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Responses of fruit bats to physical factors of selected forest patches in Mt. Kitanglad Range, Bukidnon, Philippines

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Abstract

Fruit bat species playing a vital role in forest regeneration are affected by the physical factors in the remaining tropical forest patches influenced by the anthropogenic activities in Mt. Kitanglad Range. Fruit bats were surveyed in the selected forest patches along the increasing elevation characterized by varied temperature, humidity and rainfall. Mist-netting method was done to capture fruit bats for wet and dry seasons in a year in Mt. Kitanglad Range. A total of nine (9) species of fruit bats under Family Pteropodidae such as *Ptenochirus jagori* (Greater Musky Fruit Bat), *Ptenochirus minor* (Lesser Musky Fruit Bat), *Alionycteris paucidentata* (Mindanao Pygmy Fruit Bat), *Haplonycteris fischeri* (Philippine Pygmy Fruit Bat), *Cynopterus brachyotis* (Common Short-Nosed Fruit Bat), *Rousettus amplexicaudatus* (Geoffroy's Rousette), *Macroglossus minimus* (Long-Tongue Nectar Bat), *Harpyionycteris whiteheadi* (Harpy Fruit Bat) and *Megaerops wetmorei* (White-Collared Fruit Bat) were recorded in all elevations in Mt. Kitanglad Range for both seasons. Based on the netting effort, fruit bats were not affected by seasonal variation in the selected forest patches at all elevations given the foraging, roosting and breeding sites. Fruit bats distribution showed positive correlation to temperature but negatively correlated to elevation, relative humidity and rainfall patterns in forest patches. Thus, forest patches provided habitat for fruit bats with favourable climatic conditions in different elevation. This study would recommend protection of forest patches in the higher elevation and reforestation of degraded areas in highly threatened lowland areas of Mt. Kitanglad Range.

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Introduction

The Philippines has diverse habitat ecosystems and forest types attributed to its topography and climatic conditions that contribute to the rich biodiversity. The Philippines is home to 180 species of mammals, of which 115 (57%) species are endemic. Mt. Kitanglad holds 53 native species and five (5) non-native species of mammals (Heaney *et al.,* 2006). However, due to human activities, the tropical forest in the country has been threatened by agricultural encroachment, growing population and low level of protection in the present times. Mt. Kitanglad forest had been logged commercially in the past which led to the land-use conversion at present (Opiso *et al.*, 2014; Rola *et al.*, 20014; Lopez *et al.*, 2014). This resulted to the threatened remaining forest patches and mammals that provide ecosystem services surrounded by farms, human settlements and other non-forest land-uses. Forest fragmentation becomes one of the greatest threats to biodiversity in the tropical forest (Bierregaard, 2001) and a major threat to terrestrial biodiversity (Armsworth *et al.*, 2004).

Human land uses tend to expand over time, so forests that share a high proportion of their borders with anthropogenic uses such as urban or agriculture are at higher risk of further degradation (Wade, 2003). Severe fragmentation of remaining forests may occur as small patches which have large perimeter ratios surrounded by agricultural or other non-forest lands are more readily cleared than large blocks of forest (Liu *et al.*, 1993). Reduction of biodiversity in fragmented areas may not be due to the amount of forest area or cover but more importantly to the increased perimeter to area ratio and the change in abiotic and biotic factors at the forest edge (Laurance and Yensen, 1991) which is different relative to the interior environment. These abiotic factors include light, air temperature, soil moisture and humidity (Gehlhausen *et al.*, 2000). The plant community may be modified as well due to changes in microclimate at forest edges which are different from that in the forest interior (Noss and Cooperrider, 1994; Harris 1984). Edges bordered by agricultural fields have more extreme changes in microclimate than those bordered by trees. Edge effects alter the conditions of the outer areas reducing the amount of true forest interior habitat (Harris, 1984).

The forest patches as a result of habitat fragmentation brought about by anthropogenic activities may serve as the habitat of fruit bats, which are important seed dispersers, aiding the diversity of fruiting trees (Hill and Smith, 1984; Nowak, 1991). Fruit bats may seek foraging areas in forest patches which coincided with their breeding ability in their roosting sites. The reproductive behaviour of fruit bats is dependent on the availability of food. In this breeding period, bats feed on figs and other fruit trees which are good sources of calcium, amino acids and fiber (Ratcliffe and Hofstede, 2005). As the forest-edge effects change the microclimate of forest patches which led to the invasion of exotic plants and opportunistic species, fruit bats become threatened. Forest fragmentation attributed largely due to deforestation may contribute to climate change (Bagarinao, 2010) and loss of biodiversity. Hence, the objective of this study is to survey fruit bats in different forest patches in Mt. Kitanglad Range with varied climatic conditions for dry and wet seasons along the increasing elevation affecting their distribution.

Materials and methods

Study Area Description

Mt. Kitanglad of Mindanao Faunal Region (Heaney *et al.*, 2006) located at the southern portion of the Philippines is characterized by three major vegetation types such as mossy, montane and lowland dipterocarp forest attributed to the tropical climate and mountainous topography (Fig. 1). Around 11 sites were selected from secondary to old-growth lowland dipterocarp forest (Site 3-11), montane forest (Site 2) and mossy forest (Site 1) from lower to higher elevations (Table 1). According to the Protected Areas and Management Board of Mt. Kitanglad Range Natural Park (PAMB-MKRNP), Sites 1, 2 and 10 have a closed canopy forest with more than 50% mature forest at the highest elevations. Sