. speciosa* since elevation limits its preferred habitat. Tree density is also significant for the occurrence of *S. nigrorum*.

Mann-Whitney U Test showed that at 0.05 level of significance, there is a significant difference in the number of trees (tree height < 10 m) between points where *S. nigrorum* is present and absent (Table 5). The same can be said with the number of trees (tree height > 21 m), understory layer height, tree density, percentage (%) of pandan, and percentage of mosses.

Table 4 Logistic Regression Analysis

Species	Habitat variable	B	Wald chi-square	P	Odds ratio	Remarks
Dasycrotapha speciosa	Elevation	-0.005	9.523	0.002	0.995	Significant
	% of bamboo	0.363	3.931	0.047	1.437	Significant
	Tree height > 16-20 m	0.175	5.721	0.017	1.191	Significant
Stachyris nigrorum	Tree density	-0.038	6.697	0.010	0.962	Significant

Table 5 Mann-Whitney U Test for *S. nigrorum*

Variables	Asymp. sig.	Remarks
Trees < 10 m	0.025	Significant
Trees > 21 m up	0.010	Significant
% of C. Pandan	0.001	Significant
Understory layer height	0.002	Significant
Tree density	0.028	Significant
% of C. Mosses	0.037	Significant

At 0.05 level of significance (Table 6), there is a significant difference in elevation between points where *D. speciosa* is present and absent. Elevation, 16-20 m trees, tree density, trees with DBH between 15-50 cm, percentage of climbing pandan, climbing bamboo and mosses, and anthropogenic disturbances were found to be significantly different.

Table 6 Mann-Whitney U Test for *D. speciosa*

Variables	Asymp. Sig.	Remarks
Elevation	0.000	Significant
Trees > 16-20m	0.018	Significant
DBH 15 - 50cm	0.004	Significant
% of C. Pandan	0.000	Significant
% of C. Bamboo	0.044	Significant
% of Mosses	0.000	Significant
Tree density	0.013	Significant
Anthropogenic disturbances	0.002	Significant

The variables that were found to be significant to the presence or absence of the species were significant to the overall assessment of the habitat requirements to the babblers in the area. Since *D. speciosa* is an omnivore and prefers thick undergrowth in lowland forest, foraging in understory bushes and trees or in dense growths of vines and ferns on large trees. It suits their requirements in terms of feeding, foraging and breeding. Also, variables that are significant to the occurrence or the presence or absence of *S. nigrorum* in the area correlates to the fact that this babbler is nesting in primary forest in higher elevations.

Threats to the babblers

Threats such as bird hunting, illegal tree cutting for timber and firewood and charcoal production were observed in MKNP. Tree cutting was found to be frequent in mixed forest plantation and secondary lowland forest where *D. speciosa* is commonly found. Species survival is most challenged by the presence of these anthropogenic disturbances since their continuance is mostly dependent on the presence of vast territories. These threats were noted to be specifically profound in Sitio Minoyan, Barangay Wasay, Murcia, Negros Occidental.

Other threats such as butterfly collection and snare traps for medium-sized mammals are evident throughout Sitio Minoyan, Barangay Wasay, Murcia and Guintubdan, Barangay Ara-al, La Carlota City in Negros Occidental.

Also, geothermal plants in the area which use land area for drilling disrupt the habitat of these babblers. Forest conversion for road construction fragments the forest. The researchers also noticed that there was no regular monitoring or patrolling in the protected area specifically in Sitio Minoyan, Barangay Wasay, Murcia trail.

Recommendations

The following measures are recommended to ensure effective conservation of MKNP:

1. Intensify regular forest monitoring in MKNP.
2. Establish or revisit the biodiversity monitoring system in MKNP to monitor the population of indicator species particularly babbler species.
3. Data gathered in this study must be translated into conservation initiatives and education materials to raise awareness.
4. Publish results in peer-reviewed journals so that the research results can be shared in the scientific community.
5. Lastly, illegal structures should be removed while expansion of the geothermal plant should be restricted.

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Forest bat diversity and abundance in different habitats on Mt. Kanlaon Natural Park, Negros Island

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Bat diversity and abundance in different habitats along an elevational gradient was assessed on Mt. Kanlaon Natural Park (MKNP) from 19 May – 2 June 2015 using mist netting and harp trapping methods. A total of 72 net nights and 68 trap nights as well as 65 20 m x 20 m circular vegetation plots were conducted. There were 608 bats captured representing 23 species, of which 8 are endemic to the Philippines. Ten bat species were added to the list of bats previously recorded in Mt. Kanlaon: ***Pteropus pumilus****,* ***Hipposideros ater****,* ***Hipposideros diadema****,* ***Kerivoula*** *cf.* ***hardwickii****,* ***Kerivoula pellucida****,* ***Murina cyclotis****,* ***Myotis*** *cf.* ***rufopictus****,* ***Pipistrellus*** *sp.,* ***Rhinolophus inops****, and* ***Rhinolophus subrufus****. Secondary montane forest had the highest bat diversity (H'=1.88). Logistic Regression Analysis and Poisson Distribution showed several variables (number of trees of specific height, canopy and subcanopy cover, elevation, number of dead trees and fruiting trees, distance from water, and mean DBH) with significant association to bat occurrence and abundance.*

Keywords: Bats, Mt. Kanlaon, habitat selection, diversity, abundance

NEGROS ISLAND IS LOCATED IN WESTERN VISAYAS, ONE OF THE PHILIPPINES' 6 faunal regions with at least 42 species of bats and approximately 25% of which are known to be endemic in the Philippines. It represents one of the 10 highest-ranking sites globally for megachiropteran diversity, and is listed as a priority area for the establishment of protected areas for megachiropteran conservation (O'Malley et al. 2006). Over the last 50 years, however, the lush mountain forests in the province have faced increasing threats from logging companies, charcoal manufacturers, upland farmers and forest encroachers (Garcia and Mulkins 2011).

This study aimed to determine the bat diversity and distribution in one of 4 natural parks in Western Visayas, Mt. Kanlaon Natural Park (24,557 ha in area), compare bat diversity across different habitat types and elevation gradients, correlate bat occurrence and abundance with selected habitat variables, and identify local threats to the bats in the area.

Materials and methods

Study area

Negros Island Region (Fig. 1A) is located in the Visayas and composed of 2 provinces: Negros Oriental and Negros Occidental. The area comprising the whole of Mt. Kanlaon Natural Park has been apportioned to Bago City, La Carlota City, San Carlos City, Murcia, and La Castellana (Negros Occidental Province) and the City of Canlaon (Negros Oriental Province) where their political lines of boundary all meet at a common point located at the summit-crater of Kanlaon volcano (Fig. 1B).

Sampling sites

The sampling sites located in Bago City, Municipality of Murcia, and Guintubdan within Mt. Kanlaon Natural Park included 4 habitat types: primary montane forest, secondary montane forest, secondary lowland forest, and plantation (Fig. 2).

Sampling method

Under the Wildlife Gratuitous Permit No. R6-2014-001 issued by the Office of the Regional Executive Director of DENR, Iloilo City, bat sampling was conducted from 19 May – 2 June 2015 using standard mist netting and harp trapping methods. Sampling points were established every 100 m along a transect covering a horizontal distance ranging from 500 m to 1500 m. A sampling point was usually composed of a single harp trap and mist net positioned about 5-10 m away from each other. However,

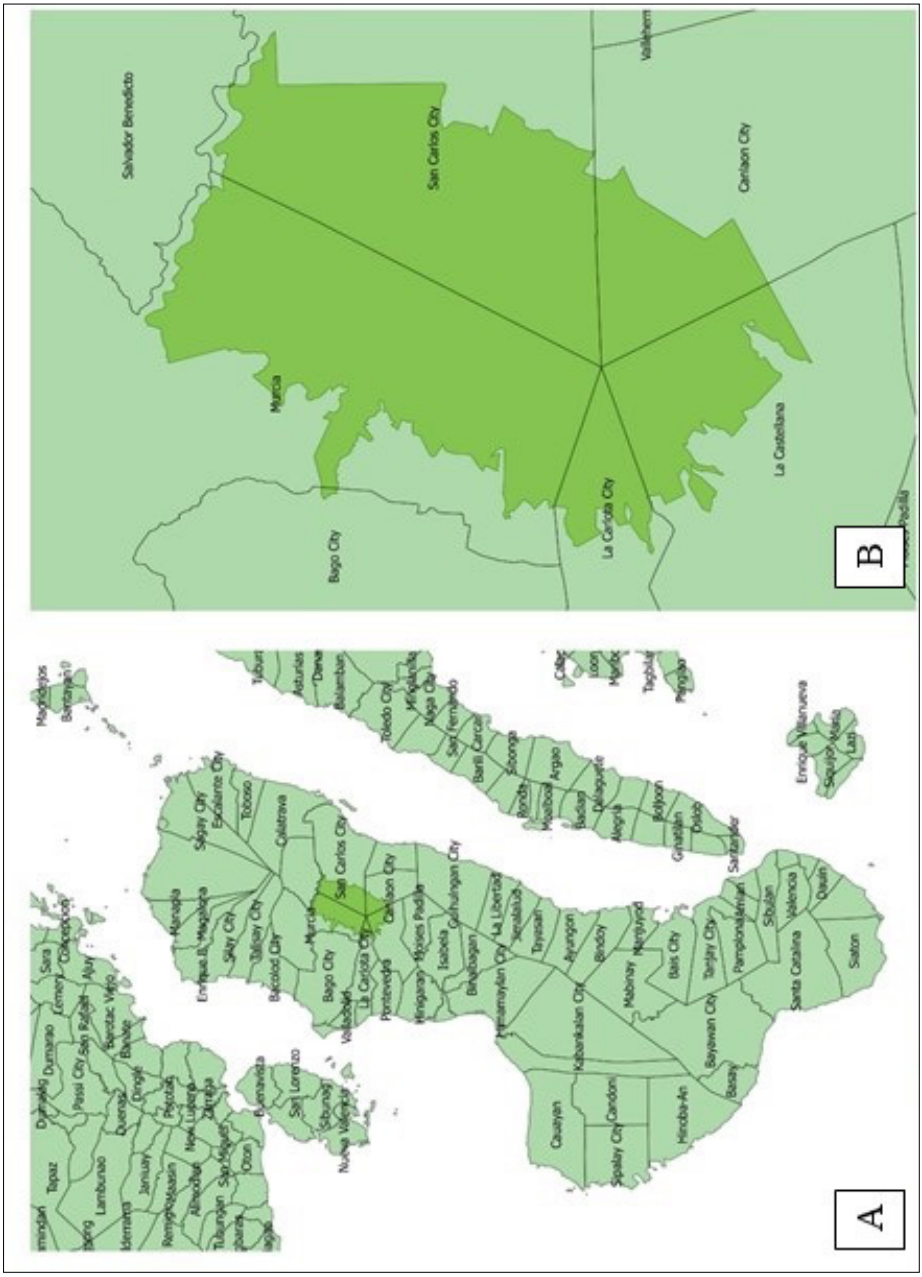

Figure 1 Negros Island map showing Mt. Kanlaon Natural Park (A) and its boundaries (B)

Figure 2 A. primary montane forest in Bago City; B. secondary montane forest in Guintubdan at 1068 masl; C. plantation in Murcia at 578 masl; D. secondary lowland forest in Murcia

there were instances in which 2 nets were deployed in a single point. There were also points in which no nets were deployed aside from harp traps because the dense subcanopy layer within the area provided no suitable flyway for bats. Furthermore, there were also points in which traps were absent and only nets were present because the trail proved to be too wide to establish harp traps. Depending on the accessibility of the location, nets and traps were positioned before dark across established trails, streams, along fruit trees, riparian zones, or along flying paths.

A total of 10 net hours was observed nightly and checking was done at 5:00-7:00 in the evening and 5:00-7:00 the following morning. Net and trap positions were moved every day to cover more distance and varying elevations. A total of 72 net nights and 68 trap nights were employed during the entire sampling duration. Retrieved specimens were processed and identified at the camp. A Key to the Bats of the Philippine Islands (Ingle and Heaney 1992) and Bats of Krau Wildlife Reserve (Kingston et al. 2006) were used in identifying the bat samples. Standard biometric

parameters of captured bats such as total length (TL), tail length, forearm length (FA), hind foot (HF) length, and ear length were measured and recorded. Sex, age, and weight were also noted. Unless there was a need for voucher specimen, all captured bats were marked using a permanent marker before release to avoid recounting. Recaptured bats were disregarded and released.

Habitat assessment was also done within a 20 m x 20 m circular plot where the nets and traps were established. Nets and traps in close proximity to each other (10 m or less) were assessed to generate identical habitat variables or habitats. A total of 65 plots were assessed in the 4 habitats covered averaging to 21 plots per sampling site. Global positioning system (GPS) coordinates and their corresponding elevations were also recorded along with the different habitat variables. Two transects were established in the first and second sampling sites and one in the third site covering a total of 24, 22, and 18 sampling points, respectively.

Data analysis

Simpson's Diversity and Shannon-Weiner Diversity Indices were used to determine bat diversity. Kruskal-Wallis Test was employed to determine if there were statistically significant differences between 2 or more groups of an independent variable (in this case, habitat type) on a continuous or ordinal dependent variable (habitat variables). Logistic Regression Analysis was used to depict the relationship between the habitat variables and the occurrence of each forest bat species. Poisson Distribution was used to depict the relationship between a habitat variable and bat abundance.

Results and discussion

Species composition

A total of 608 bat individuals were recorded comprising 23 bat species belonging to 5 families in Mt. Kanlaon Natural Park (Table 1). Of the 608 bat individuals, 8 (35%) were Philippine endemics including the endangered *Nyctimene rabori*, near threatened *Pteropus pumilus,* and *Kerivoula pellucida,* and the data deficient *Rhinolophus subrufus*. *Myotis* cf. *rufopictus* was also documented once in plantation forest.

A previous study in MKNP in 2007 by the Philippine National Oil Company (PNOC) - Energy Development Corporation recorded 6 species of fruit bats and 6 species of insectivorous bats.

Table 1 List of bats recorded in Mt. Kanlaon Natural Park

Suborder	Family	Scientific name	Common name	Endemicity	IUCN status
Megachiroptera	Pteropodidae	*Cynopterus brachyotis*	Lesser short-nosed fruit bat	Resident	LC
Megachiroptera	Pteropodidae	*Haplonycteris fischeri*	Philippine pygmy fruit bat	Endemic	LC
Megachiroptera	Pteropodidae	*Harpyionycteris hiteheadi*	Harpy fruit bat	Endemic	LC
Megachiroptera	Pteropodidae	*Macroglossus minimus*	Dagger-toothed long-nosed fruit bat	Resident	LC
Megachiroptera	Pteropodidae	*Nyctimene rabori*	Philippine tube-nosed fruit bat	Endemic	E
Megachiroptera	Pteropodidae	*Ptenochirus jagori*	Greater musky fruit bat	Endemic	LC
Megachiroptera	Pteropodidae	*Pteropus pumilus*	Little golden-mantled flying fox	Endemic	NT
Microchiroptera	Hipposideridae	*Hipposideros ater*	Dusky leaf-nosed bat	Resident	LC
Microchiroptera	Hipposideridae	*Hipposideros diadema*	Diadem leaf-nosed bat	Resident	LC
Microchiroptera	Hipposideridae	*Hipposiderosm obscurus*	Philippine forest roundleaf bat	Endemic	LC
Microchiroptera	Megadermatidae	*Megaderma spasma*	Lesser false vampire bat	Resident	LC
Microchiroptera	Verspertilionidae	*Kerivoula* cf. *hardwickii*	Hardwicke's wooly bat	-	-
Microchiroptera	Verspertilionidae	*Kerivoula pellucida*	Clear-winged wooly bat	Resident	NT
Microchiroptera	Verspertilionidae	*Kerivoula* sp.	Wooly bat	-	-
Microchiroptera	Verspertilionidae	*Murina cyclotis*	Round-eared tube-nosed bat	Resident	LC
Microchiroptera	Verspertilionidae	*Myotis* cf. *rufopictus*	Orange-fingered myotis	-	-
Microchiroptera	Verspertilionidae	*Pipistrellus javanicus*	Javan pipistrelle	Resident	LC
Microchiroptera	Verspertilionidae	*Pipistrellus* sp.	Pipistrelle bat	-	-
Microchiroptera	Rhinolophidae	*Rhinolophus arcuatus-large*	Arcuate horseshoe bat	Resident	LC
Microchiroptera	Rhinolophidae	*Rhinolophus inops*	Philippine forest horseshoe bat	Endemic	LC
Microchiroptera	Rhinolophidae	*Rhinolophus* sp.	Horshoe bat	-	-
Microchiroptera	Rhinolophidae	*Rhinolophus subrufus*	Small rufous horseshoe bat	Endemic	DD
Microchiroptera	Rhinolophidae	*Rhinolophus virgo*	Yellow-faced horseshoe bat	Resident	LC
Total number of species		23			
Total number of endemic species		9			
Total number of threatened species		1			

Legend: LC - Least Concern; E - Endangered; DD - Data Deficient; NT - Not threatened

This current survey added 12 species to that list, the fruit bat *P. pumilus* and 11 species of insect bats such as *Hipposideros ater, Hipposideros diadema, Kerivoula* cf. *hardwickii, Kerivoula pellucida, Kerivoula* sp., *Murina cyclotis, M.* cf. *rufopictus, Pipistrellus* sp., *Rhinolophus inops, Rhinolophus* sp., and *Rhinolophus subrufus*. This could be attributed to the harp trapping method which was not done in the previous study. The 2 studies documented a total of 24 species with 8 endemic species within the forest of Mt. Kanlaon.

Bats of Mt. Kanlaon Natural Park and Northern Negros Natural Park

Northern Negros Natural Park (NNNP) was reported to have a total of 17 bat species, 4 of which are endemic (Manupac 2014). Comparing this to Mt. Kanlaon, 9 species (*P. pumilus, H. obscurus, K.* cf. *hardwickii, K. hardwickii, M. spasma, M.* cf. *rufopictus, R. inops, Rhinolophus* sp., and *R. subrufus*) were not reported in NNNP while 2 species (*Eonycteris spelaea* and *Myotis muricula)* in NNNP did not occur in the record from MKNP. These account for 8 endemic species residing within Negros' protected area forest cover.

The number of fruit bats recorded in both natural parks are the same while the number of insectivorous bat species are greater in MKNP. The threatened endemic species *N. rabori* is present in both natural parks. In all three habitat types compared, NNNP recorded a higher number of fruit bat species. Total fruit bat species richness, however, is determined to be the same for both natural parks. The number of insectivorous bat species documented for both parks in three habitat types was higher in MKNP than in NNNP. Overall insectivorous bat species richness showed that MKNP recorded six more species compared to NNNP. Overall, species richness is higher in MKNP in both secondary montane forest and plantation. Species richness is also equal in both parks in the secondary lowland forest (Fig. 3).

Species diversity

A sampling point usually consisted of a single harp trap and mist net positioned about 5-10 m away from each other. However, the dense subcanopy layer within the area sometimes provided no suitable flyway for bats or the trail proved to be too wide to establish the traps. Due to these topographic and time constraints in each habitat type, there was an unequal trapping and netting efforts employed during the sampling.

Species diversity was found to be highest in the secondary montane forest with H' and D values of 1.8764 and 0.8624, respectively (Fig. 4). A Shannon-Wiener index value of 1.0-3.0 indicates moderate species diversity. Simpson's diversity

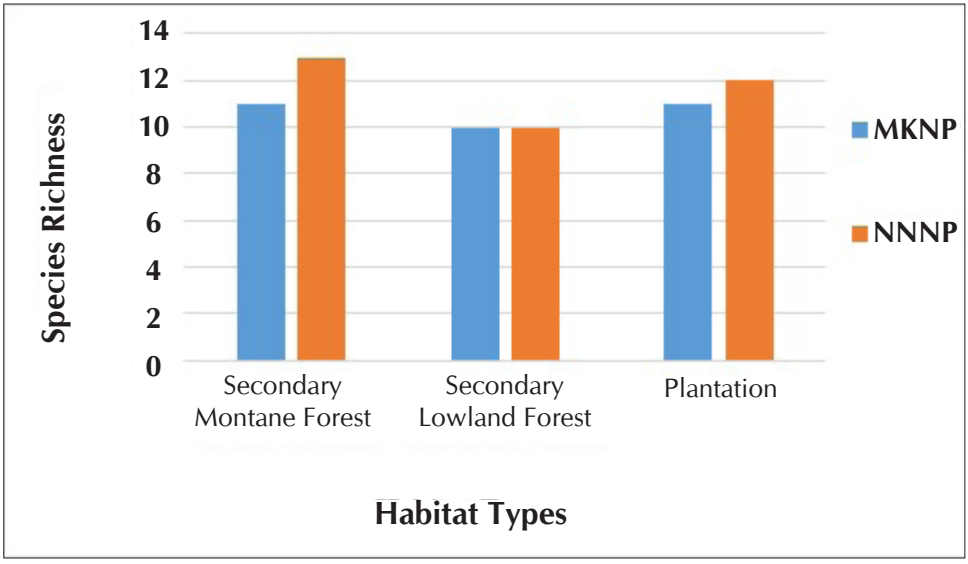

Figure 3 Total species richness among 3 different habitat types in Mt. Kanlaon Natural Park (MKNP) and Northern Negros Natural Park (NNNP)

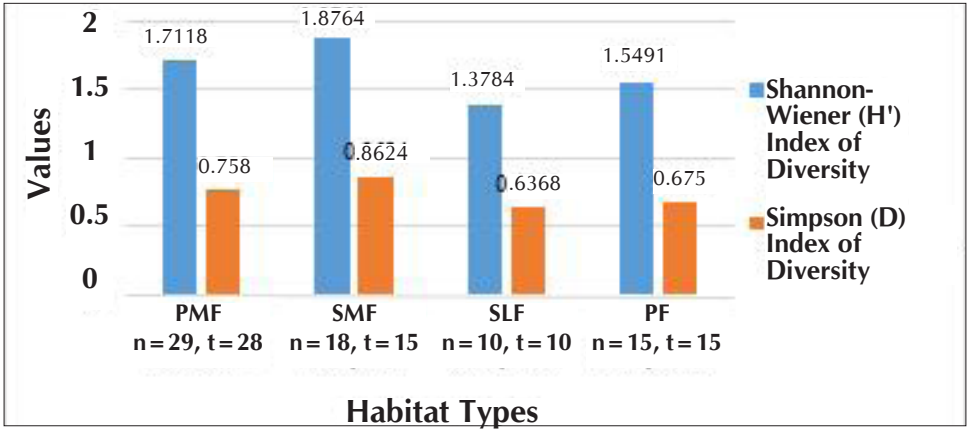

Figure 4 Species richness and diversity values of the different habitat types of Mt. Kanlaon Natural Park (Legend: PMF – primary montane forest; SMF – secondary montane forest; SLF – secondary lowland forest; PL – plantation; n = netting nights, t = trapping nights)

index ranges between 0 and 1 and implies increasing diversity as D value increases. Both indices of diversity suggested a moderate species diversity for that habitat type. Natural forests provided suitable habitats for native forest species including those threatened and endangered (Brockerhoff et al. 2008). Overall diversity in MKNP is moderate (H′ = 2.0262 and D = 0.8378).

Bat distribution in different habitat types

Bat distribution is closely similar in the 4 habitat types. The most number of captured individuals is found to be in the secondary lowland forest constituting 28% of the 608 individuals recorded from the 4 different habitat types. However, species richness in this habitat is lowest among the 4 at 10 species. The most number of species was recorded in the secondary montane forest (Table 2).

Species richness is highest in secondary montane forest with an elevation of 1000-1300 masl comprising 13 bat species of which 5 are endemic. Primary montane forest and plantation forest both have 12 bat species. Endemism is highest in the former recording 6 species and the latter having 4. Bat foraging activity is often concentrated in riparian zones and in gaps of older and more diverse forest stands. Riparian zones were also observed more than twice in primary montane forest and are especially important because they provide drinking water and high quality foraging and roosting habitats (Taylor 2006). It is noteworthy to add that there are 3 endemic species supported in the plantation forest of Guintubdan which include the endangered *N. rabori*. *Myotis* cf. *rufopictus* was also recorded in this habitat type.

In the 4 habitat types covered, some bat species were captured in only one habitat type and some were found in all 4. *H. fischeri, M. minimus, P. jagori, R. arcuatus-l,* and *R. virgo* were recorded in all habitat types and may be less vulnerable to habitat disturbances because they can move from one area to another.

Elevation

Elevation affects species richness such that with increasing elevation, species richness declines steadily (Heaney et al. 1998). Except for a few species, most of the bat species were recorded within their known specific elevation ranges.

Hipposideros obscurus was recorded once in primary montane forest at 1276 masl exceeding its usual 1100 masl range limit. *R. subrufus* was also found at 1588 masl about 500 m away from its known range. *R. virgo* also exceeded its known elevation range.

Table 2 Distribution of forest bats in different habitat types in Mt. Kanlaon Natural Park

Species	Primary montane forest	Secondary montane forest	Secondary lowland forest	Plantation
Fruit bats				
Cynopterus brachyotis	-	✓	✓	✓
Haplonycteris fischeri	✓	✓	✓	✓
Harpyionycteris whiteheadi	✓	✓	-	-
Macroglosus minimus	✓	✓	✓	✓
Nyctimene rabori	-	✓	✓	✓
Ptenochirus jagori	✓	✓	✓	✓
Pteropus pumilus	-	-	✓	-
Insectivorous Bats				
Hipposideros ater	-	-	✓	✓
Hipposideros diadema	-	✓	-	-
Hipposideros obscurus	✓	-	-	-
Kerivoula cf. *hardwickii*	-	✓	-	-
Kerivoula pellucida	-	✓	-	-
Kerivoula sp.	✓	-	✓	-
Megaderma spasma	-	-	-	✓
Murina cyclotis	-	-	-	✓
Myotis cf. *rufopictus*	-	-	-	✓
Pipistrellus javanicus	✓	-	-	-
Pipistrellus sp.	-	-	-	✓
Rhinolophus arcuatus-large	✓	✓	✓	✓
Rhinolophus inops	✓	✓	-	-
Rhinolophus sp.	✓	✓	-	-
Rhinolophus subrufus	✓	-	-	-
Rhinolophus virgo	✓	✓	✓	✓
Total no. of species	12	13	10	12
Total no. of endemic species	6	5	4	3

Species richness in low, middle, and high elevations

Elevation was divided into low, middle, and high ranging from 400-800 masl, 801-1100 masl, and 1101-1700 masl, respectively. Insectivorous bats had a higher species richness in both low and high elevations (Fig. 5). Insects such as mosquitoes were observed to be numerous in the high elevation primary montane forest. Bodies of water were not far off from where the traps were placed and were determined to have a 300 m average distance. Bodies of water are necessary for mosquitoes and other insects as they breed and go through the stages of their life cycle. Some bat species roost near or forage over water (Taylor 2006). Bodies of water were also observed at low elevation as well as open canopy areas which provide ample foraging areas for insectivorous bats (Kusch et al. 2004).

Manupac (2014) reported that the highest species richness was observed at high elevation and can be attributed to the intact forest cover and number of trees of specific height which are found to have a significant influence on specific bat occurrence and abundance. Species richness, however, was found to be decreasing with increasing elevation. This corresponds to the observation of Heaney et al. (1998) that bats have a certain elevation range in which their activity peaks and then declines upon reaching a certain elevation point.

Relative abundance

Rhinolophus arcuatus-large had the largest number of captured individuals constituting 35% of the 160 individuals captured in the primary montane forest. This species is known to inhabit lowlands with at least 1050 masl on agricultural lands to primary forest (Heaney et al. 1998). In a study by Balete et al. (2011), *R. arcuatus* showed a wide elevational distribution in different habitat types (from mixed reforestation/agricultural areas to primary lower montane forests) ranging from 100-1476 masl and appeared to be most abundant in the middle and upper elevations. *Haplonycteris fischeri* follows *R. arcuatus-l* in number with 50 individuals. This species thrives at high elevation specialist and is common in primary forest, especially at middle elevations, but is rare in secondary forest. Count record trend corresponds to this observation as individual count decreased with decreasing elevation. On the contrary, *Hipposideros obscurus, Rhinolophus subrufus,* and *Rhinolophus* sp. had the least number of individuals, each composed of a single capture.

With a sampling effort of 15 net nights and 18 trap nights, a total of 146 individuals were recorded in the secondary montane forest. *Rhinolophus virgo* was the most abundant species comprising 22% of the total bat individuals captured. *R.*

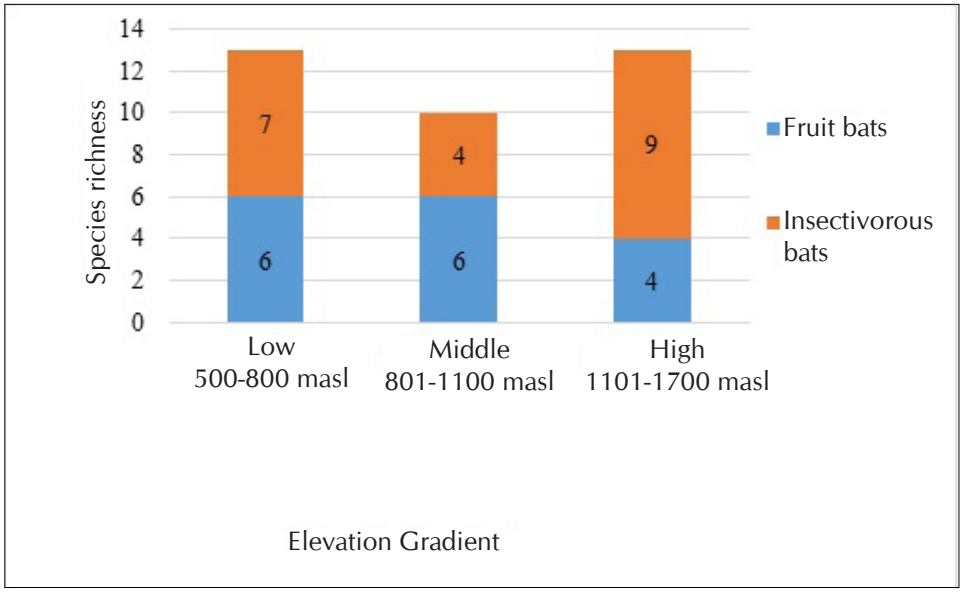

Figure 5 Comparison of species richness in low, middle, and high elevation

virgo is known to inhabit a wide range of habitat types from secondary forest, primary lowland forest, and mossy forest on small islands. It often roosts in caves (Esselstyn et al. 2004). *R. arcuatus-l* follows after *R. virgo* with 32 individuals recorded. Four individuals of the endangered *Nyctimene rabori* was recorded in this habitat type. The least abundant species, composed of one individual each, were *Hipposideros diadema*, *Kerivoula* cf. *hardwickii*, *Kerivoula pellucida*, and *Rhinolophus inops*.

In the secondary lowland forest, *Cynopterus brachyotis* composed the majority of the individuals with a relative abundance of 56%. Abundance could be attributed to the presence of plants they forage such as *Ficus* and *Musa* sp. as well as other fruiting trees present in this site. *Ptenochirus jagori* is the second most abundant species recorded. This species is most common in lowland forest, uncommon in montane forest, and absent in mossy forest (Heaney et al. 1998). *P. jagori* is endemic and widely distributed in the Philippines except in the Batanes/Babuyan and Palawan Faunal Regions. *N. rabori* is recorded in this habitat type consisting of 5 individuals. *Pteropus pumilus* had the least number of individuals recorded (one) constituting 0.6% of the 169 individuals captured. This species is near threatened due to habitat degradation and hunting pressure.

C. brachyotis was the most abundant species in the plantation with a relative abundance of 53% due to its wide distribution and high tolerance. *R. arcuatus-l* is

the second most abundant. *N. rabori* is also recorded in this habitat type with 6 individuals captured. The least abundant species comprised 4% (one individual) of the 133 individuals captured in this habitat type. These include *Hipposideros ater, Murina cyclotis, Myotis* cf. *rufopictus, Pipistrellus* sp., and *R. virgo*.

Out of the 608 bat individuals recorded in 4 different habitat types, the most abundant species was *C. brachyotis* with 180 individuals constituting 30% of the bat samples. *C. brachyotis* is a widespread species found in a variety of habitats. It is frequently associated with secondary forests, fruit orchards, and urban areas. Disturbance-tolerant species tend to have a wider distribution than those that are restricted to specific habitat types (Achondo et al. 2014). The Philippine endemics *H. fischeri, R. virgo,* and *P. jagori* follow with relatively considerable numbers and were encountered in all habitat types. *N. rabori* occured in 3 habitat types with 15 individuals recorded. Forest conservation in these areas is of utmost importance to protect the population of this species residing in MKNP. The least abundant species were all comprised of singly captured individuals. These were *P. pumilus, H. diadema, H. obscurus, K.* cf. *hardwickii, K. pellucida, M. cyclotis, M.* cf. *rufopictus, Pipistrellus* sp. and *R. virgo*.

Correlation analyses

Kruskal-Wallis test showed that there is a significant difference between the 16 habitat variables assessed among the 4 habitat types. Nine species were considered for habitat preference assessment. Logistic regression analysis was done to predict the probability of the occurrence of bat species in relation to a certain variable/s (predictors). On the other hand, Poisson distribution analysis was used to determine the relationship of the predictor/s to bat abundance.

From the results, number of trees of specific height, canopy cover, distance from water, and elevation were determined to have a significant influence on the occurrence of *H. fischeri*, *H. whiteheadi, N. rabori,* and *P. jagori* (Table 3). *H. fischeri* occurrence is positively correlated with canopy cover while negatively correlated with the number of trees with a height of 16-20 cm. However, it is apt for *H. fischeri* to be common in primary forests where canopy cover is dense and tree height decreases with increasing elevation (Heaney et al. 1998). *N. rabori* is more likely to be found in areas distant from water and there is a negative correlation between elevation and number of trees with height 10-15 cm with *P. jagori*. This implies that for each unit increase of these variables, it becomes less likely to attract such species. *P. jagori* is most common in lowland forests and despite having a generally stable population, it is vulnerable to habitat destruction (Heaney et al. 1998).

Table 3 Logistic regression analysis values

Species	Habitat variable	B	Wald chi-square	p	Odds ratio	Remarks
Haplonycteris fischeri	No. of trees with height 16-20 cm	-0.318	10.915	0.001	0.728	Significant
	Canopy % cover	0.15	8.425	0.004	1.162	Significant
Nyctimene rabori	Distance from water	0.006	8.557	0.003	1.006	Significant
Ptenochirus jagori	Elevation	-0.004	10.538	0.001	0.996	Significant
	No. of trees with height 10-15 cm	-0.052	6.727	0.009	0.95	Significant

Elevation, number of dead and fruiting trees, distance from water, and number of trees of specific height (10-15 cm) all contribute to the likelihood of *H. fischeri* increase in abundance for each unit of increase in variable. Meanwhile, subcanopy cover and mean DBH of trees >16 cm decrease *H. fischeri* abundance (Table 4). Canopy and understory cover increases *H. whiteheadi* abundance denoting that this species thrives in intact habitats such as primary forests where it is moderately common while having slight tolerance for lightly disturbed forests (Heaney et al. 2006).

Existing local threats

Human populations and their increasing pressure on natural ecosystems contribute to threats in bat population. These threats include forest loss and degradation through logging and development which affect lowland forests and their associated wildlife inhabitants (Wiles and Brooke 2009).

Because of its establishment as a natural park, large-scale deforestation is not a significant threat to the wildlife inhabitants of Mt. Kanlaon especially that of forest bats. However, habitat degradation is still a persisting problem for the wildlife of Mt. Kanlaon due to timber poaching in some parts of the primary montane forest in Bago City particularly those that are near human settlements. A vast majority of bats rely on forest completely or to some extent. Thus, declining forest cover, deforestation of lowland forests, fragmentation, and continuing modification of mature and secondary forests have major impacts on most taxa by reducing foraging and roosting habitats. Some bats, though seemingly tolerant to habitat degradation, remain to be vulnerable to changes in extent and quality of habitat.

Table 4. Poisson distribution values of bat species in MKNP

Species	Habitat variable	B	Wald Chi-square	p	Odds Ratio	Remarks
Haplonycteris fischeri	Elevation	0.008	14.615	0.000	1.008	Significant
	Subcanopy % cover	-0.084	15.556	0.000	0.920	Significant
	No. of dead trees	0.384	10.990	0.001	1.467	Significant
	Distance from water	0.006	12.406	0.000	1.006	Significant
	No. of trees with height 10-15 cm	0.030	4.770	0.029	1.030	Significant
	Mean DBH of trees >16cm	-0.067	8.738	0.003	0.935	Significant
	No. of fruiting trees	0.379	4.238	0.040	1.461	Significant
Harpyionycteris whiteheadi	Canopy % cover	0.002	0.006	0.006	1.002	Significant
	Understory % cover	0.006	0.018	0.018	1.006	Significant
Nyctimene rabori	Elevation	-0.006	6.214	0.013	0.994	Significant
Ptenochirus jagori	No. of trees with height 10-15 cm	-0.120	5.715	0.017	0.887	Significant
	No. of trees with height 16-20 cm	0.386	4.851	0.028	1.471	Significant
	Mean DBH of trees >16 cm	0.103	5.181	0.023	1.108	Significant
	No. of trees with DBH 51-100 cm	-0.234	5.817	0.016	0.791	Significant
	No. of fruiting trees	-1.520	5.901	0.015	0.219	Significant

According to a local guide, bat hunting, particularly flying foxes, is a tradition among the locals living in Mt. Kanlaon. Although laws have been passed concerning the hunting of bats for food and sport, it is still being practiced. Historically, flying foxes were taken using stone projectiles, sticks, long-handled hoop nets, etc. However, with improved access to remote areas, and wider availability of equipment such as firearms, air rifles, nets, and traps, hunters can easily take more number of bats. A study by Cariño et al. (2006) noted that bats comprised 11 of the 72 bird and animal species killed by hunters in Negros. Among those captured were threatened species such as *Acerodon jubatus, Dobsonia chapmani,* and *Pteropus pumilus*. According to Wiles and Brooke (2009), "most hunters were low income subsistence farmers who tend to be poorly educated and killed bats and other wildlife primarily for home consumption". On one occasion, a hut, presumably a hunter's, was seen in the primary montane forest of Energy Development Corporation (EDC) Area and bird feathers were seen on the ground nearby. A handful of other traps for non-volant mammals were also observed from time to time, as well as traces of butterfly and bird hunting.

Acknowledgment

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Diversity and distribution of herpetofauna in Balesin Island, Polillo, Quezon, Philippines

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A survey of the ecosystems and herpetofauna of Balesin Island in the Polillo group of islands was conducted on 19-22 July 2015. The survey was part of a bigger biodiversity study of the whole island for a conservation management program planning for Balesin Island Resort. Several standard survey techniques were used to assess the island's herpetofauna. GIS-based mapping was done to identify the boundaries of the island's habitat types and the herpetofaunal distribution. A vegetation survey was likewise conducted. Seven major habitat types were identified. A total of 16 species of herpetofauna were documented including 2 amphibians, 1 agamid, 3 geckos, 6 skinks, 3 snakes, and 1 monitor lizard. ***Malayopython reticulatus*** *was reported present by the locals on the island but was not observed during the study. With the exception of* ***Laticauda laticauda****, all herpetofauna documented in Balesin Island have been recorded elsewhere in the Polillo group of islands.*

Keywords: Biodiversity, distribution, GIS, herpetofauna, vegetation map

PHILIPPINES IS ONE OF THE 17 MEGADIVERSE COUNTRIES BECAUSE OF ITS high level of species diversity and endemism. It is an archipelago that provides multiple habitat types to 7,641 islands, thereby serving as home to many endemic species. Among with the highest endemism are amphibians and reptiles. Current data show that 112 species (84%) of amphibians are endemic while 258 species (66%) of reptiles are endemic (Diesmos et al. 2015, Diesmos et al. 2002).

Balesin Island is a 429-ha island resort, part of the Polillo group of islands and situated northeast of Quezon and Camarines and southwest of the Polillo, Patnanungan and Jomalig islands (Fig. 1). The island is surrounded by Lamon Bay on the west, Pacific Ocean on the east, and located at 14°25′17.10′′N and 122°2′12.27′′E. It has a Type II climate with no pronounced dry season. Mean annual rainfall is 111.56 inches with a maximum rainfall from December to January and mean annual temperature of 26.6°C.

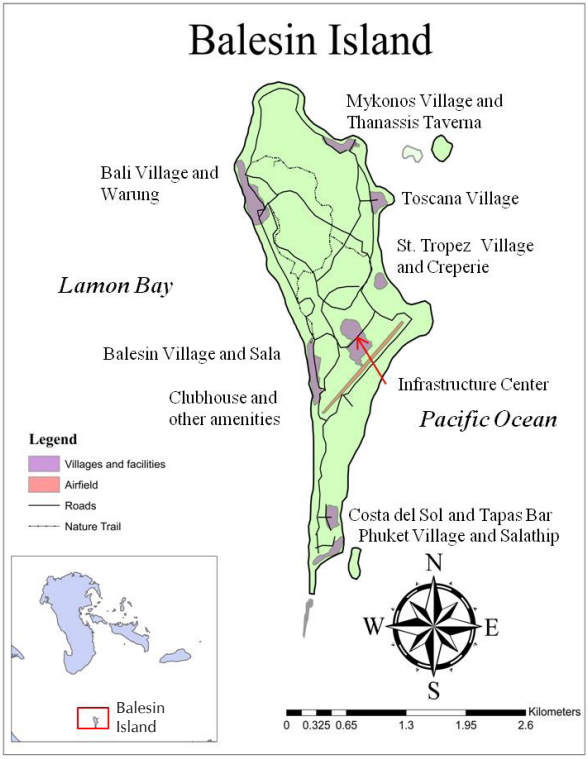

Figure 1 Balesin Island and some of its features Inset: Polillo Island Group and location of Balesin Island, Polillo, Quezon (red square)

The island is accessible mainly through chartered flight from Manila. It currently features 8 themed villas or clusters, a 1.5 km concrete airstrip, water reservoirs, nature trail, concrete roads, different amenities, and a barangay. Balesin Island Resort is a high-end tourist spot with significant natural habitats for biodiversity conservation. This extensive biodiversity study of the island was conducted for a conservation management program for Balesin Island Resort.

Materials and methods

Site characterization

The exact location of each sampling area was determined using Global Positioning System (GPS) to develop GIS maps. Google Earth and Quantum GIS (ver. Wiens) were used to plot a vegetation map. Coordinates for fauna were incorporated in the generated map that showed the 7 major habitat types and other features of the island (Fig. 2). The vegetative composition of each area (types and species of plants), presence of decayed logs, distance from water source, and litter composition were noted.

Sampling and data gathering

A combination of timed searches and night time drive-by, opportunistic sampling, and detection of advertisement calls was employed (Rödel and Ernst 2004, Heyer et al. 1994). Timed searches were regularly conducted between 1000 h and 2300 h. All accessible microhabitats were searched by raking the forest floor litter, probing epiphytes and tree hollows, upturning rocks and logs, and splitting-open decayed logs.

Nine straight line pitfall traps were set in selected habitat types (Fig. 2). Six habitat types previously identified by Achondo and Afuang (2011) were considered for this study: beach forest, mangrove forest, old-growth forest, grassland, scrubland, and plantations.

A pitfall station composed of 4 pits (pipes measuring 12 cm diameter x 30 cm depth) interconnected by a durable plastic sheet (3 m long and 30 cm high), with the bottom edge embedded into the ground (Fig. 3).

A total of 3.45 km of the island's nature trail was traversed several times for opportunistic sampling and night time drive-by, including the major roads in the island.

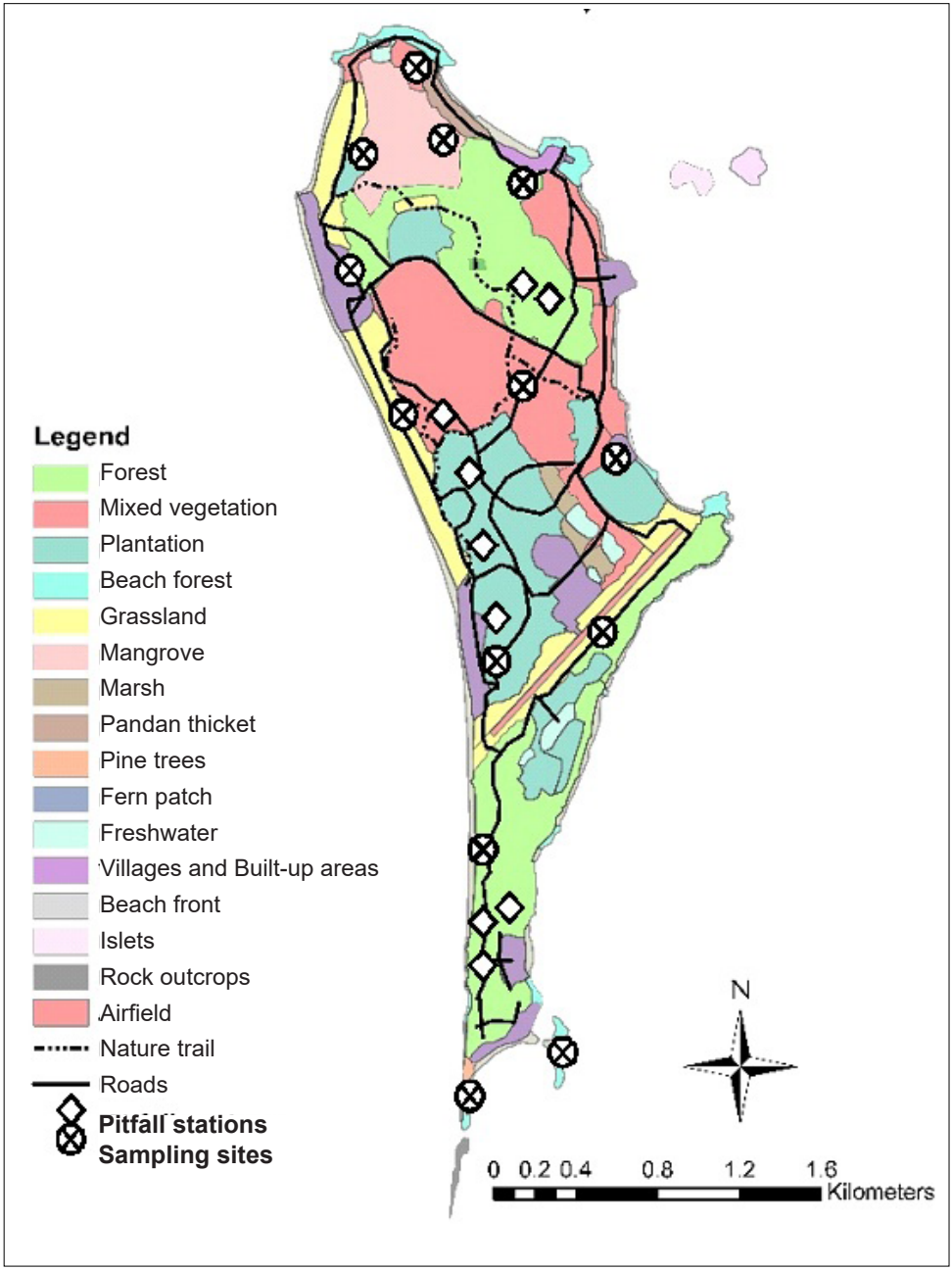

Figure 2 Pitfall station sites and other sampling points distributed in the different habitats within Balesin Island, Polillo, Quezon. Roads and nature trail were also utilized for opportunistic sampling.

Figure 3 Straight line fence and pitfall station used in the study

Diversity and similarity indeces

Shannon's Diversity Index (H') for each habitat type was computed using the formula:

$$H' = \sum p_i l_n p_i$$

where: p_i = number of individual per species/ total number of individuals
L_n = natural logarithm

Species Richness Index was computed using the formula:

$$R = S/\sqrt{N}$$

where: S = number of species in the habitat
N = total number of individuals

Jaccard Index of Similarity (j) was computed using the formula:

$$j = (c/A + B\text{-}c)*100$$

where: A = number of species in 1st community
B = number of species in 2nd community
c = number of species common in both communities.

Results and discussion

Habitat types

Seven major habitat types and other special microhabitats (Fig. 4) were observed in the island. Forest (115.02 ha), mixed vegetation areas (92.93 ha) and plantations (83.42 ha) make up 80% of the vegetation cover of the island.

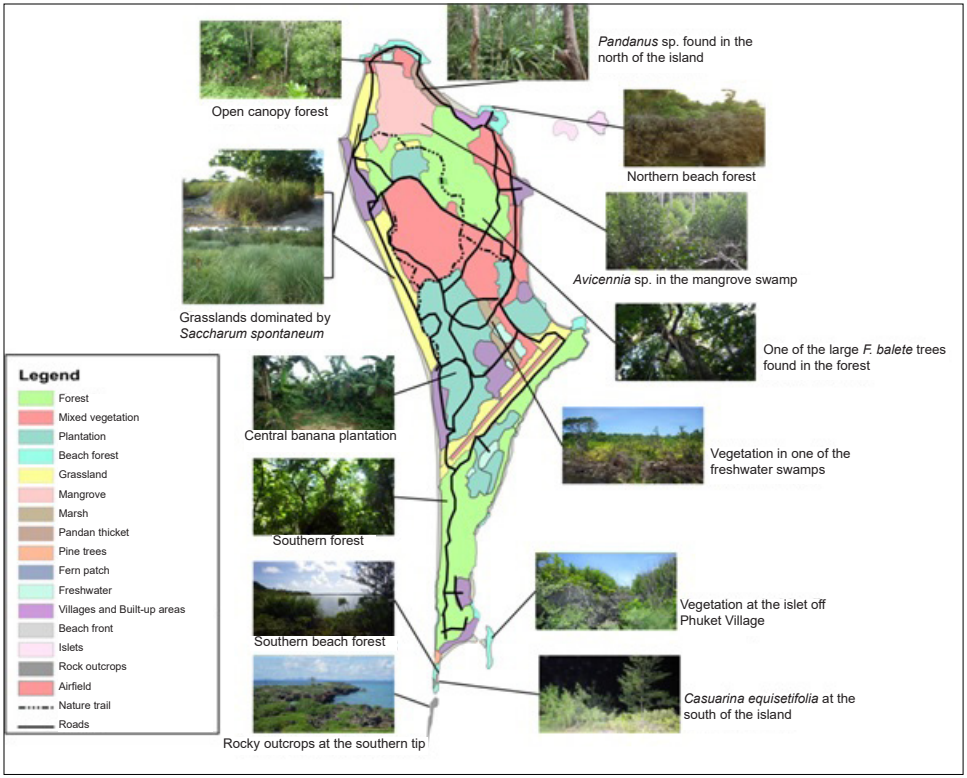

Figure 4 Extent and distribution of the different types of vegetation found within Balesin Island, Polillo, Quezon

Forest

The middle part of Balesin Island is mostly forest. The northernmost and southernmost portion of the island is a closed-canopy forest and the central portion is open-canopy forest. The northern forest and southern forest are separated by plantations, infrastructure facilities, and the airstrip.

Forests in the north are dominated by large trees of the family Moraceae such as *Ficus* sp., *Osmoxylon* sp., *Polyscias nodosa, Sterculia* sp., and other dipterocarps. The southern forest is composed of trees with smaller diameter at breast height (DBH) (<100cm) such as members of family Arecaceae (*Pinanga maculata* and *Areca* sp.). Aside from dipterocarps and Zingiberaceae, species of *Philodendron lacerum*, other vines, and woody lianas were also numerous in both forest areas.

Mixed vegetation

Mixed vegetation areas are cultivated and shrubland areas overlapping with the forest are planted with ornamental plants that serve as ecotones for other habitat types. The largest mixed vegetation is a close and open canopy forest dominated by small dipterocarps, some coconuts, and other ornamental trees toward the northern section of the island.

Plantation

Cultivated areas, primarily planted with bananas and coconuts, are the second largest habitat type in the island. Several bubble gardens grow fresh leafy vegetables, herbs and strawberries. The largest fruit tree farm is found on the south of the airstrip.

Beach forest

Beach forests are characterized by small plants growing on coralline rocks. It is generally dominated by flowering plants such as *Scaevola frutescens* and *Ipomoea pes-caprae* that are restricted to the eastern portion of the island. Small individuals of *Barringtonia* sp. are found at the southern beach forests. The rocky outcrops near Mykonos Village harbor a rare coastal plant, *Podocarpus costales*. The island offshore of the Phuket Village area is also a beach forest.

Grassland

Extending from the northwestern section up to the areas surrounding the airstrips are the island's grassland habitats dominated by *Saccharum spontaneum that* grows over sandy soil.

Mangrove and freshwater marsh

The inland mangrove swamp that is restricted to the north has two types of vegetation. On the northeastern edge are individuals of *Avicennia* sp. while the southwestern portion is covered by herbaceous plants and epiphytes such as orchids and *Hoya* sp.

Several freshwater marshes with muddy substrate support herbaceous plants, small coconuts, and other small, thin-branched trees beside the freshwater reservoirs developed in the island.

Special habitat types

Special habitat types are dominated by single plant species. Some of the small portions of the island are covered with *Pandanus* stand, pine stand, fern patch, and the rock outcrops. Although the species cover only a very small portion of the island, it provides unique microhabitats.

The *Pandanus* stands, present at both the northeastern and southeastern tip of the island, form a thicket which separates the beach forest from those of the inner forest. The small fern patch composed of *Nephrolepis* sp. is observed within the forest in the northern portion of the island. The pine trees (*Casuarina equisetifolia*) are in the southern tip of the island.

Species accounts

A total of 16 species (2 amphibians and 14 reptiles) were found in Balesin Island and the islet near Phuket Village.

Amphibians: Rhacophoridae

Polypedates leucomystax was detected through the calls of the male. The largest number of individuals observed or heard was in the freshwater ponds in Balesin Club House, Balesin Village, and the forest beside Mykonos Village. A single individual was observed in one of the banana plantations (Fig. 5).

Amphibians: Bufonidae

Rhinella marina is a noted invasive species which was observed in the freshwater fish ponds of Balesin Club House and Balesin Village. Only few individuals were observed beyond these areas. Single individuals were encountered in the grassland surrounding the airstrip, the Balesin Royal Village, and one of the banana plantations (Fig. 6).

Reptiles: Agamidae

Draco spilopterus was observed in the forest at the northern portion of the island during the early morning hours (Fig. 7).

Reptiles: Gekkonidae

Cyrtodactylus philippinicus was observed mainly on the forested and plantation areas seen scampering along the trails and road at the central and northern areas in the island (Fig. 8).

Hemidactylus platyurus was commonly found in villages and human habitation. Calls were also heard at several locations in the forested areas (Fig. 9).

Hemidactylus frenatus was commonly found with *H. platyurus* in villages and human habitations (Fig. 10).

Figure 5 Common tree frog *(Polypedates leucomystax)* found in the banana plantation

Figure 6 Giant South American toad *(Rhinella marina)* found in one of the freshwater ponds near Balesin Clubhouse

Figure 7 Philippine flying lizard *(Draco spilopterus)* captured from the forested area in the north of the island

Figure 8 One of the captured Philippine bent-toed gecko *(Cyrtodactylus philippinicus)*

Reptiles: Scincidae

Brachymeles boulengeri is an endemic, burrowing skink, caught in the forested area surrounding Station 2 of nature trail. It was caught with a pitfall trap (Fig. 11).

Lamprolepis smaragdina philippina was observed inhabiting the forested area of the island. One individual was observed sleeping inside a coiled leaf during a night survey while the other one was seen feeding on an insect (Figure 12).

The highest number of *E. multicarinata* was observed at the northern forested areas. The location was a mixture of both open and close canopy with one side leading to an unpaved road to the island's garbage dump. Few individuals were seen in the forested areas in the central and southern portion of the island (Fig. 13).

Eutropis multifasciata (common eutropis) was seen in the islet near Phuket Village. Individuals in the forested areas were also reported by the other members of the team.

Emoia cf. *atracostata* was only observed in the islet near Phuket Village and not in the beach forest areas in the main island (Fig. 14).

Pinoyscincus abdictus aquilonius is the most common skink in the island. Numerous small to medium-sized individuals were seen scampering throughout the island, especially in the forested areas. Five of the 7 individuals caught by the pitfall traps belong to this species.

Reptiles: Varanidae

Medium-sized individuals were seen in St. Tropez Village behind the archery range. Tour guides reported additional individuals at one of the banana plantations, built-up areas, garbage dump, and forested areas in the north (Fig. 16).

Reptiles: Colubridae

Ahaetulla prasina (elongate-headed tree snake) was observed in the balete tree near Station 2 of nature trail. No other individuals were seen from other portions of the island.

Chrysopelea paradisi (paradise tree snake). A dead *C. paradisi* specimen was observed in one of the major roads leading to the northern portion of the island.

Figure 9 Flat-bodied house gecko *(Hemidactylus platyurus)* found in St. Tropez Village, Balesin Island

Figure 10 Common house gecko *(Hemidactylus frenatus)* living among the garden rocks of Balesin Clubhouse

Figure 11 Boulenger's short-legged skink *(Brachymeles boulengeri)* captured from one of the forested areas

Figure 12 Green tree skink *(Lamprolepis smaragdina philippina)* captured from one of the banana plantations

Figure 13 Two-stripped eutropis *(Eutropis multicarinata)* seen climbing one of the trees in the island

Figure 14 Grey swamp skink *(Emoia* cf. *atracostata)* seen in the islet off Phuket Village in Balesin Island

Figure 15 One of the captured *P.a. aquilonius* from one of the banana plantations

Figure 16 Enteng's monitor lizard *(Varanus dalubhasa)* seen behind the Archery Range

Figure 17 Black-lipped sea krait *(Laticauda laticauda)* seen sleeping in the islet

This species is relatively common and was previously caught on the island by Achondo and Afuang (2011).

Reptiles: Elapidae (Laticaudinae)

Laticauda laticauda was seen in one of the ledges of the islet near Phuket Village. No other individuals were observed in other areas of Balesin Island (Fig. 17).

For the small size of Balesin Island, the ecotonal continuity of vegetation and relationship of the island's habitats allow species to move from one habitat type to another (Table 1). The observed distribution of the species such as *P.a. aquilonius, H. platyurus, V. dalubhasa, L. smaragdina,* and *C. philippinicus* showed distinct distribution in several habitat types. Balesin Island's herpetofauna are concentrated on 3 locations: (1) forest areas, cultivated areas, villages and facilities in the north and center of the island, (2) forest and cultivated areas around Costa del Sol Village, and (3) just before Phuket Village and the islet off Phuket Village. Herpetofaunal diversity decreases toward the northern and southern tips of the island (Fig. 18).

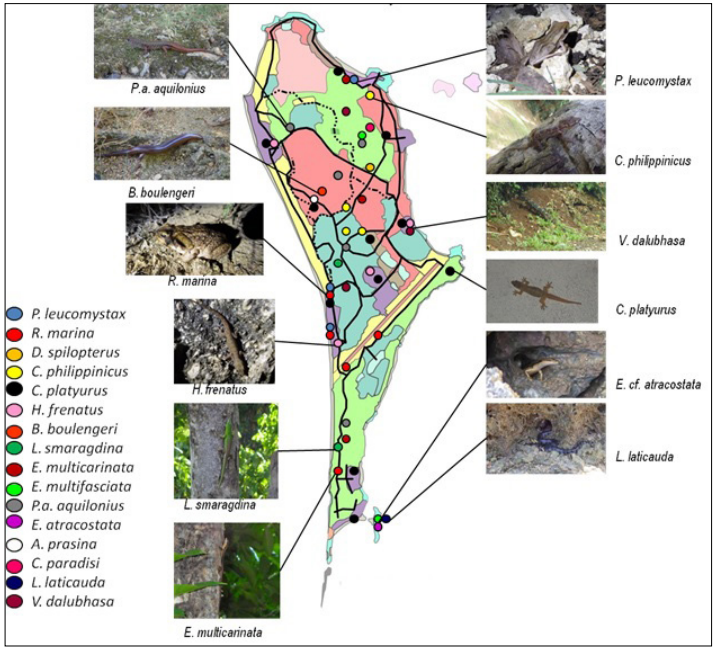

Figure 18 Pitfall station sites and other sampling points distributed in the different habitats within Balesin Island, Polillo, Quezon. Roads and nature trail were also utilized for opportunistic sampling

Table 1 List of amphibian and reptile species found in Balesin Island

Species	Habitats[a]							No. of ind.	Abundance (p_i)	Mode of detection
	BF	F	G	P	MV	MFM	H			
Amphibians										
P. leucomystax	-	-	-	x	x	-	x	10	0.08	AES/ VES
R. marina	-	-	x	x	x	-	x	9	0.07	AES/ VES
Reptiles										
A. prasina	-	x	-	-	-	-	-	1	0.008	VES
B. boulengeri	-	x	-	-	-	-	-	1	0.008	Trap
C. paradisi	-	x	-	-	-	-	-	1	0.008	Remains
C. philippinicus	-	x	-	x	x	-	-	6	0.048	VES
D. spilopterus	-	x	-	-	-	-	-	2	0.016	VES
E. atracostata	x	x	-	-	-	-	-	2	0.016	VES
E. multicarinata	-	x	-	x	x	-	-	10	0.08	VES/ Trap
E. multifasciata	x	x	-	-	-	-	-	1	0.008	VES
H. platyurus	-	x	x	-	-	-	x	14	0.112	AES/ VES
H. frenatus	-	-	-	-	-	-	x	5	0.04	VES
L. smaragdina	x	x	-	-	-	-	-	2	0.016	VES
L. laticauda	x		-	-	-	-	-	1	0.008	VES
M. reticulatus	-	x	-	-	-	x	-	-	-	Reported by locals
P.a. aquilonius	-	x	-	x	x	-	-	58	0.46	VES/ Trap
V. dalubhasa	-	x	-	-	x	x	x	2	0.016	VES

[a]BF – Beach forest, F – Forest, G – Grassland, P – Plantations, MV – Mixed Vegetation, MFM – Mangroves and freshwater marsh, H – Human habitation
pi = number of individual per species/total number of individuals
VES – Visual encounter survey, AES – Acoustic encounter survey

The pattern of distribution is due to the availability of more resources and niches in the center of the island. Thirteen species were found to be forest-associated. The grassland areas, freshwater reservoir, and beach forest harbor few species. It is interesting to note that the small islet offshore of Phuket Village harbors 3 species, which is comparatively higher compared to the number of species encountered in the grassland areas.

Skinks are the most abundant with 6 recorded species. The highest number of individuals was recorded for *P.a. aquilonius*. Gekkonids are the second most diverse group within the island. Two of the 3 recorded species were found to be associated with human habitation and facilities. Snakes were seldom encountered on the island and Varanids were seen but not captured.

The highest Shannon Diversity Index (H') was recorded for human habitation (H' = 1.48) (Fig. 19). Diversity Index for the forest was only 1.10 despite having the most number of species. Seventy-one percent (71%) of the individuals recorded in the forest belong to one species only (*P.a. aquilonius*). Jaccard Index was j = 41.18%. The large index value signifies that the species composition of the disturbed habitats (human habitation, plantation, and mixed vegetation areas) is not markedly different from that found in the undisturbed habitats (forest, beach forest and grassland). Six species were shared by both disturbed and undisturbed areas. This includes species such as *C. philippinicus, E. multicarinata, E. multifasciata, P.a. aquilonius, V. dalubhasa,* and the invasive *R. marina*.

The initial rapid site survey conducted by Achondo and Afuang in 2011 documented 7 reptiles and no amphibian species on the island (Table 2). Due to the longer duration of the present study (4 days vs. 2 days) and the use of multiple sampling methods, the known herpetofaunal diversity on the island were doubled including the first island record of *P. leucomystax* (native) and *R. marina* (introduced). It is interesting to note that during the 2011 and 2015 survey, the presence of *M. reticulatus* was only based on interviews with the locals.

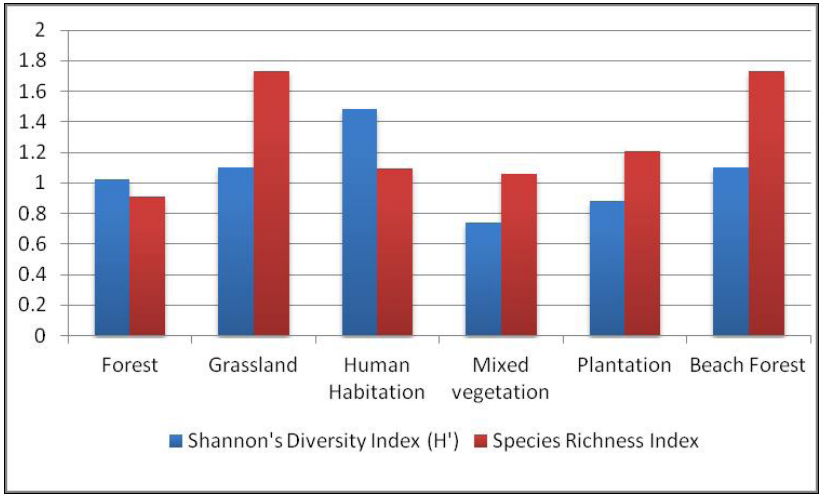

Figure 19 Shannon's Diversity Index (H') and Species Richness Index for the major habitat types found within Balesin Island, Polillo, Quezon

Table 2 Comparison of herpetofaunal diversity with other Polillo Islands

Species	Islands			
	Balesin Island (2015)	Balesin Island (2011)[a]	Polillo Island[b,c,d]	Patnanungan[e]
Amphibians				
Polypedates leucomystax	x	-	x	x
Rhinella marina	x	-	x	x
Reptiles				
Ahaetulla prasina	x	-	x	x
Brachymeles boulengeri	x	-	x	x
Chrysopelea paradisi	x	-	x	-
Cyrtodactylus philippinicus	x	x	x	-
Draco spilopterus	x	x	x	x
Emoia atracostata	x	-	-	x
Eutropis multicarinata	x	x	x	x
Eutropis multifasciata	x	x	x	-
Hemidactylus platyurus	x	-	x	x
Hemidactylus frenatus	x	-	x	x
Lamprolepis smaragdina	x	x	x	x
Laticauda laticauda	x	-	-	-
Malayopython reticulatus	x	x	x	x
Pinoyscincus abdictus aquilonius	x	x	x	x
Varanus dalubhasa	x	x	x	x

[a]Achondo and Afuang (2011). A rapid survey on the ecosystem and terrestrial vertebrate fauna of Balesin Island, Polillo, Quezon.
[b]Hampson (2003). Amphibian distribution and abundance in the Polillo Islands.
[c] Gonzalez (2007a). Pioneering community-based conservation sites in the Polillo Islands, Philippines: Technical report on the biodiversity survey of priority sites in the Municipality of Burdeos.
[d]Ledesma MM (2003). Lizard diversity patterns along disturbance gradients in Polillo Island: Implications for effective conservation.
[e]Gonzalez (2007b). Pioneering Community-based conservation sites in the Polillo Islands, Philippines: Technical report on the biodiversity survey of priority sites in the Municipality of Patnanungan (Patnanungan LCA).

The 2 amphibians and 12 of the 14 reptiles documented are also present on the other islands of Polillo. It is noteworthy that *L. laticauda* has not been previously reported in the existing literature on the herpetofauna of Polillo group of islands since most surveys were focused on terrestrial habitats.

The similarity in the herpetofauna of Polillo and Balesin despite being separated by at least 20 km of sea means that individuals from the nearby islands are able to get to Balesin Island through rafting or through human activities.

Conservation of Balesin Island's herpetofauna

The island's management had initiated methods of protecting the island's biodiversity. Conservation measures which had been implemented includes removal of rat, dog and cat populations which prevented the locals from hunting *V. dalubhasa* and *M. reticulatus*.

It was reported that the initial method for eliminating the rats involved poisoned baits which had an adverse effect on wildlife that feeds on rats (J. Castro, pers.comm; unreferenced). It was observed that there was a decrease in the number of snakes seen on the island after the implementation of this technique. Due to this observation, the use of poisoned baits were discontinued and snake populations are expected to recover.

The impact of human activities is very evident especially in small islands like Balesin. Perhaps the greatest threat to the island's herpetofauna is due to accidental killings (e.g., being hit by vehicles). The remains of at least 5 species were associated with roadkills (C. paradisi, V. dalubhasa, C. philippinicus, R. marina and an unidentified snake). Reports of M. reticulatus being ran over by passing vehicles on the road were also recorded. It is recommended that areas frequently traversed by animals will be mapped to regulate the speed of vehicles in the area.

V. dalubhasa is also being accustomed to human presence. It is not generally dangerous to the animals since the management prevent hunting and consumption of this species. There are reports of individuals which had become "tamed". Some individuals had also become dependent on human waste as primary food source (*pers. obs.*).

An emerging threat in the island is the presence of *R. marina*. For such a small island, this invasive species is an explosive breeder with no known predators on the island. It has the ability to colonize most areas if not eradicated. Suitable eradication methods will involve hand-picking of frogs and temporarily drying of freshwater pools where tadpoles are located.

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Introduced frogs in buffer zone and adjacent areas of Mt. Banahaw de Lucban, Quezon Province, Luzon Island, Philippines

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*Mt. Banahaw de Lucban, a part of the Mt. Banahaw San Cristobal Protected Landscape, is home to diverse endemic frogs including **Platymantis banahao**, **P. montanus**, **P. naomii**, **P. luzonensis**, **P. pseudodorsalis**, and **P. indeprensa**. This study was conducted to determine the occurrence of the 5 introduced frog species in the Philippines, namely: **Rhinela marina** (Linnaeus), **Lithobates catesbeianus** (**Rana catesbeiana**) (Shaw), **Hoplobatrachus rugulosus** (Wiegmann), **Hylarana erythraea** (Schlegel), and **Kaloula pulchra** Gray. Using quadrat methods and direct count of introduced frog populations in 5 barangays located at the foot of Mt. Banahaw de Lucban, a total of 373 frogs belonging to 4 species were counted. **Rhinella marina** has the highest occurrence (210 individuals) followed by **K. pulchra** (118), **H. rugulosus** (23), and **H. erythraea** (22). **Lithobates catesbeianus** was not observed during the survey. Interviews conducted with farmers and locals highlighted the sudden increase of **K. pulchra** population in the recent years. The species occurring nearest to the protected area was **Hylarana erythraea.***

THE INTRODUCTION AND SPREAD OF NON-INDIGENOUS SPECIES HAVE significant negative impacts on biodiversity (McGeoch et al. 2016). Invasive alien species (IAS) have been identified as a cause of major population decline and extinction of native species in various ecosystems worldwide (Zug GR and Zug PB 1979; Drake et al. 1989; Lodge 1993).

Biological invasion is now widely considered as a form of global change (Vitousek et al. 1996). Factors such as increased trade volumes and increasingly

Keywords: Invasive alien species, frogs, Mt. Banahaw, buffer zone

complex trade routes contribute to its widespread. Interactions from other forms of global change such as climate change interact to increase the likelihood of the invasive species' establishment and spread (McGeoch et al. 2016). In addition to severe economic consequences (Pimentel et al. 2001), the introduction of species into a new environment can have devastating ecological impacts (Mack et al. 2000; Parker et al. 1999).

Despite the global risk to the environment and economies that these species pose, there is no established systematic evaluation and monitoring process in place. Monitoring species movements and geographical range must be given importance to understand and track the consequences of biological invasion (McGeoch et al. 2016).

Understanding the nature of such interactions is also critical for establishing conservation priorities. Given the limited resources, conservation efforts need to focus on species and areas where the invader's impact is most severe.

Invasive species have been repeatedly identified as one of the major causes of amphibian declines worldwide (Stuart et al. 2004). Some invasive frog species not only compete with local and endemic species but also prey on them (Diesmos et al. 2008).

Mt. Banahaw de Lucban, a part of the Mt. Banahaw–San Cristobal Protected Landscape, is considered as one of the remaining forested areas in Southern Luzon (Gascon 2002). It was declared as a protected landscape under Republic Act 9847 signed on December 11, 2009 by then President Gloria Macapagal Arroyo. Extremities in elevation within the protected landscape have allowed the formation of a wide range of habitats from the steep ridges down to the flat plains of the lowlands. This explains why its Mt.ain ranges support a high diversity and endemicity of floral and faunal species.

In Mt. Banahaw de Lucban alone, *Platymantis banahao* and other endemic *Platymantis* frog species in the Philippines and Luzon (e.g. *P. montanus*, *P. naomii, P. luzonensis, P. pseudodorsalis, P. mimulus*, and *P. indeprensa)* can be found (Diesmos 1998; Atienza et al. 2015). These endemic species may be affected by their invasive species counterparts that are known to occur in the area.

The Philippine amphibian fauna includes 5 introduced frogs, namely: Marine toad (*Rhinella marina* Linnaeus), Asian bullfrog (*Hoplobatrachus rugolosus* Osbeck), American bullfrog (*Lithobates catesbeianus* (=*Rana catesbeiana*) Shaw, green paddy frog (*Hylarana erythraea* Schlegel), and Asiatic painted frog (*Kaloula pulchra* Gray) (Alcala and Brown 1998; Brown et al. 2002).

A native of Central and South America, *R. marina* was first introduced to the Philippines in the 1930s as a biological pest control agent (Merino 1936). It occurs in most of the major islands throughout the Philippines except in Palawan. Studies on introduced populations of *R. marina* from other parts of the world showed that the species has had adverse ecological impacts on native frog species (Zug GR and Zug PB 1979).

In the 1960s, *L. catesbeianus* was introduced to the Philippines for commercial farming. A native of North and Central America, introduced populations of *L. catesbeianus* are now established in France, Italy, Spain, the Netherlands, Hawaii, India, Korea, Taiwan, Japan, Thailand, and Indonesia (Frost 2007). The bullfrog has been implicated in losses of native frogs in the United States (Kiesecker and Blaustein 1998). Further, it is a known carrier of chytridiomycosis—an emerging fungal disease responsible for mass mortalities in frogs and major declines of amphibian populations worldwide (Hanselmann et al. 2004; Stuart et al. 2004; Garner et al. 2006).

Hoplobatrachus rugulosus naturally occurs in the western regions of mainland Asia, Taiwan, and Indochina. It was introduced in Borneo in the 1960s (Inger and Stuebing 1997; Frost 2007). The species is now thought to be widespread in the Philippines (Alcala and Brown 1998; Brown et al. 2001).

Hylarana erythraea (Schlegel) is highly adaptable to its environment and is a resilient species with stable population. *Kaloula pulchra* is a recent introduction among the 5 invasive species (Joshi 2006).

Thus, this study aims to determine the presence of introduced frogs in the buffer zone and adjacent areas of Mt. Banahaw de Lucban.

Methodology

Study site

The Municipality of Lucban, Quezon Province (Fig. 1) is located at the southeast part of Luzon Island. Lucban has a total area of 130.46 km^2, with a total of 32 barangays within its jurisdiction. It lies at 14°6′48″N latitude and 121°33′25″E longitude. Mt. Banahaw de Lucban is situated in Lucban, Quezon province and is classified as a mossy type of forest with a little commercial value but is significantly important as a protection forest. This type of forest is characterized by a low relative temperature and high uniform humidity. It is foggy throughout the year with short strong winds, and rains are generally amply distributed (Gascon 2002). The area consists of different habitat types, including secondary growth forest, mixed grassland

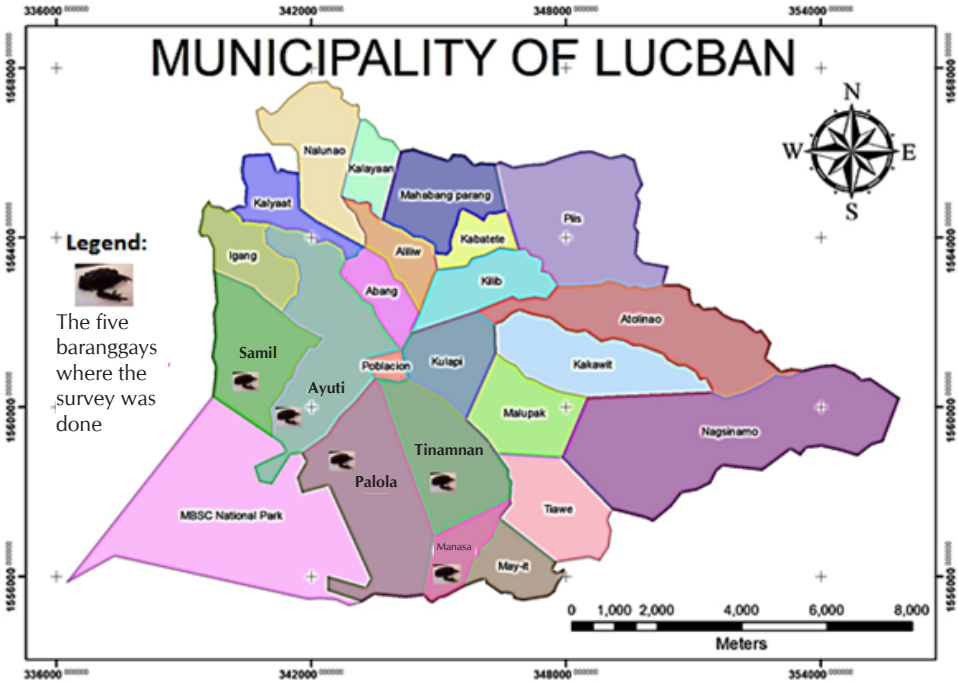

Figure 1 Map of Lucban, Quezon indicating the 5 barangays that served as the sites for the study

and agroforest areas, secondary lowland evergreen forest, and montane and mossy forest.

Five barangays, namely, Samil, Ayuti, Palola, Manasa, and Tinamnan, which lie adjacent to the protected area, were chosen as study sites. These barangays are classified as lowland agroforest. The community engages in agriculture and trade to sustain their livelihood. Agriculture, particularly rice, coconut, and crop production, is the most common source of income in the area.

The study was conducted from September to November 2015. Quadrats measuring 20 m x 50 m were established depending on the availability or occurrence of the species in each barangay. All accessible microhabitats confined within the strip transect were hidden and searched by raking the forest floor litter and humus, probing epiphytes and tree hollows, upturning rocks and logs, and splitting open decayed logs. Each quadrat was sampled once during the day and once at night. Diurnal sampling was undertaken between 0800 and 1100 hours while nocturnal search, with the aid of headlamps or torches, was done between 1800 and 2200 hours.

Sampling of the invasive frogs was done by performing visual and aural searches to record the following parameters:

- Species identification
- Species abundance (number of individuals per species)

Frogs were captured by using sweep nets or by hand. Captured animals were identified by species level. Weighed species were measured in terms of snout-vent length and total length (TL).

Results and discussion

A total of 373 individual introduced frogs belonging to 4 species were observed (Table 1).

Table 1 Counts of invasive alien frog species in 5 barangays of Mt. Banahaw de Lucban

Species	Samil	Ayuti	Palola	Manasa	Tinamnan	Total
Rhinella marina	37	28	27	50	68	210
Lithobates catesbeianus	0	0	0	0	0	0
Hoplobatrachus rugulosus	4	6	2	5	6	23
Hylarana erythraea	3	4	3	5	5	22
Kaloula pulchra	10	9	11	18	70	118
Total	54	47	43	78	149	373

Rhinella marina had the highest number of individuals observed followed by *Kaloula pulchra*. From this result, we can infer that these 4 invasive species occur near the protected area and have the potential to harm the native and endemic wildlife in the area. Only *Lithobates catesbeianus* was not encountered in the area.

The snout-vent length (SVL) was found to be within the known range for each species. It was however notable that both *R. marina* and *K. pulchra* were larger in Barangay Tinamnan than the other barangays. This can be attributed to better access to food and suitability to its habitat. The SVL range of the species considered in each study site is presented in Table 2.

Table 2 Snout-vent length of invasive alien frogs from the Municipality of Lucban

	Snout-vent length (mm)				
Species	**Samil**	**Ayuti**	**Palola**	**Manasa**	**Tinamnan**
Rhinella marina	90-155	101-190	111-180	105-180	150-179
Lithobates catesbeianus	0	0	0	0	0
Hoplobatrachus rugulosus	110-115	90-103	89-99	101-119	100-106
Hylarana erythraea	40-68	35-56	35-70	50-58	32-65
Kaloula pulchra	50-70	48-63	70-73	40-70	44-77

Local knowledge

Rhinella marina. This species is locally known as palakang sirit, Nazareth, and palakang lason. Interviews with locals revealed that they are familiar with this conspicuous frog since it is often encountered in disturbed and residential areas, but not in the forest of Mt. Banahaw de Lucban. Locals do not consume this frog and have no idea of its role in the environment. A common misconception about this species is that it can give a person warts if contact is made with its skin. Locals consider the noise of the frogs at night when it rains or when trying to find a mate as a nuisance.

Lithobates catesbeianus (Rana catesbeiana). Although not encountered in the study, some of the locals are familiar with this frog and believed that they saw it in other barangays, farther from Mt. Banahaw de Lucban. Some of them also confused this species with *Hoplobatrachus rugulosus* or *Rhinella marina* because of their similar appearances from afar.

Hoplobatrachus rugulosus. Locally called palakang bukid, palakang palayan, and palakang tubigan, this frog is common in fields and open areas and also tends to overlap with *Rhinella marina* habitat range. This frog species is edible. Some locals admitted that they consume its meat. Most of the locals did not know that this species is harmful to local fauna, which can become its prey. They have observed that this frog eats anything (e.g., crabs and snails) that its mouth can swallow.

Hylarana erythraea. Locally known as palakang saging or tree frog, this frog species is found in farms and plantations. Among the 5 invasive frog species, this is found nearest to the secondary lowland forest of Mt. Banahaw de Lucban and has the

potential to invade and interact with the endemic and local frog species in the area. Some locals claim that they have seen these frogs on the forest edge. If true, then this frog might have already adapted to the area and may bring harm to the ecosystem. Although the survey yielded a small number of individuals for this species, farmers have confirmed that this species is found in the area, even though it is not as visible or commonly seen as *Rhinella marina*. This frog was also found in homes, particularly in comfort rooms and other parts of the houses.

Kaloula pulchra. Interviews with local farmers in Barangay Tinamnan have confirmed that the population of this species has been rising since 2010. In one subdivision in particular, this species is found almost everywhere during rainy season and it has displaced *Rhinella marina* in that area. Locals find this frog as a nuisance because of its loud and irritating mating call. Despite its small size and rounded shape, locals reported that species like *Hylarana erythraea* can be found on the second and third floor of their houses. However, the locals perceived no threat from this species.

Conclusion

Four out of 5 introduced frog species known to occur in the Philippines were encountered in the 5 barangays which are situated near Mt. Banahaw de Lucban. Although this study cannot infer the impact of these species on the biodiversity and ecosystem of Mt. Banahaw de Lucban, these frogs may pose a threat, especially *Hylarana erythraea* which, according to anecdotal information, are already found in the forest edges of Mt. Banahaw de Lucban and may have already done harm in the ecosystem of Mt. Banahaw de Lucban.

In general, most of the locals and elders interviewed were familiar with the 5 introduced frog species, but they are not familiar with their role and the harm that they may cause to the community and ecosystem as a whole. Further studies must be conducted to determine the interactions, diet, and possible harmful effects of these introduced frogs to native species and ecosystems.

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Foraging behavior association between Irrawaddy dolphins (*Orcaella brevirostris*) and tidal net fisheries in the coastal waters of Pulupandan, Negros Occidental, Philippines

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The coastal waters of Pulupandan, Negros Occidental has been known to be a core feeding area for a small population of endangered Irrawaddy dolphins, which have been observed foraging within close proximity to permanent tidal nets used by locals. Foraging behavior and interactions with tidal nets were observed during a series of boat-based surveys from April to September 2015. Foraging behavior was classified based on proximity to the tidal nets: net (0 < 50 m) and open water (> 50 m) foraging. Specific preference for any of the tidal nets was measured using Coefficient for Area Use. Catch per Unit Effort (CPUE) was obtained to determine the productivity of each tidal net. The total time spent foraging in open water did not prove to be significantly different from the time spent foraging in tidal nets (α = 0.05), suggesting minimal differences between these areas. There was no significant difference in the CPUE in all 6 tidal nets. However, dolphins appeared to prefer one specific tidal net, having significantly (α = 0.05) spent more time engaging in net foraging than in other nets. Pearson Correlation Coefficient showed significant relationship between net foraging and CPUE.

Keywords: Irrawady dolphins, foraging behavior, tidal net fisheries, Negros Occidental

FOR THE PAST YEARS, CONSERVATION OF CETACEANS HAS BECOME AN increasingly important priority, especially in the developing countries of the tropics and the subtropics (Adams et al. 2004). The principal challenge, however, lies in balancing the resource needs of local human communities with the survival requirements of other organisms (Sanderson and Redford 2003) that call for conservation. The long standing dispute on the ecological interactions between marine mammals and fisheries has always been rooted and associated with the traditional belief that their presence negatively affects prey populations that are of commercial interest to humans (Bowen 1997) and that fisheries may have impacts on these species as well (Smith and Jefferson 2002). In areas where humans and other organisms overlap and share resources such as freshwater and near-shore coastal areas, the interactions and perceptions towards wildlife are influenced by various factors. Hence, identifying and understanding these factors could prove useful for wildlife conservation (D'Lima et al. 2013).

Among all the cetaceans in the Philippines, the Irrawaddy dolphin (*Orcaella brevirostris)* is considered as one of the least known and the most critically endangered cetacean species. Although they may have been identified and listed as "Vulnerable" on the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species, most sub-populations of *O. brevirostris* are considered to be critically endangered (CR) and are declining (Reeves et al. 2008; IUCN 2013). The first sighting of Irrawaddy dolphins in the Philippines was documented during an investigation of dugongs (*Dugong dugon)* in 1986 (Kataoka et al. 1995) in Palawan. However, the first geographically isolated population of Irrawaddy dolphins discovered in Malampaya Sound in Palawan was reported to be in immediate danger of extirpation due to its small population size, limited range, and high mortality rate (Dolar et al. 2002; Smith et al. 2004).

In 2007, another sub-population of Irrawaddy dolphins in the Philippines was reported in the Visayas region and was initially perceived to be limited to Iloilo Strait on the coastal waters of southern Panay and northeastern Guimaras (Dolar et al. 2009). Further investigations by Dolar et al. in 2010 and 2011 showed that the dolphin's range had extended and seemed to mainly occur in the waters of Buenavista in Guimaras, and Bago City and Pulupandan in Negros Occidental (IUCN 2013). The dolphins were found in shallow coastal waters, making them susceptible to human-induced threats because of their proximity to human communities.

Throughout the years, studies on Irrawaddy dolphins were focused mainly on estimating population size for conservation efforts (Reeves et al. 2008) and only a few detailed studies gave emphasis on their behavior (Ponnampalam et al. 2013), leaving much to be explored. Knowing and understanding both their population and behavior are equally important in providing rational measures for conservation. For

many species, the behavior that individuals exhibit within different habitats clearly indicates the ecological function that those areas provide (Hastie et al. 2004) and the time allocation on a particular behavior is significant in understanding its relationship with the environment (Steiner 2012). According to Sinervo's Theory of Optimum Foraging (1997), animals are most likely to be seen foraging for food when observed in the wild. Because an animal's survival and reproductive success rely on its behavior, a thorough understanding of a species' behavior and ecology is essential for planning out effective conservation and management programs as in the cases of establishing wildlife and nature reserves and reducing human-wildlife conflict (Shumway 1999). This also provides useful measures for evaluating the species' predation impact on prey populations and community structure, given that their presence may have major influence on the structure and function of some marine communities (Bowen 1997).

Previous studies on the sub-population of Irrawaddy dolphins in the coastal waters of Pulupandan and Bago City suggested that dolphins spend most of their time foraging, especially in areas with tidal nets (de la Paz 2012; Formilleza et al. 2014; Señoron et al. 2014). The tidal net fishery or tangab is one of the major livelihoods in Pulupandan, Negros Occidental. It is a multi-million industry focusing on krill (Euphausiacea) production, which are eventually processed through salting and fermentation, and are sold as "*guinamos*" or shrimp paste (Tajanlangit 2012). Hence, this study was undertaken to further understand the association between the foraging behavior of Irrawaddy dolphins and the tidal net fisheries in the coastal waters of Bago and Pulupandan, Negros Occidental, Philippines.

Materials and methods

Study site

The coastal waters of Bago and Pulupandan are located in the western side of the province of Negros Occidental in Western Visayas. This area faces west to the Guimaras Strait (Fig. 1). Preliminary surveys revealed that the Irrawaddy dolphins found in Guimaras Strait were often seen along shores of Bago-Pulupandan which is also an estuary that receives freshwater and mineral output from the Bago River (de la Paz 2012).

The Pulupandan coastal waters range from Barangay Patic (10° 29′03″N, 122°49′07″E) to Barangay Culo (10°32′57″N, 122°49′43"E). A total of 6 tidal nets (Fig. 2) situated at different locations within the area were observed to be operating. Hence, the study made use of these tidal nets to further understand the Irrawaddy dolphins' specific spatial preferences when foraging.

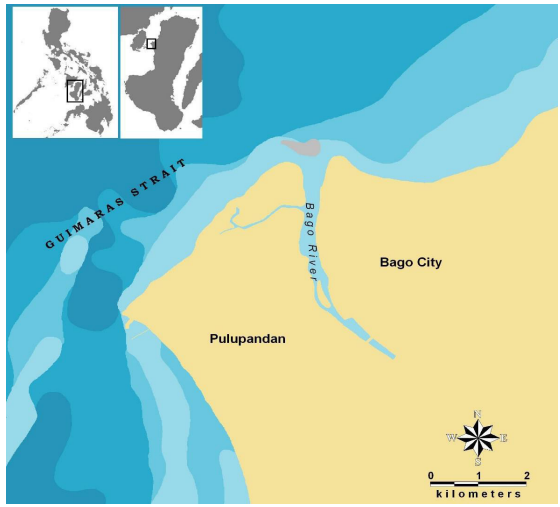

Figure 1 Map of the coastal waters of Bago and Pulupandan (Image from de la Paz 2012)

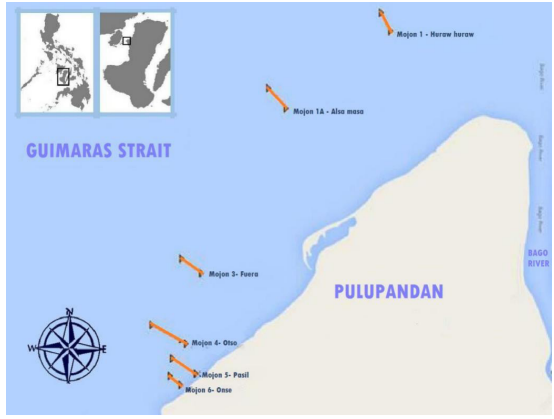

Figure 2 Map of the plotted tidal nets in the coastal waters of Pulupandan

Survey method

Boat-based surveys for 28 days from April to September 2015 were conducted in the coastal waters of Pulupandan, Negros Occidental. Surveys were only conducted on favorable sea conditions (Beaufort Sea State 0–3) with the use of a motor-powered fishing boat.

Surveys were launched from Paco Beach, Barangay Zone 1A at around 0630 H following a predetermined route parallel to the coastline. Search effort for dolphins commenced as soon as the boat was launched since the dolphins have been known to come close to the shore. Three observers were positioned on the right, middle, and left sides of the bow of the boat and took turns in searching for dolphins using binoculars and the naked eye.

Once a dolphin or a group of dolphins was spotted, search effort was stopped and the researchers' boat would slowly approach the dolphins within 40 m range. The reason for slowing down and keeping distance is to minimize disturbance to the dolphins. In addition, dolphin population in the area is small and researchers follow more or less the same individual dolphins hence, may represent almost the entirety of the population.

Sighting location and time was recorded using a Garmin Global Positioning System (GPS) unit. Dolphin behavior was recorded every 10 minutes and categorized either as foraging, resting, socializing or traveling (Table 1). Interaction with the dolphins ends when dolphins are already too far for the researcher to effectively observe the dolphins. When the researchers can no longer observe the dolphins, search effort recommenced.

Data processing

Foraging preference

Foraging behavior was further categorized as either open-water foraging or tidal net (barrier) foraging (D'Lima et al. 2013) (Table 2). Tidal net foraging was defined as foraging within 50 m from tidal net. A dolphin foraging beyond 50 m from the tidal nets was categorized under open-water foraging. Pulupandan had 6 tidal nets (tangabs) operating in the study area where the dolphins usually occurred. Dolphin's preference for foraging with any of these tidal nets was measured as:

$$\mathbf{P} = \frac{\mathbf{N}}{\mathbf{T}}$$

P is the dolphin's preference for a specific tidal net, N is the total time the dolphins were observed tidal net foraging within the 50 m proximity of a specific tidal net, and T is the time spent feeding in all the tidal nets.

Quantification of the dolphin's activity was done using the Activity Index (AI), which ranges from 0.0 to 1.0, and represents the time the animals were engaged in a particular activity (behavior) within an area, as a proportion of the observable total

Table 1 Ethogram of *Orcaella brevirostris* group behavior*

Group behavior	Description
Feeding/ Foraging	Frequent asynchronous dives in varying directions in one location; surfacing and respiration display no obvious pattern; dolphins often chase fish and occasional fish capture can be observed; prey is often tossed high out of the water and caught by the dolphins; flippering often observed supposedly to herd fish
Travelling	All dolphins move in one direction, surfacing and diving synchronously; chasing fish or even social behevior extremely uncommon; movement in a faster pace usually over a larger distance than while swimming when foraging; porpoising often observed; a displacement of 100 m from the initial location
Resting	Low level of activity, with the dolphins apparently floating stationary and motionless at the surface, with some occassional slow forward movement; regular surfacing and diving while staying in one location
Socializing and playing	Various vigorous activities including leaping out of water, high speed movement with frequent direction changes and prolonged body contact with other dolphins; occasional splashes in aggregations of dolphins

*adapted from de la Paz 2012

Table 2 Ethogram of the types of foraging performed by *Orcaella brevirostris**

Foraging behavior	Description
Net or barrier foraging	Barrier-foraging at tidal nets as a strategy performed within 50 m or less of fixed tidal nets, in which Irrawaddy dolphins distinctly used tidal nets to aid their foraging
Open-water foraging	Foraging strategy adopted by individual dolphins in open waters, more than 50 m away from tidal nets and which did not fall into any other foraging strategy
Group foraging	Cooperative foraging wherein a group of 6 to 11 dolphins less than one body length from each other coordinated to herd fish
Mud-plume foraging	Dolphins created plumes of mud in the water, which they use to catch fish

*adapted from D'Lima et al. 2013

time spent by dolphins engaging in any other activity during the day (Karczmarski et al. 2000). It is expressed as:

$$\text{Activity Index (AI)} = \frac{B}{S}$$

where:
B is the time dolphins are engaged in a particular activity behavior.
S is the time spent by dolphins engaging in all activities.

The Index of Activity and subsequently its mean AI was calculated separately for each of the 4 categories of behavior (Foraging/Feeding, Travelling, Resting/Milling and Socializing/Playing).

Catch per Unit Effort

Catch per Unit Effort (CPUE) was determined for each tidal net to measure its secondary productivity. A schematic diagram of the tidal net boca is shown in Fig. 3. The CPUE of each tidal net was computed using formulas by D'Lima et al. (2013) and Uychiaoco et al. (2010) on tidal net fisheries. Since tidal nets are of unequal sizes, the total catch in kilograms (kg) was divided with the number of units of gear ("boca") operating at that time and the soaking time to provide the monthly CPUE of each tidal net.

$$\text{CPUE} = \frac{\text{Total catch (in kilograms)}}{\text{Total \# of units of gears (bocas) x soaking time}}$$

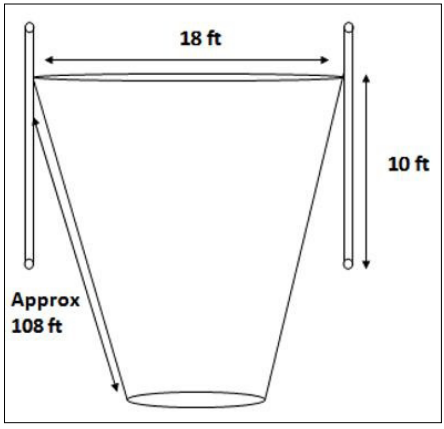

Figure 3 Schematic diagram of the tidal net boca and its dimensions

Figure 4 Krill harvest in Mojon 4 tidal net (Photo by Karl Espinosa)

The soaking time was established to be the same for all tidal nets because these were set and closed at the same time in relation to the movement and changing of the tide. As the tides rise and fall (vertical movement), the tidal current (which is the horizontal flow) also shifts. According to surveys carried out with the tidal net fishermen and owners, the soaking time is greatly dependent and is highly influenced by shifting of tides. Majority of the tidal net operators confirmed a maximum of 6 hours of soaking time. Beyond this would result in either the destruction of their tidal mesh nets or loss of catch as the water shifts its movement horizontally or both.

All the data were encoded on IBM SPSS for statistical analysis. Independent sample T-test was used to compare between open water foraging and barrier foraging. Irrawaddy dolphins' tidal net preference and the CPUE of each tidal net were compared using One-way Analysis of Variance (ANOVA) and a post hoc analysis through Duncan Multiple Range Test.

The Pearson's Correlation was used to determine the relationship that exists between the Irrawaddy dolphins' tidal net preference (tidal net foraging) and CPUE of each tidal net.

Results and discussion

Activity budget of Irrawaddy dolphins

Results of the behavioral observations revealed that Irrawaddy dolphins significantly spent extended hours on feeding/foraging compared to other activities at $\alpha = 0.05$ (Fig. 5). The generated p-value at 0.000 indicates that there is a significant difference among the dolphin activities. This shows that the time the dolphins spent

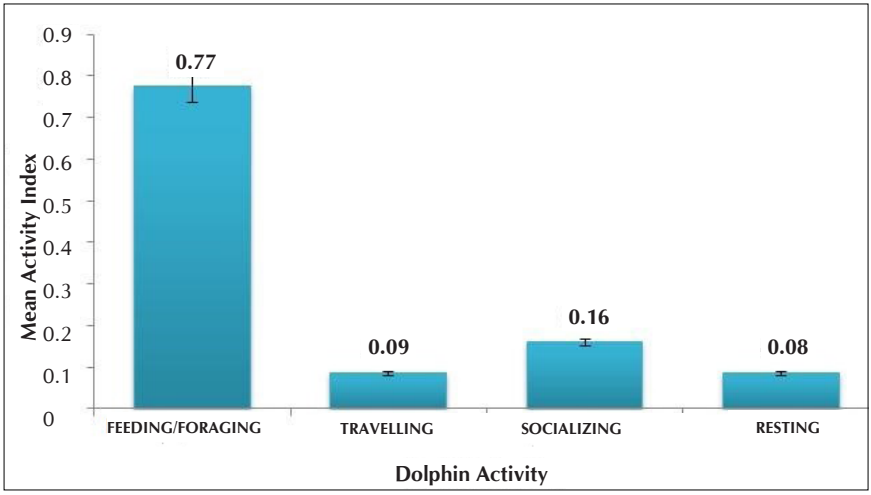

Figure 5 Mean activity indices of dolphin behavior

in a particular behavior is not the same for all behaviors and there exists at least one significant difference among the means of the different activities.

This is affirmed by Sinervo's Theory of Optimum Foraging (1997), where he stated that animals are mostly likely seen foraging for food when observed in the wild. For many species, the behavior that an individual exhibits within different habitats clearly indicates the ecological function that those areas provide (Hastie et al. 2004). With foraging having the highest mean activity index value of 0.77 (Fig. 5), it is indicative that the area is mainly utilized for foraging. Specific areas within the habitat serve as important feeding grounds for these dolphins. This corresponds with previous researches done by de la Paz (2012) and Señoron et al. (2014), where they mentioned that dolphins allocate majority of their time for foraging. In addition, Formilleza et al. (2014) aforementioned in their study that regardless of the varying tidal states and lunar phases, foraging was still dominant among other activities. Socializing, which was observed together with foraging, had the second highest mean activity index value of 0.16, followed by travelling and resting with mean activity indices of 0.09 and 0.08, respectively.

Foraging behavior of Irrawaddy dolphins

The Irrawaddy dolphins were observed exhibiting a wide range of behaviors associated with foraging, some of which are remarkably unique to this species. One of these behaviors which was observed several times was the spitting of jets of water from the surface, which could possibly be a foraging technique to herd or stun their

prey. The same behavior was also observed in freshwater populations (Jefferson et al. 2008; Menon 2009). Dolphins chase fish to the surface and then round them up by shooting jets of water from their mouth (Bright 2013). There were also instances when fish were observed flying out of the surface in a manner in which they appeared to have been thrown or spit out by the dolphins.

Another notable behavior observed is the occasional lifting of the flukes out of the water upon diving which could signal deep dives to the bottom (Fig. 6A) (Jefferson et al. 2008).

Figure 6 A. Sequence photographs of an Irrawaddy dolphin with its fluke up during a slow, terminal dive near tidal nets (Photo by C.J.M. Jarabelo); B. An Irrawaddy dolphin spy-hopping; C. An Irrawaddy dolphin flippering near the Philippine Bulk Corporation in Pulupandan (Photos by KP Casipe)

Irrawaddy dolphins were observed not to be particularly active and have relatively discreet surfacing behavior. They are not considered as acrobatic species compared to other cetacean species and were rarely observed to porpoise in the water and seldom exhibited leaps or low breaches. Spy-hopping, the vertical rise out of the water, was observed several times (Fig. 6B). Irrawaddy dolphins are often seen spitting streams of water while spy-hopping.

It was also observed that individuals tend to socialize with other members of the population during foraging. Flippering, a behavior usually associated with the herding of fish, was often seen among groups (Fig. 6C). Flippering was associated with asynchronous dives and obvious fish herding techniques. It was categorized as foraging or feeding. On the other hand, flippering associated with high dolphin-to-dolphin body contact and aggressive play behavior was considered as socializing (de la Paz 2012).

Comparison of net and open-water foraging of Irrawaddy dolphins

Although dolphins were observed spending more time feeding in open water (M = 11.5, SD = 7.7) than near tidal nets (M = 11.2, SD = 7.3), there was no significant difference between the two types of feeding at 0.05 level of significance (Fig. 7).

Open water feeding usually involved foraging near small fishing boats (Fig. 8) which make use of gill nets. However, when observed in areas near tidal nets, they were observed to spend longer time for foraging in these areas.

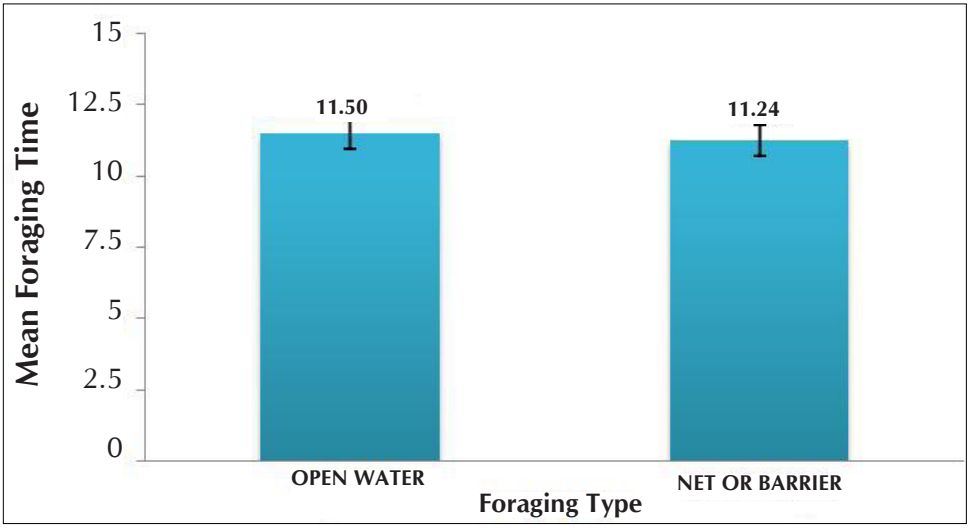

Figure 7 Mean foraging time for net and open-water foraging of Irrawaddy dolphins

Figure 8 An Irrawaddy dolphin diving near a small fishing boat in Pulupandan

In recent studies of Irrawaddy dolphins conducted by Señoron et al. (2014) and Formilleza et al. (2014), foraging near tidal nets was observed in multiple occasions. In fact, de la Paz (2012) mentioned that the Irrawaddy dolphin population could be attracted to common fishing grounds of fishermen. This particular attraction to fishing activities was observed in the Mekong River in Cambodia, where the largest concentration of Irrawaddy dolphin sightings occurred in areas with abundant clusters of gill nets, indicating a strong potential for fatal entanglements (Smith et al. 2014). Thus, it suggests that anthropogenic activities like fishing, whether beneficial or not, may have some ecological influence on Irrawaddy dolphins. Studies by Smith (1995) and Barone (1895) in Mediterranean Sea, reported that cetaceans consistently seek and consume prey from fishermen's nets, thus inducing economic distress due to their incursions towards fishing gears. This certain kind of interaction is considered to be non-cooperative and puts the cetaceans at high risk of net entanglement.

Cooperative interaction between fishers and dolphins have been reported in Chilika Lagoon, India where Irrawaddy dolphins spend approximately half of their foraging time close to stake nets (D'Lima et al. 2013). Here, the dolphins herded fish from shallow channels towards stake nets where they trap the fish before eating them. Apparently for the dolphins here, co-existence with human fisheries tended to increase their chances of succeeding in foraging. However, it was still not clear whether dolphins' barrier-foraging was due to the presence of stake nets, or due to high density of preferred species coincidentally targeted by fishers. This type of foraging may not be exclusive to the Irrawaddy dolphins in Chilika Lagoon, and could

be a form of adaptation to the presence of tidal nets (D'Lima et al. 2013). In fact, this kind of positive cooperative fishing is also prominent in Laguna, Brazil. In 1847, bottlenose dolphins (*Tursiops trucantus*) were also observed cooperating in fishing operations. When dolphins detect fish, they round them up and herded the fish to the nets cast by fishermen (Pryor 1990). Tun (2004) described that fishermen and Irrawaddy dolphins in Myanmar communicated through audio and visual signals. Fishermen send out audio signals by the use conical wooden pin, cast net, paddle, and making guttural sound by mouth whereas dolphins send signals by aerial display of body parts such as flukes during fishing. Dolphins herd the fish against sand banks and drive them toward small boats. Herding being performed by the Irrawaddy dolphins help fishermen catch more fish with less fishing effort. In a way, dolphins also benefit from this cooperative fishing because they can prey easily on fish that are stunned by the net throws.

In the coastal waters of Bago and Pulupandan, some fishers believed that Irrawaddy dolphins aid them in their fishing activities, while others believed that the dolphins disturb their fishing activities. Those who perceived positive benefits cited that the presence of the dolphins serves as an indicator of the presence of fish and shrimps. They also observed dolphins herding fishes towards tidal nets. On the other hand, those who perceived negative benefits affirmed that the dolphins compete with the fish catch and believed that this species destruct tidal nets, thus drive fishes away from fishing area (de la Paz 2012).

Insignificant difference between open-water and tidal net foraging, however, may indicate that the dolphins' feeding behavior may not necessarily be affected by the presence of the tidal nets alone, but rather on several other factors such as the preference for different types of prey, water movement, and bathymetry.

Foraging preference of Irrawaddy dolphins between tidal nets

The 6 tidal nets investigated varied in length, number of unit gears (locally known as *bocas*), and location. Fishers and tidal net operators identified each tidal net as (1) Mojon 6, located at the bridge of Asian Alcohol; (2) Mojon 5, located near Asian Alcohol; (3) Mojon 4, also located near Asian Alcohol; (4) Mojon 3; (5) Mojon 1A; and (6) Mojon 1, located in close proximity to the mouth of Bago River (Fig. 2).

Irrawaddy dolphins were observed to have significantly spent more time foraging in one particular tidal net in comparison to all other tidal nets. Mojon 4 had the highest coefficient of tidal net use with a value of 0.653 (Fig. 9), hence indicating that the dolphins preferred foraging in the area around this particular tidal net. According to Dahood (2009), dolphins may give up inefficient foraging areas and remain in more profitable areas where they have less energy expenditure, like

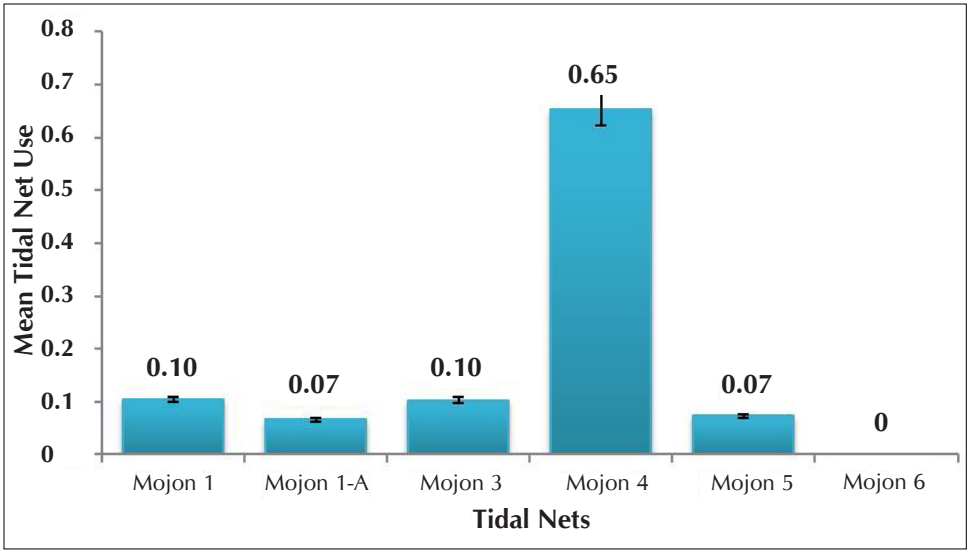

Figure 9 Mean coefficient of tidal net use of Irrawaddy dolphins

those with food readily available for them. The high degree of foraging in the area may probably indicate high abundance and availability of desired prey. In a recent study by Formilleza et al. (2014), it was mentioned that the dolphins had associated themselves with varying sectors during different tidal states and lunar phases. It was found that during low tide and low to mid-flood tide, the dolphins had the same area preferences. During these 2 tidal states, the dolphins spent a significantly high amount of time in sector 7, where Mojon 5 (M = 0.0733, SD = 0.12702) and Mojon 4 (M = 0.6533, SD = 0.24826) operate. With the latter situated at the core of sector 7, this may suggest that their preference for this tidal net could be accredited to food availability and possibly, aggregation of desired prey species brought about by the flow of water current. A drogue deployment in the study area was conducted by the Institute of Environmental and Marine Sciences or IEMS in Silliman University(2014) to determine the water current of the study area during ebbing and flooding tides. The current of the water during ebbing tide moves southwest to south. With the south seaward movement of the water, prey could possibly go with the current and eventually aggregate in areas around Mojon 4 and Mojon 3 given that they are located in the southwest seaward part of the study area. Hence, suggesting that the Irrawaddy dolphins' preference for this area may be influenced by the movement of their prey, enabling the dolphins to minimize their energy expenditure (Gregory and Rowden 2001).

Furthermore, there is higher concentration of tidal nets in the vicinity of Mojon 4. The dolphins were also observed to forage frequently in areas near Mojon

4, Mojon 5, Mojon 6, and Mojon 3 as compared to areas around Mojon 1A and Mojon 1 which are farther from Mojon 4. This concentration of tidal nets might also have attributed to more prey being trapped in the area (Fig. 10). In a study conducted by de la Paz in 2012, it was observed that sector 7 was the most utilized area of Irrawaddy dolphins. He also found out that as distance from sector 7 increases, area use of dolphins decrease. This particular association with tidal nets was also observed in the channels of old Peam Krasop and Lam Dam in Cambodia where the largest concentration of Irrawaddy dolphin sightings occurred in locations where there were abundant gill net clusters (Smith et al. 2014). The dolphins' tendency to utilize habitats which overlap with human fishing grounds may consequently pose a strong potential for fatal net entanglement.

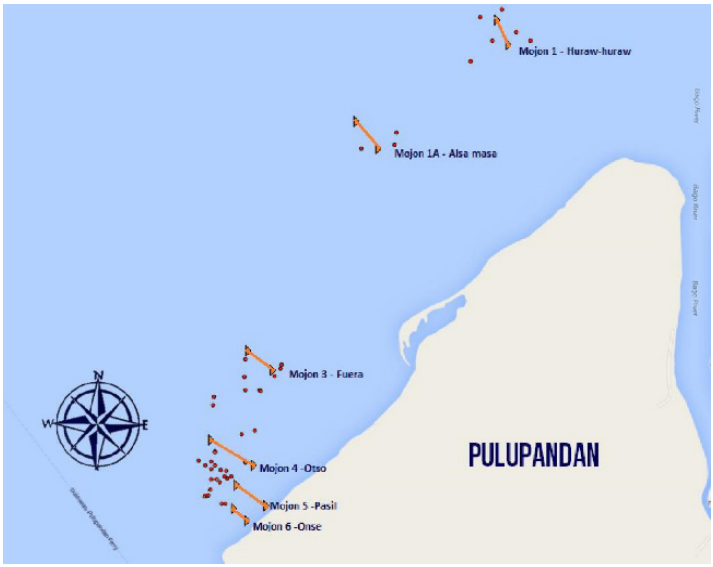

Figure 10 Map of the plotted tidal nets (orange lines) and barrier foraging sighting (red dots) within the study area

It can be noted that the high concentration of tidal nets was also located near the port where there was daily dredging. The dredging activity may have positively and negatively influenced the foraging activities of the dolphins. Indirect impacts on marine mammals from dredging stem from changes to their physical environment or to their prey. Physical characteristics, such as topography, depth, waves, tidal currents, sediment particle size, and suspended sediment concentrations, are altered by dredging (Tillin et al. 2011). Dredging can cause alterations in the water current and water quality, and can also result in the destruction of benthic communities, thus, degrading the habitat. According to Smith et al. (2014), dredging causes the

degradation of key fisheries (feeding grounds for dolphins), thus result in abandoning the area as part of their range. However, this activity might have positively resulted to renourishment due to the regular mixing of nutrients, hence, attracting fish and other prey preferred by Irrawaddy dolphins. Dredging disturbance of sediments has been reported to enhance diversity and abundance of benthic fauna near dredged channels because it could possibly enhance the release of organic nutrients from the sediment plume, hence, has the potential to increase the amount of food temporarily available to marine mammals (Todd et al. 2014).

Mojon 1 (M = 0.1033, SD = 0.17898) and Mojon 3 (M = 0.1033, SD = 0.12342), situated within sectors 10 and 8, respectively, also had high tidal net preference. According to de la Paz (2012), dolphins were observed to move north towards sector 10 in a unidirectional movement after feeding in sector 7 during the early hours of the day. This could be due to the water current during flooding tide where it reverses and moves from south to north (IEMS 2014) (Fig. 11). It was also observed that upon arrival in sector 10, the dolphins foraged closer to shore, suggesting that prey movement may have shifted along with the direction of tides. Moreover, this preference may be due to the area's proximity to the river mouth where there is constant freshwater output and sediments settling on the substrate that makes it shallower.

De la Paz (2012) also observed sediment plumes while dolphins were foraging, suggesting that the dolphins engage in benthic feeding. Moreover, high tidal net preference of the dolphins to Mojon 4 as well as Mojon 1 can also be attributed to the high plankton density since these areas receive direct nutrient outputs from Pulupandan Creek and mouth of Bago River.

Mojon 6 (M = 0.0000, SD = 0.0000), which is situated near Mojon 4 and Mojon 5 had the lowest coefficient of tidal net use. This may be due to the fact that it competes with the other 2 tidal nets for fish catch. Since the location of Mojon 6 is in the southeastern part of the study area, movement of current would still be limited in this area especially during ebbing tide (Fig. 10, Fig. 11). In general, low preference of the area is attributed to its location since there are more profitable areas like Mojon 3, Mojon 4 and Mojon 5. Hence, dolphins would prefer those areas because they can minimize their energy expenditure there.

Since the time spent by Irrawaddy dolphins foraging along the coastal waters of Pulupandan were observed to vary from one tidal net to another, ANOVA was utilized to compare and determine the differences in the total time spent foraging in each tidal net. Generated p value at 0.002 indicates that there is a significant difference in the time spent by the dolphins foraging in a specific tidal net, which means that the total time the dolphins spend foraging in a specific tidal net is not the same for all tidal nets and there exists at least one significant difference.

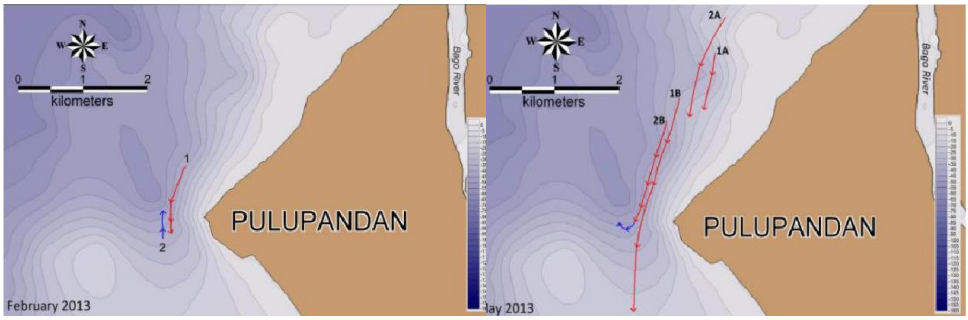

Figure 11 Drogue deployment within the study area from February to May 2013. Direction of Ebb current in red line segments and flood current in blue line segments (Image from IEMS 2014)

Post hoc analysis through Duncan Multiple Range Test strongly showed that Irrawaddy dolphins highly preferred net foraging in Mojon 4; thus, suggesting that this area is of great importance to the foraging and survival success of the dolphins. As mentioned earlier, this strong spatial preference for foraging is due to its location within the study area. In addition, the coastal water of Pulupandan supports diverse variety of fish species such as Belonidae (needlefishes), Clupeidae (herring and sardines), Serranidae (groupers), Chanidae (milkfish), Ostraciidae (trunkfishes), Tetraodontidae (puffers), Lehtrinidae (emperors), Carangidae (jacks), Caesionidae (fusiliers), Mullidae (goatfishes), Dasyatidae (rays), and Siganidae (rabbitfishes) families, and even cephalopods such as squid, cuttlefish, octopus, and shrimps (de la Paz 2012). Since Irrawaddy dolphins are known to take on a generalized diet (Arnold 2002), presence of these prey species also greatly contributes to the high frequency of foraging sightings of the dolphins in the study area and frequent feeding activity, suggesting that the area is indeed an important feeding habitat for Irrawaddy dolphins.

Comparison of the total catch per unit effort in each tidal net

Catch per unit effort (CPUE) as a measure of productivity indirectly implies resource availability of an area. Computed CPUE of the tidal nets showed that Mojon 4 is the highest (M = 28.147, SD = 19.813), indicating that it is the most productive tidal nets in the area. The high productivity of this tidal net might be due to its location within the study area. Mojon 4, as seen in Fig. 2, is situated in the southwest part of the area and since prey movement is influenced by the movement of the water current, the southwest to south (Fig. 11) direction of current during ebbing tide could possibly attribute to concentration of catch in this tidal net. As water current moves to the southern seaward part of the study area, more fish could possibly be trapped in this particular tidal net. In addition, its close proximity to the port where there could have been renourishment due to the regular mixing brought about by the dredging,

as well as the direct nutrient output from the Pulupandan creek which might also influence or enhance the productivity of the area, could be the reason why the area is mostly favored by the dolphins for their foraging. The tidal net with the second highest CPUE is Mojon 3 (M= 23.267, SD= 11.138) (Fig. 12). Like Mojon 4, its location may also contribute to its high productivity. Mojon 1 (M= 13.047, SD= 10.277) followed with the third highest catch.

In the case of Mojon 1, the high productivity might be influenced more by its proximity to the river mouth. Areas at the river mouth where freshwater and seawater meet and mix are particularly rich in minerals and organic minerals (King 2007). The high productivity of this area is due to the photosynthetic activity of phytoplankton and land runoff. These areas are able to trap productive bottom sediments and high levels of nutrients from land runoff (Correll 1978). The sediments coming from the river that have settled on the seafloor make the area much shallower which also attracts the Irrawaddy dolphins because they are known for benthic feeding and they prefer shallow areas. However, this relationship between depth and time expenditure is weak (Sutaria 2009). In addition, river mouths also serve as an important nursery area for many marine species and provide essential route for diadromous species to migrate between their spawning and main feeding areas (McDowall and Nakaya 1988).

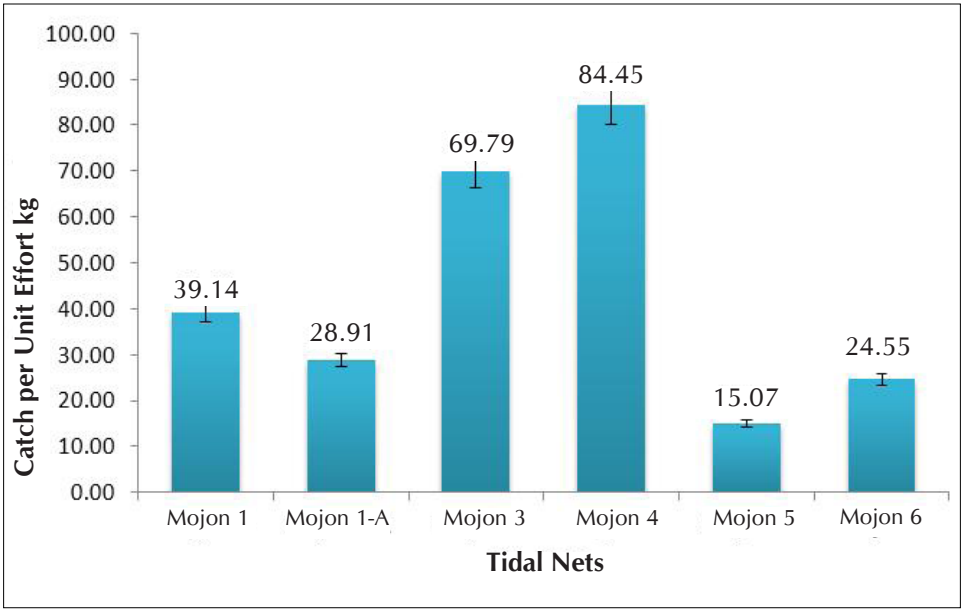

Figure 12 Catch per unit effort of each tidal net in Mojon 1 to Mojon 6

The other 2 tidal nets located south of Mojon 4 were reported to have the lowest catch. This may be attributed to competition with the other 2 tidal nets for fish catch because of their respective locations. The 2 nets that are situated south of Mojon 4 are both at the eastern part of the study area (Fig. 2). Although water current moves from southwest to south (Fig. 11), it moves seaward when it is ebbing tide, thus, favored movement and possibly accumulation of prey in tidal nets like Mojon 3 and Mojon 4.

To test and compare whether there is significant difference in the CPUE of each tidal nets, ANOVA was utilized. The generated p value of 0.105 indicates that there is no significant difference in the CPUE among tidal nets.

Relationship between Irrawaddy dolphins' site preference and CPUE

Data on tidal net preference against CPUE was shown as scatterplot to determine possible relationships (Fig.13). Since it showed a linear relationship between the two variables, the Pearson Correlation Coefficient was utilized to measure the degree of relationship between the Irrawaddy dolphins' tidal net preference and CPUE of tidal nets. The correlation coefficient was computed to be 0.624 and was found to be significant at $\alpha = 0.01$ (two-tailed test, $p\ (0.006) < \alpha\ (0.05)$) indicating that a significant relationship exists between the Irrawaddy dolphins' site preference and CPUE of tidal nets. Consequently, if the CPUE is high, it also follows that the Irrawaddy dolphins preferred this tidal net when foraging. This may imply that foraging preference is greatly influenced by the presence of prey as evidenced by the profusion of tidal nets.

The relationship between CPUE and foraging preference showed that productivity of a specific area is one of the factors that influenced the foraging behavior of Irrawaddy dolphins (D'Lima et al. 2013). Furthermore, de la Paz (2012), Formilleza et al. (2014), and Señoron et al. (2014) denoted in their studies that areas with more tidal nets were considered most likely the main feeding area for the small group of dolphins. This may also be due to the presence of these tidal nets that facilitate trapping, thus increasing the chances of catching prey in the area. Delphinids have been known to give up inefficient foraging areas and remain in more profitable areas where they have less energy expenditure, like those with food readily available for them (Dahood 2009). With the south seaward movement of the water during ebbing tide, prey moves along with the current and eventually aggregate in areas with more tidal nets like Mojon 4 and Mojon 3, given that they are located in the southwest seaward part of the study area. In addition, the shifting of water current from south to north during flooding tide also aids in bringing prey to the tidal nets near the mouth of Bago River like Mojon 1 and Mojon 1A. This also suggests that the specific foraging

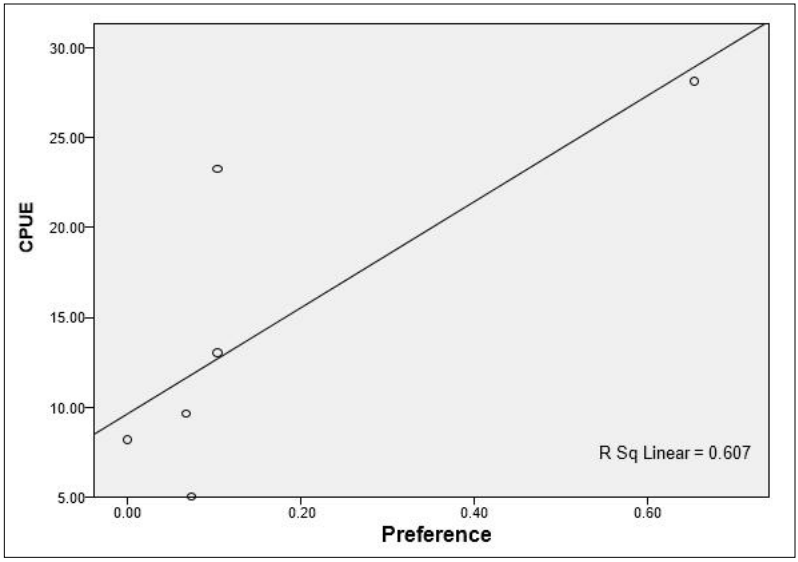

Figure 13 Scatterplot showing linearity between dolphins' tidal net preference and catch per unit effort

preference of Irrawaddy dolphins in this area is influenced by the movement of their prey which, as suggested by Gregory and Rowden (2001), enables the dolphins to minimize their energy expenditure.

Furthermore, Irrawaddy dolphins are considered as indicator of abundant harvest by local fishermen. It has been observed by fishers in Chilika Lagoon, India, that the presence of these dolphins in areas near tidal net aids in augmenting more catch (D'Lima et al. 2013). Hence, this shows a positive relationship between the dolphins and the humans during this cooperative process. However, it should also be considered that these tidal nets provide possibility of net entanglements.

Conclusion

The Irrawaddy dolphins predominantly engaged most of its time in foraging, followed by socializing, travelling, and resting being the least exhibited by the dolphins. Foraging behavior of Irrawaddy dolphins include diving with flukes up, water and fish spitting, and flippering which is also strongly observed when they engage in socializing. The dolphins foraging behavior was classified as either open-water foraging or tidal net foraging (also known as barrier foraging). However, there was really no significant difference between open water and tidal net foraging. In

terms of their foraging preferences, Irrawaddy dolphins significantly preferred Mojon 4. This tidal net also had the highest productivity in terms of CPUE, suggesting that dolphins prefer areas with high productivity when foraging. The location of the tidal net along the coastal area coincides with the movement of water current which drives the prey, thus influences the net's productivity. This favorable area does not only provide them with their maximum requirements for survival; high productivity also means less energy expenditure for the dolphins.

These results are useful in strengthening and establishing protection especially of identified core feeding grounds of the Irrawaddy dolphins. With the investigated association between tidal nets and the foraging behavior of Irrawaddy dolphins, it is essential to take into account the potential of the tidal nets to be hazardous to the Irrawaddy dolphins.

Recommendations

For future researches involving the Irrawaddy dolphin population in the coastal waters of Bago and Pulupandan in Negros Occidental, the researchers highly recommend the investigation of the spatial and temporal variations within the area to understand the behavioral patterns of this dolphin species. A longer time for surveying is also to be considered. Since surveys end at midday, extending the time and area of observation can help in verifying the activities of the dolphins.

The researchers would also like to lay the following considerations to further understand which environmental factors drive the foraging preferences of Irrawaddy dolphins and also for the development of effective conservational management of this species: (1) thorough investigation of the species richness and composition of the tidal net catch, for this could possibly give light to the dolphins' diet; (2) continuous monitoring of physicochemical parameters such as temperature, pH, depth, salinity, and dissolved oxygen; (3) bathymetric and hydrological factors; and (4) seasonal variations. All of these environmental features are also essential in predicting the consequences of exposure to different stressors.

For the conservation and management of the Irrawaddy dolphins, the researchers recommend the close monitoring and regulation of the number of permanent nets in the area, since this could possibly be fatal to the dolphins. Since a Marine Protected Area (MPA) is already in the works with legal process, the researchers recommend regulation of the number of boats operating in areas that were identified as main foraging/feeding grounds of the dolphins to minimize the risk of collision and net entanglement.

Threats to the Irrawaddy dolphins such as boat traffic, net entanglement, pollution, habitat degradation, and other anthropogenic activities should also be closely studied for the implementation of laws and restrictions and establishment of protected areas. Mostly, it is important to raise awareness and educate the coastal communities especially the local fishers on how to respond to dolphins that are stranded in nets. The researchers hope that all of these recommendations would aid in the conservation, as well as in the protection of the Irrawaddy dolphins in the coastal waters of Bago and Pulupandan.

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Endoparasites of selected captive endemic threatened wildlife species in Negros Island, Philippines

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*This study aimed to detect, identify and determine the prevalence of endoparasites in selected endemic threatened wildlife species of Negros Island at the Negros Forests Ecological Foundation Inc. Biodiversity Conservation Center in Bacolod City. From 23 July to 14 August 2015, three fecal samples were each collected from three individuals of captive species: **Sus cebifrons negrinus**, **Rusa alfredi**, **Penelopides panini panini**, and **Gallicolumba keayi**. Analysis of 36 samples using Direct Fecal Smear, Simple Flotation and Sedimentation Techniques, showed that only **S. c. negrinus** were infected with endoparasites. Ascaris vitulorum was the most prevalent endoparasite (92%), followed by **Giardia duodenalis** (14%) and **Balantidium coli** (6%). Degree of infection was found to be mild or below 500 based on the number of eggs per gram of fecal sample. It is recommended that administration of antihelminthics to captive **S. c. negrinus** individuals should be done periodically coupled with better sanitary measures so that parasitic infection in the enclosures will be reduced.*

ENDOPARASITES ARE PARASITES WHICH LIVE WITHIN THE BODY OF A HOST and are dependent on at least one gene or its product from that host to complete their own life cycle. Infections brought about by endoparasites can be a major problem causing health problems and even mortality of captive wild animals (Borghare et al. 2009). In the wild, animals might have a natural resistance against parasitic infections

Keywords: Endoparasites, wildlife species, fecal analysis, Negros Island

or live in a balanced system with their parasites (Goswami 1994). However, the change in environment and living conditions, from freedom to captivity, influences the animal's ecology and might increase its sensitivity for parasitic infections.

The various ways by which parasites can be brought in the conservation centers are various such as follows: through the animals' food, through intermediary and paratenic hosts (snails, ants, cockroaches, rodents, etc.), through newly acquired parasitized animals, and through infected zoo staff and visitors. These mechanisms should be taken into consideration in the control of the health status of the captive animals in the conservation center.

This study aimed to detect the presence and prevalence of endoparasites among four selected captive endemic species kept at Negros Forests Ecological Foundation Inc.-Biodiversity Conservation Center (NFEFI-BCC), a wildlife rescue and rehabilitation center in Bacolod City, Negros Occidental, Phlippines. Species studied include the Visayan warty pig *(Sus cebifrons negrinus),* Visayan spotted deer *(Rusa alfredi),* Visayan tarictic hornbill *(Penelopides panini panini),* and Negros bleeding heart pigeon *(Gallicolumba keayi).*

Materials and methods

Fecal samples from four selected endemic threatened species were collected at NFEFI-BCC, Bacolod City, on 23-24 July and 13-14 August 2015, with consideration for the life cycle of the endoparasites. Selected species were *S. c. negrinus, R. alfredi, P. p. panini*, and *G. keayi*.

Three fecal samples from each of the four selected species were taken and replicated times for a total of 36 experimental units. Laboratory tests including Direct Fecal Smear Method, Simple Flotation Technique, and Sedimentation Technique were conducted at the Provincial Animal Disease Diagnostic Laboratory, Provincial Veterinary Office, Bacolod City, on 23 July to 14 August 2015 under the supervision of the registered medical technologist.

Direct Fecal Smear Method was done by mixing a small amount of fecal sample with Normal Saline Solution (NSS). The mixture was then mounted on a glass slide.

Simple Flotation Method, useful for the examination of eggs of nematodes, was done by mixing 0.5 g fecal sample with 2.5 mL water and straining through a gauze pad. The filtrate was poured into a test tube and centrifuged at 2000 rpm for 5 minutes. The supernatant was discarded and the test tube was refilled with water and centrifuged 2-3 turns until the supernatant turned clear. The sediment

was mixed in a test tube with 1.7 mL salt solution and centrifuged. A drop from the top layer of fluid was mounted on a clean and dry glass slide using a pipette.

Sedimentation Technique, useful for the examination of eggs of trematodes and cestodes, was done by mixing 0.5 g fecal sample with 2.5 mL water and straining through a gauze pad. The filtrate was poured into a test tube and centrifuged at 2000 rpm for 5 minutes. The supernatant was discarded and the test tube was refilled with water and centrifuged 2-3 turns until the supernatant turned clear. Then, a drop of the sediment was mounted on a clean, dry glass slide.

Mounted samples were observed under the low power objective (10x) of a compound microscope and examined for the presence of endoparasites or their eggs. The level of severity of infection was graded into three categories based on eggs per gram (EPG) of fecal samples: below 500 (mild), 500 to 1000 (moderate) and more than 1000 (severe) (Thawait, 2014). For flotation, presence of eggs was counted. The prevalence of endoparasites was computed using the formula:

$$\text{Percent Prevalence} = \frac{\text{No. of parasites detected}}{\text{Total no. of samples}} \times 100\%$$

Results and discussion

Endoparasites were only detected in the fecal samples of *S. c. negrinus* in the four dates of collection except in the fecal sample of replicate 2, 3 and 1 of the said species in the first, second and third enclosures respectively (Fig. 1, Table 1). No parasites were observed in the fecal samples of *R. alfredi* and *G. keayi* except for a single infection of endoparasite in *P. p. panini* in one replicate, possibly due to the proper animal care practices at NFEFI-BCC.

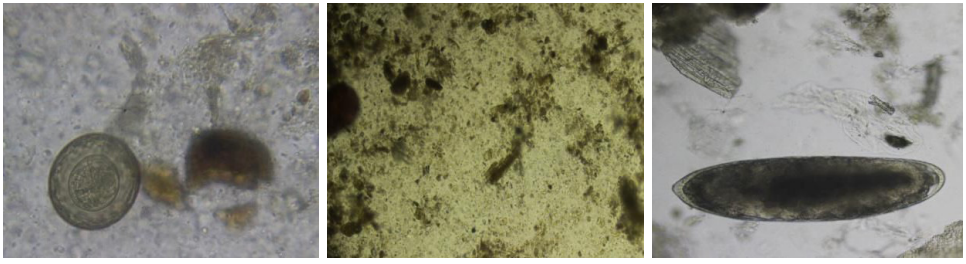

Figure 1 *Ascaris vitulorum, Giardia duodenalis* and *Balantidium coli* as seen under the low power objective of a compound microscope

Table 1 Prevalence of endoparasites in 4 captive endemic threatened species in NFEFI-BCC

Species	Total No. of Fecal Samples	No. of Parasites Observed	Prevalence (%)
S. c. negrinus	36	*Ascaris vitulorum* (33)	*Ascaris vitulorum* (92)
		Giardia duodenalis (5)	*Giardia duodenalis* (14)
		Balantidium coli (2)	*Balantidium coli* (6)
R. alfredi	36	0	0
P. p. panini	36	Bird fluke (1)	Bird fluke (3)
G. keayi	36	0	0

The endoparasites identified in the fecal samples of *S. c. negrinus* include one nematode, *Ascaris vitulorum,* and 2 protozoans, *Giardia duodenalis* and *Balantidium coli*. Only *S. c. negrinus* in the first enclosure exhibited mixed infection which is a combination of either 2 or 3 endoparasites while samples from the other pigs had a single infection of endoparasites. On the other hand, a bird fluke was observed in replicate 3 of the *P. p. panini* in the second enclosure.

Out of the 36 fecal samples collected from the 3 Visayan warty pigs, the prevalence of endoparasites was 91.67%. Specifically, the prevalence of *A. vitulorum, G. duodenalis* and *B. coli* was 92%, 14%, and 6% respectively. The prevalence of trematode was 3% out of 36 fecal samples collected from the 3 *P. p. panini*. Computation of degree of infection of nematode eggs using Sedimentation Technique were mild or below 500 eggs per gram based on the number of eggs per gram of fecal sample.

The detection and degree of infection of the eggs of trematode/cestode using Sedimentation Technique revealed that trematodes and cestodes are not evident in the selected species except for the bird fluke (a trematode) in the fecal sample of the *P. p. panini* in the second enclosure. The degree of infection brought about by this trematode is mild or below 500 eggs per gram.

These results conformed to reports that nematodal infection was the most prevalent type of infection and was higher than cestodal infection (Thawait et al., 2014). Panayotova-Pencheva (2013) reported that the most widely spread helminthes

in zoos are nematodes, followed by cestodes and trematodes. Nematodes are most often represented by orders Ascaridida, followed by Strongylida, Enoplida (Trichuridae, Capillariidae), Oxyurida, and Rhabditida. Protozoa ranked second after nematodes in frequency. Bauri et al. (2012) reported that *B. coli* had a 60-90% prevalence rate in swine animals while Uysal et al. (2009) found that *G. duodenalis* was detected in 9 (3.7%) fecal specimens of pigs, *B. coli* cysts in 4 (1.6%) and *Ascaris* spp. eggs in 9 (4.1%).

The presence of the nematodes in the fecal samples of *S. c. negrinus* may be attributed to the physical environment where these animals are confined. It was observed by the researchers that *S. c. negrinus* prefered to stay in the mud which is usually inhabited by the parasites. In addition, the fecal matter of the warty pig is usually left attended or allowed to decompose in the place which could contribute to the proliferation of endoparasites in the area. The water that they drink or the food that they eat might also be contaminated.

The *P. p. panini* in the second enclosure with blood fluke identified in its fecal matter was not anymore provided with anti-helminthic medicine because the trematode was no longer detected in the last 2 dates of examination.

Conclusion

The presence of endoparasites was detected among 4 selected captive endemic species kept at NFEFI-BCC, Bacolod City. Only the captive *S. c. negrinus* were found to be infected while the other selected species, *R. alfredi, P. p. panini,* and *G. keayi,* were found to be free from endoparasites. *A. vitolurum, G. duodenalis* and *B. coli* were identified, of which, *A. vitolurum* was the most prevalent. Majority of *S. c. negrinus* has single infection of endoparasites but few have mixed infection of either two or three of the endoparasites. The degree of infection brought about by these nematodes is mild or below 500 based on the number of eggs per gram of fecal sample. Trematodes and cestodes are not evident in the fecal samples.

It is suggested that there is a need for detailed epidemiological investigation on the prevalence of endoparasites in captive threatened endemic species with respect to season, age, climate, and other factors. Additional tests can be done such as the Stool's Dilution Technique to determine the number of nematode eggs per gram of fecal sample to further quantify the severity of infection. Administration of antihelminthics to *S. c. negrinus* should be done periodically, and coupled with better sanitary measures so that parasitic infection in the enclosures will be reduced. It is recommended that animals will not be released back into the wild if found positive for the helminthic infection because they may spread the infection to other susceptible wildlife.

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Invasive Alien Plant Species (IAPS) of Malagos Watershed in Calinan, Davao City and Mt. Musuan, Bukidnon

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This study compared the species richness and diversity of Invasive Alien Plant Species (IAPS) between Malagos Watershed, Calinan, Davao City, a landscape watershed near an urban area and Mt. Musuan, Bukidnon, a lower montane ecological research site. Whittaker plots were used in sampling. Identified IAPS in Malagos Watershed, were ***Sphaerostephanos*** *sp.,* ***Elephantopus scaber*** *Linn.,* ***Colocasia esculenta*** *(L.) Nakai, and* ***Asystasia gangetica*** *CV. Present in both sites were* ***Piper aduncum*** *L.,* ***Gmelina arborea*** *Roxb,* ***Spathodea campanulata*** *Beauv., and* ***Chromolaena odorata*** *(L.) King. Also encountered in the Mt. Musuan plots were* ***Acacia mangium*** *Willd.,* ***Flagellaria indica*** *L.,* ***Lantana camara*** *L.,* ***Leucaena leucocephala****,* ***Lygodium japonicum****,* ***Mikania micrantha****,* ***Salvinia molesta****, and* ***Swietenia macrophylla****. The IAPS in Malagos Watershed obtained a Simpson index of D-1 = 0.5110; evenness of 0.4502; biodiversity index of H= 0.946. Mt. Musuan obtained D-1 = 0.80317; evenness of 0.74727; H=2.48491.*

BIOLOGICAL INVASION IS CONSIDERED AS THE SECOND THREAT TO biodiversity loss next to habitat destruction (Sharma et al. 2005). The introduction of invasive alien species (IAS), which is recognized by Schlaepfer et al. (2011) as non-

Keywords: Invasive Alien Plant Species (IAPS), Whittaker sampling plots, Malagos Watershed, Davao City, Mt. Musuan, Bukidnon

native species that cause biodiversity loss, had been observed to alter terrestrial and aquatic communities globally. Ecologists and conservationists believe that invasion by non-native species is a leading cause of recent species extinctions and biodiversity loss (Gurevitch and Padilla 2004).

Addo-Fordjour et al. (2008) identified IAS as species that have the ability to disperse long distances to new sites, easily establish in areas modified by human activities, compete with native species and spread rapidly from their initial point of establishment, and have a tendency to be difficult to eradicate. Species become invasive because they are able to access resources in the environment that native species do not utilize (Bowling and Vaughn 2009). They establish sexually productive populations that cause significant changes in natural or artificial ecosystems (Richardson et al. 1998). It has been hypothesized that introduced species might easily invade other areas of low diversity than areas of high species diversity as first observed by Darwin in 1859 (Stohlgren et al. 1999).

Merrill's notes on introduced plants included in the Flora of Manila (1912), revealed that 50% of the species listed had been introduced by man. Of the 1,007 plants in the Flora of Manila, 334 had been brought into the country fairly recently, wherein 242 were deliberately introduced and 92 were introduced accidentally. Numerous alien plants have successfully invaded natural and human-altered habitats in the Philippines through deliberate and accidental introductions within the past 400 years.

Thus, this comparative study looks into the diversity and distribution of invasive alien plant species (IAPS) in a landscape watershed near an urban area (Malagos Watershed) and a lower montane Long-Term Ecological Research (LTER) site situated in a rural location (Mt. Musuan).

Materials and methods

Location of the study

The first sampling site was at Malagos Water Baguio District, Calinan, Davao City. It is where the Philippine Eagle Foundation is located. It has a total land area of 232 ha and is 32 km away from Davao City. It has been reforested since 1990. Malagos watershed is surrounded by an agroecosystem, a fragmented rehabilitated forest, situated in a highly urbanized area. The second sampling site was at Mt. Musuan Botanical and Zoological Garden, Sayre Highway, Musuan, Bukidnon. It is approximately 180 km away from Davao City (Fig. 1, Fig. 2). Mt. Musuan, one of the permanent plots for research of CMU, is surrounded with other forest fragments and agroecosystem. These locations were selected because both sites are protected areas.

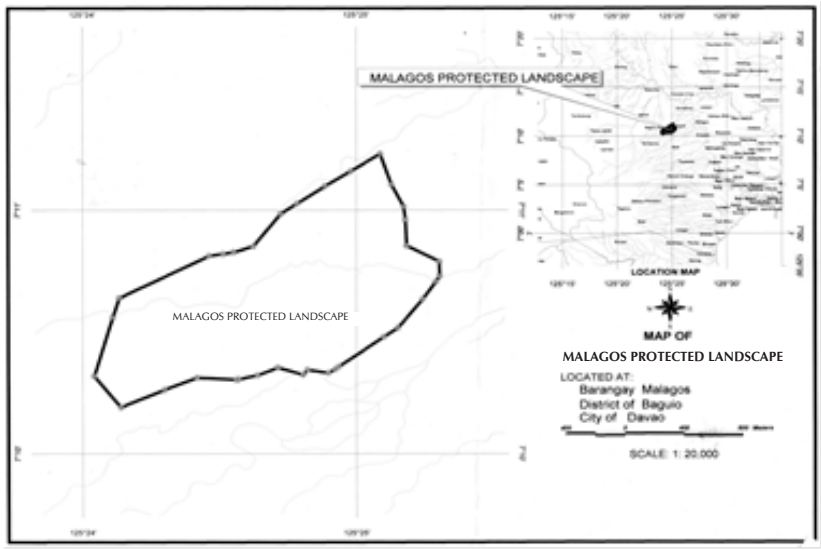


Figure 1 Map of Malagos Watershed at Baguio District, Calinan, Davao City (DCWD 2015)

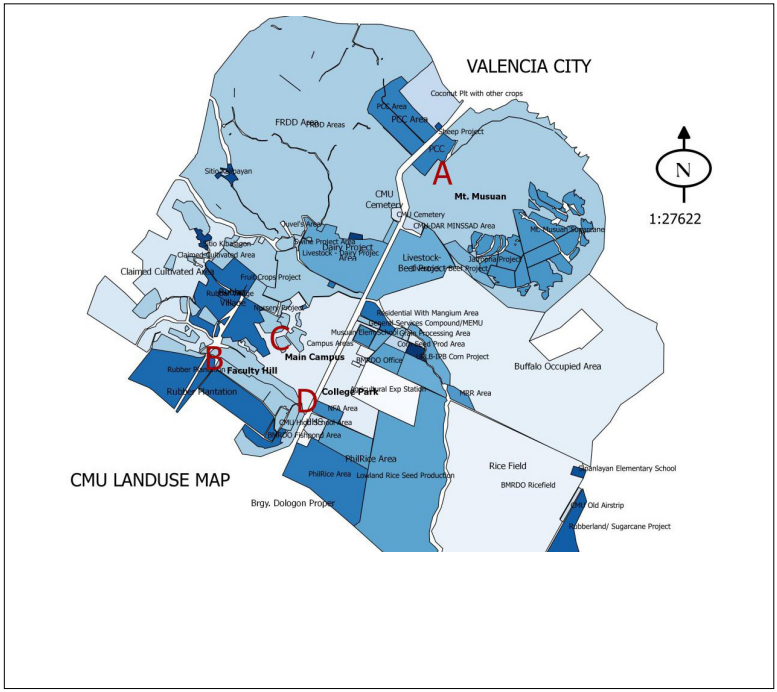


Figure 2 Map of Mt. Musuan at Sayre Highway, Musuan, Bukidnon

Research design

Physical survey using standard sampling and Whittaker plots was applied to produce qualitative description and analysis of IAPS in the two locations. The vegetation sampling design was done with a line transect point system and Whittaker plots were applied for each point (Fig. 3). It is a standard system used for assessing plant communities at multiple scales (Stohlgren et al. 1999). Each plot consisted of one main plot (20 m x 50 m), one center plot (5 m x 20 m), two adjacent plots (2 m x 5 m), and 10 small plots (0.5 m x 2 m). These 10 small plots were distributed in six of the small plots that were placed in the main plots and four plots were placed at the center plot.

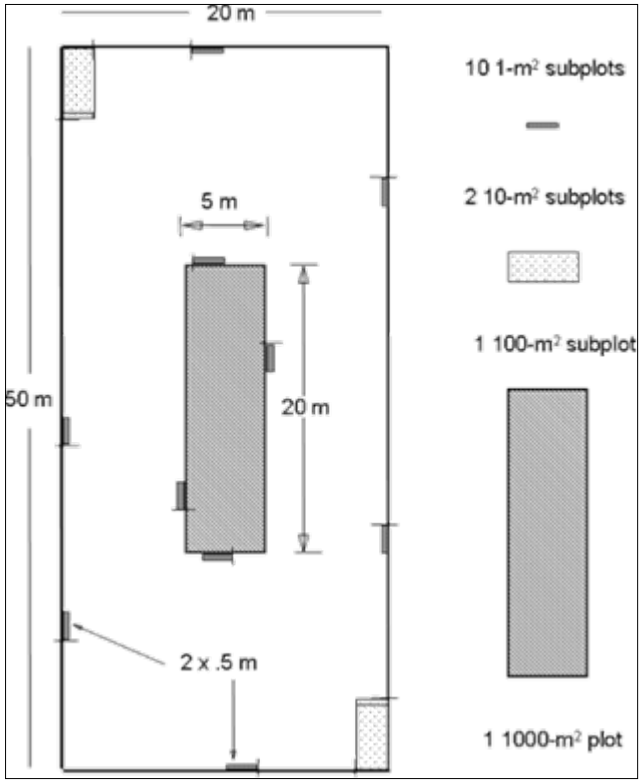


Figure 3 Standard Whittaker plots established in each sampling site in Malagos Watershed at Baguio District, Calinan, Davao City (DCWD 2015) and Mt. Musuan, Maramang, Bukidnon

Data collection and analysis

The series of samplings were conducted on 29-30 September 2015, 25-26 November 2015, and 28-29 April 2016. The IAPS seen in each quadrat were recorded, pressed, photographed, and identified with details. Identification was done using relevant materials such as herbarium specimen comparisons and consultations with Dr. Victor B. Amoroso, a University Professor of Central Mindanao University (CMU) and Career Scientist III of Department of Science and Technology and Mr. Fulgent P. Coritico, a Researcher of CMU. Samples were submitted to CMU Museum. Counting was done for each quadrat and sub-quadrat.

Results and discussion

A total of eight IAPS on the IUCN Red Alert List of Invasive Species were identified in the Malagos Watershed (Table 1, Plate 2). These include *Spharostephanos* sp., *C. esculenta, E. scaber*, C. *odorata, G. arborea*, *P. aduncum, A. gangetica*, and *S. campanulata*. Among the 791 individuals of IAPS, *Spharostephanos sp.* (bracken fern, family Dennstaedtiaceae) is the most numerous. It is one of the most successful weeds in the world. In India, it is a common fern present in and around grazing lands and forest areas (Dawra et al 2002).

In Mt. Musuan, 12 IAPS were identified (Table 1, Plate 1). These species are *A. mangium*, *C. odorata*, *F. indica, G. arborea, L. camara, L. leucocephala, L. japonicum, M. micrantha, P. aduncum, S. molesta, S. campanulata,* and *S. macrophylla*. The 12 flora species are found in Mt. Musuan either as naturally growing or cultivated. The said species were also recorded by Amoroso et al. in their study on Mt. Musuan in 2000.

Comparative species richness, evenness, Shannon Weiner (H) diversity value, for the two sites, in Table 2 showed a very low H = 0.9464 and evenness of 0.4502 for Malagos Watershed. The Simpson's index obtained was 0.5110, which is halfway to 1.0. This implies that the IAPS in the area are not so diverse, with uneven species distribution based on 1-D and evenness values. Notable is that these species belong to the list of top 100 and are in the Alert List for Environmental Weeds (Lowe et al. 2000). Mt. Musuan showed higher values for H, evenness and diversity index, compared to those obtained for IAPS of Malagos Watershed.

Table 1 The comparative list of Invasive Alien Plant Species in Malagos Watershed, Baguio District, Calinan, Davao City and in Mt. Musuan in Sayre Highway, Musuan, Bukidnon

Family	Origin	Scientific name	Common name	Malagos Watershed	Mt. Musuan
Acanthaceae	Malaysia, Indonesia and Pacific Islands	*Asystasia gangetica* CV	Chinese violet	2	
Araceae	Myanmar, Bangladesh	*Colocasia esculenta* (L.)	Nakai taro, gabi	93	
Asteraceae	North America	*Chromolaena odorata* (L.)	King hagonoy, siam weed	4	241
Asteraceae	South and Central America	*Mikania micrantha*	Mile-a-minute		378
Bignoniaceae		*Spathodea campanulata* Beauv.	African tulip	4	8
Compositae	India and Mexico	*Elephantopus scaber* Linn.	Elephant's ear, dila-dila	165	
Fabaceae	Northeastern Queensland in Australia	*Acacia mangium* Willd.	Acacia		22
Fabaceae	Central America	*Leucaena leucocephala*	Miracle tree, ipil-ipil		83
Flagellariaceae	Africa	*Flagellaria indica* L.	Governor's plum		144
Lygodiaceae	Eastern Asia	*Lygodium japonicum*	Japanese climbing fern		483
Piperaceae	West Indies	*Piper aduncum* L.	Buyo-buyo	2	29
Meliaceae	Central and South America	*Swietenia macrophylla*	Mahogany		11
Salviniaceae	Southeast Brazil	*Salvinia molesta*	Water fern		903
Thelypteridaceae	New Guinea	*Sphaerostephanos* sp.	Marsh fern	520	
Verbenaceae	Asian countries	*Gmelina arborea* Roxb	White teak	1	12
Verbenaceae	West Indies	*Lantana camara* L.	Big sage, baho-baho		357
		Total		791	2671

Plate 1 Invasive flora species found in Mt. Musuan in Sayre Highway, Musuan, Bukidon in 2015

Acacia mangium Willd.
FABACEAE

Chromolaena odorata (L.) King & Rob.
ASTERACEAE

Flagellaria indica L.
FLAGELLARIACEAE

Gmelina arborea Roxb.
LAMIACEAE

Lantana camara L.
VERBENACEAE

Leucaena leucocephala (Lam.)de Wit
FABACEAE

Lygodium japonicum (Thumb.) Sw.
LYGODIACEAE

Mikania micrantha (L.) Kunth.
ASTERACEAE

Piper aduncum L.
PIPERACEAE

Salvinia molesta D.S. Mitchell
SALVINIACEAE

Spathodea campanulata Beauv.
BIGNONIACEAE

Swietenia macrophylla King
MELIACEAE

Plate 2 Invasive flora species in Malagos Watershed, Baguio District, Calinan Davao City (2015)

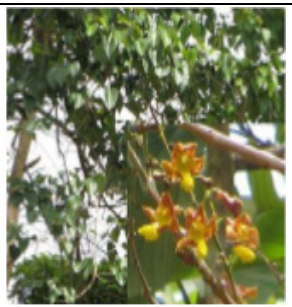
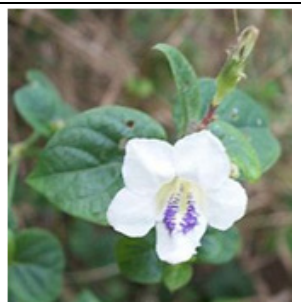
 *P. aquilinum*	 *C. esculenta*	 *E. scaber*	 *C. odorata*
 *G. arborea*	 *P. aduncum*	 *A. gangetica*	 *S. campanulata*

Table 2 Comparative species richness, evenness, H value, and diversity of Malagos Watershed and Mt. Musuan Invasive Alien Plant Species

Species	Malagos Watershed species richness	Mt. Musuan species richness
Chinese violet *(A. gangetica)*	0.0025	
Taro, gabi *(C. esculenta)*	0.1179	
Hagonoy, siam weed *(C. odorata)*	0.0051	0.09023
Mile-a-minute (M. micrantha)		0.14152
African tulip *(S. campanulata)*	0.0051	0.00300
Elephant's ear, dila-dila *(E. scaber)*	0.2091	
Acacia *(A. mangium)*		0.00824
Miracle tree, ipil-ipil *(L. leucocephala)*		0.03107
Governor's plum *(F. indica)*		0.05391
Japanese climbing fern *(L. japonicum)*		0.18083
Buyo-buyo *(P. aduncum)*	0.0025	0.01086
Mahogany *(S. macrophylla)*		0.00412
Water fern *(S. molesta)*		0.33808
Marsh Fern *(Sphaerostephanos* sp.)	0.6591	
White teak *(G. arborea)*	0.0013	0.00449
Big sage, Baho-baho *(L. camara)*		0.13366
Shannon Weiner, H	0.9464	2.48491
Evenness	0.4502	0.74727
Simpson's Index of diversity, 1 – D	0.5110	0.80317

Table 3 and Table 4 provide data on distribution category for Malagos watershed and Mt. Musuan. Table 3 shows that *C. odorata*, *G. arborea* and *A. gangetica* are randomly distributed while the rest are clustered.

Table 3 Distribution category of Invasive Alien Plant species in Malagos Watershed, Baguio District, Calinan, Davao City in 2015

	Species	Variance	Mean	Chi-sq	d.f.	Probability	Species distribution
1	*Spharostephanos sp.*	4271.334	40.000	1281.40	12	0.0000	Clustered
2	*Colocasia esculenta*	507.308	7.154	850.968	12	0.0000	Clustered
3	*Elephantopus scaber*	769.398	12.692	727.430	12	0.0000	Clustered
4	*Chromolaena odorata*	0.397	0.308	15.500	12	0.2146	Random
5	*Gmelina arborea*	0.077	0.077	12.000	12	0.4459	Random
6	*Piper aduncum*	0.308	0.154	24.000	12	0.0204	Clustered
7	*Asystasia gangetica*	0.141	0.154	11.000	12	0.5295	Random
8	*S. campanulata*	1.231	0.308	48.000	12	4.20E-06	Clustered

Table 4 Distribution category of Invasive Alien Plant Species at Mt. Musuan Zoological and Botanical Garden, Sayre Highway, Musuan, Bukidnon

	Species	Variance	Mean	Chi-sq	d.f.	Species distribution
1	*C. odorata*	671.2692	18.5385	434.5145	12	Random
2	*M. micrantha*	3491.9102	29.0769	1441.1057	12	Random
3	*F. indica*	633.5769	11.0769	686.3749	12	Random
4	*S. molesta*	17791.9355	69.4615	3073.6897	12	Random
5	*L. camara*	2282.2693	27.4615	997.2941	12	Random
6	*S. campanulata*	3.7564	0.6154	73.2500	12	Random
7	*S. macrophylla*	9.3077	0.8462	132.0000	12	Random
8	*L. japonicum*	4463.8076	37.1538	1441.7267	12	Random
9	*P. aduncum*	44.6923	2.2308	240.4138	12	Random
10	*G. arborea*	7.7436	0.9231	100.6667	12	Random
11	*A. mangium*	21.5641	1.6923	152.9091	12	Random
12	*L. leucocephala*	235.5897	6.3846	442.7952	12	Random

Conclusion and recommendation

This research focused on establishing a baseline data for both areas. The results showed that Mt. Musuan has more IAPS present, and which are randomly distributed compared to Malagos Watershed. Effective mitigating measures should be applied to ensure the conservation of native species and the provision of ecological services of the ecosystems where they are found. With these observations, it is recommended that further studies and assessments of appropriate management options to control and mitigate the spread of IAPS in these sites be conducted.

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Ecotypes and hypericin content of *Hypericum pulogense* Merrill

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***Hypericum pulogense** Merr. was first described by Merrill and Merritt in 1910. A number of the over 400 species of **Hypericum** have long been known for their curative properties worldwide; hence, the interest in this indigenous species. In the tropics, the genus thrives in higher elevation of low temperature. Mount Pulag where it grows presents distinct vegetation zones. In the mossy forest and grassland zones, three ecotypes were encountered within a 3-km trail of 300-m gradation in elevation. As expected, there was pronounced variation in both plant size and habit among these ecotypes. Anatomical observation showed the presence of translucent ducts in their leaves. However, the red colored hypericin was absent in these ducts. This was confirmed by thin layer chromatography of the plant extracts. Hypericin is considered the plant constituent responsible for the antidepressant activity of the commercially valued St. John's wort, **Hypericum perforatum** L. Other constituents of **H. perforatum** with reported biological activities are phloroglucinol derivatives and essential oil components. The observed **H. pulogense** emitted the characteristic odor that may be due to these constituents. This study presents the first report on the potential medicinal property of the local representative of the genus **Hypericum**.*

CONSERVATION OF PLANT DIVERSITY IS IMPERATIVE FOR A COUNTRY WITH pronounced genetic loss like the Philippines. During the photo documentation of plant species in Mt. Pulag, Benguet, Philippines covering 108 species in 91 genera under 51 families (Aguilar et al. 2000), 22 species in 18 genera proved to be closely

Keywords: *Hypericum pulogense*, ecotypes, hypericin

related to known medicinals in other parts of the world (Cardenas et al. 2000). This part of the country with high elevation is of interest for plant conservation because local representatives of some temperate genera can only be found here. One of these plants is *Hypericum pulogense* that was described by Merrill and Merritt in 1910. It is closely related to *Hypericum perforatum*, commercially sold as St. John's wort, which is valued for its anti-depressant activity. This is attributed to the dianthrone hypericin. St. John's wort is one of the most commonly prescribed medication in Europe (Schulz et al. 1998) with a market value exceeding $ 570 million worldwide (Raina et al. 2005). This study checked the presence of hypericin in *H. pulogense* and recorded this indigenous species' morphological variations highlighted by the distinct vegetation zones of Mt. Pulag.

There are ca. 400 species of *Hypericum* occurring in all continents. It is considered cosmopolitan but is absent in the artic and desert areas and most of the lowland tropics. In South-East Asia (SEA), the genus is reported in Malesia, Indo-China and Thailand (Brink 1999). The English common name of the genus is St. John's wort and a number of its species are traded as ornamentals. Among those considered medicinal, the most popular and the most studied is *H. perforatum* because of its antidepressant activity attributed to hypericin. Hypericin continues to be a substance of interest for its antivirucidal activity (Tang et al. 1990) and for its potential application for photodynamic therapy (Okpanyi et al., 1990).

Merrill and Merritt (1910) described in detail the vegetation zones of Mt. Pulag, from base up to the summit: the pine region, the mossy forest and the grassland. These zones were well-demarcated. They described *H. pulogense* as "erect, glabrous, suffrutescent herb 20 - 40 cm high". Observations on this species was done in the mossy forest, from ca. 2,000 – 2,600 m above sea level (masl) and at the grassland from ca. 2,600 m up to the summit at 2,922 masl. They noted the abundance of the species in the open grasslands of the summit and in open places in the mossy forest.

Hypericum species in South-East Asia with reported medicinal uses are *H. gramiineum, H. japonicum, H. monogynum, H. papuanum,* and *H. uralum*. Tested species did not show the presence of hypericin. Strong anti-viral, antidepressant, antimicrobial activity, with limited side effects were reported although there is very little information on the presence of active compounds in SEA (Brink 1999).

Materials and methods

Collection permit was applied for prior to the conduct of the research. Figure 1 shows the sites of collection: the campsite (C) at the fringe of grassland close to the mossy forest, the mossy forest (M), and the grassland summit (S).

Plant samples of *H. pulogense* from the different sites were observed for morphological variations. Leaf sections were made and observed under the microscope. Leaf samples were also air dried to detect hypericin by thin layer chromatography (Wagner and Bladt 1993). Commercial St. John's wort (Healthy Options®) was used as reference material. The hypericin in this herbal product comes from the flower of *H. perforatum*. Flower of St. John's wort is known to have higher hypericin content than the leaf (Raina et al. 2005).

Air dried leaves were ground using Wiley mill of 1 mm sieve and 0.5 g of the powder was extracted in 5 ml methanol for 5 min with heating. The clear filtrate was used directly for TLC. Ten μl of the filtrate was spotted on Silica Gel 60 F_{254} plate (Merck®) and the chromatogram developed in ethyl acetate: formic acid: glacial acetic acid: water (100:11:11:27) solvent system. The plate was first viewed in visible light. Thereafter, the plate was sprayed with Natural Products/PEG reagent and viewed under UV_{365}. Documentation was done using a Canon® SX170 IS camera.

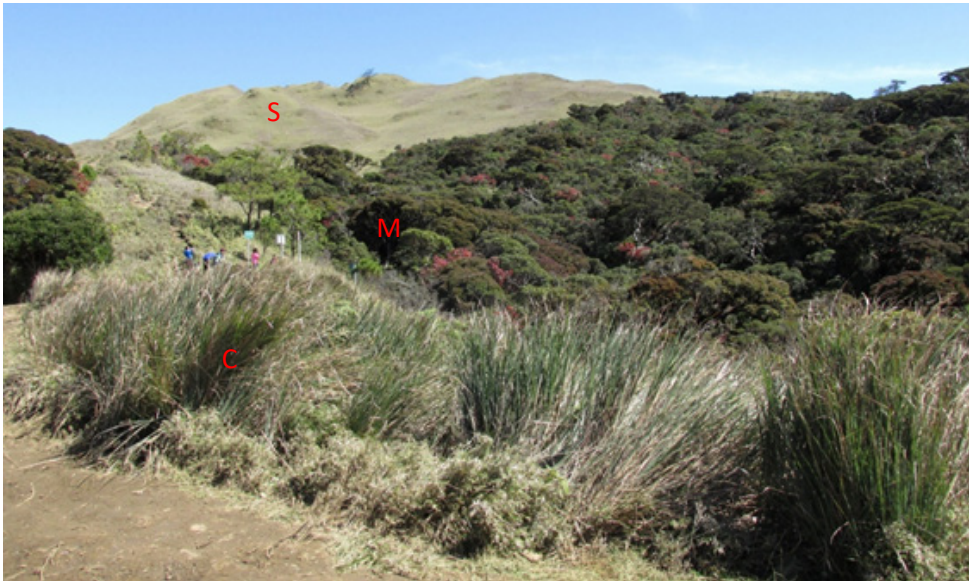

Figure 1 Foreground up, the campsite area (C) at the fringe of the grassland, mossy forest (M), and open grassland leading to the summit (S) of Mt. Pulag

Results and discussion

The harsh condition in the open grassland of the summit allowed only the growth of a small herb, erect with minimal branching and with compressed internodes (S). The plants thrived well, more of a woody shrub than a suffrutescent herb, at the fringe of the grassland where trees of the mossy forest provided protection from strong winds. Branching was pronounced and internodes compressed (C). Inside the mossy forest along the trail, the plant featured a decumbent habit apparently growing towards open areas where sunlight was available. Other features that are distinct in each of these ecotypes are presented in Table 1.

Star-shaped yellow flowers were borne at the terminal of the branches and these develop into red berries. As expected the highly branched bush growth of plants at campsite bore plenty of flowers. Flowers were hardly encountered in the mossy forest and grassland areas.

Figure 2 Habit of *H. pulogense* ecotypes growing at the fringe of the grassland (C), at the summit (S) and in the mossy forest (M)

Table 1 Variations in morphological characteristics of *H. pulogense* ecotypes (n = 10)

Characteristics	Campsite (C)	Summit (S)	Mossy forest (M)
Plant height	85 cm	15 cm	30 cm
Habit	Shrub, erect	Herb, erect	Woody herb, branches decumbent
Branching	Pronounced	Rare	Moderate
Leaf types	2	1	2
Leaf size(s)	1.7 x 1.0 cm 1.0 x 0.4 cm	0.8 x 0.2 cm	1.4 x.0.7 cm 1.0 x 0.4 cm
Internode	Compressed	Compressed	Extended

The leaves of the three ecotypes were as previously described: chartaceous to subcoriaceous, elliptic to oblong-elliptic, obtuse, sometimes slightly retuse, sessile but not connate, slightly glaucous and strongly glandular beneath (Merrill and Merritt 1910). Phyllotaxy was decussate. In the mossy forest, change in leaf size was apparent with bigger leaves developing in shaded areas. The corresponding internodes were extended. The bushy habit and apparent advanced age, as evidenced by its height and thick stem, resulted in two sizes of leaves of plants at the campsite. The big leaves were attached to the main stem while smaller ones were at the branches.

H. perforatum leaves, when viewed against the light, showed red dots where the red hypericin is contained in oil glands. In the case of *H. pulogense*, the dots on the leaves were not red. Under the microscope, these appear as empty glands (Fig. 3).

Figure 3 Oil glands of *H. pulogense* devoid of hypericin

This observation was confirmed by thin layer chromatography. Leaf extracts of *H. perforatum* showed the red band of hypericin at Rf 0.9 (arrow) when viewed under visible light. This band was absent in the three extracts of *H. pulogense* ecotypes (Fig. 4). The red band at Rf 0.3 of the leaves of plants from mossy forest was due to another pigment which was also present in the stem.

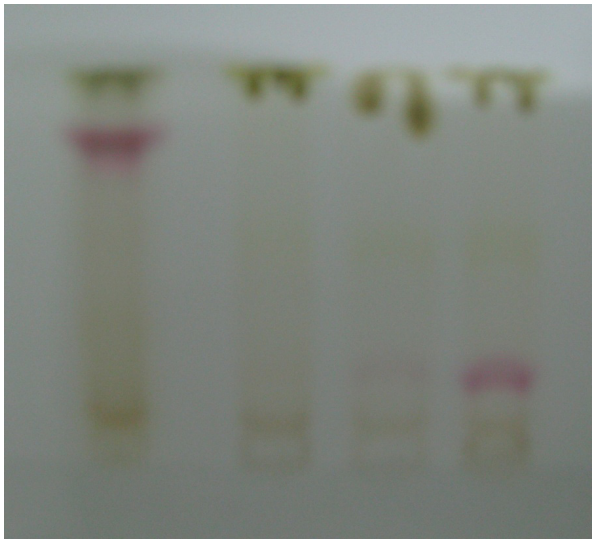

Figure 4 Chromatograms of flower extract of *H. perforatum* (Std) and leaf extracts of the three ecotypes (C, S and M) of *H. pulogense* with red hypericin (arrow) at Rf 0.9 viewed under visible light

Sprayed with Natural Products/PEG reagent to enhance visualization and viewed under UV_{365}, hypericin of the standard at Rf 0.9 fluoresced red. No hypericin bands appeared in the three other extracts (Fig. 5). Under UV light, the chromatogram of the *H. perforatum* standard to detect hypericin differed from the other three chromatograms of *H. pulogense* because flower was used. Flowers were sparse for two of the three ecotypes of *H. pulogense*; hence, the use of leaf extracts. It was noted that *H. pulogense* flowers encountered in the field did not exhibit the red dots indicative of hypericin. The chromatograms of the three *H. pulogense* ecotypes viewed under UV_{365} were similar and conformed with the published chromatogram of *H. perforatum* herb. Light blue fluorescing band of chlorogenic acid was at Rf 0.45 while flavonoids fluorescing in different colors were in the Rf 0.6 – 0.8 range. All these structures exhibited quenching when viewed under UV_{254}.

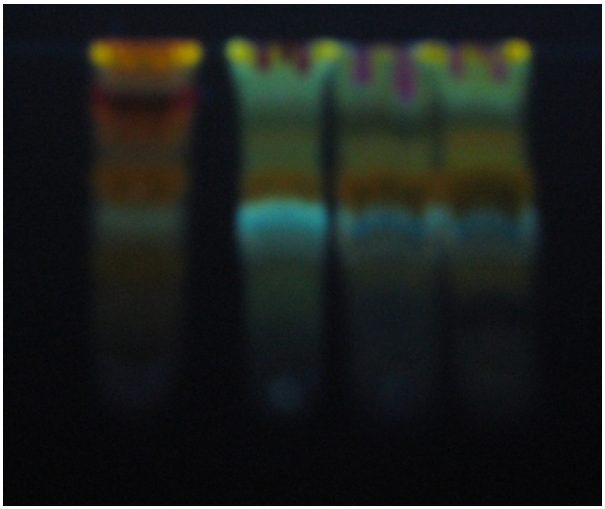

Figure 5 Chromatograms of leaf extracts of the three ecotypes of *H. pulogense* (C, S and M) with chlorogenic acid at Rf 0.45 and flavonoids in the Rf 0.6 – 0.8 range viewed under UV365. Hypericin (arrow) was absent in *H. pulogense*. Flower extract of *H. perfora*

Conclusion

The plasticity of some morphologic characters of *H. pulogense* was best exhibited in the distinct vegetation zones of Mt. Pulag, Benguet. The variation in habit, in particular, showed the adaptation of the plant species to the varied growth conditions prevailing in the different vegetation zones. It was the lone species of the genus described by Merrill and Merritt (1910) in this area. It is notable that the tall plants growing at the fringe of the grassland, almost double in height than the upper height range limit given by these authors, may have developed and colonized the area in the last few decades. These plants with thicker stems are obviously older than the plant samples observed at the summit and in the mossy forest. At the exposed summit and inside the mossy forest, the plant had no chance of reaching advanced age nor robust stature. The increase in number of visitors in Mt. Pulag in recent decades may have contributed to this thriving *H. pulogense* population at the fringe of the grassland where the conditions favor better plant growth.

H. pulogense does not contain the anti-depressant hypericin just like the few other Southeast Asian species that have been studied (Brink 1999). There is no report on its local medicinal use. Nevertheless, the absence of hypericin does not negate its

potential biological activities as shown in the other SEA species. Conservation of this plant species may not be an urgent concern at the moment since it continues to thrive at the high elevations of Mt. Pulag where it has been first described over a hundred years back. Further study of its bioactive constituents may be of merit.

Acknowledgment

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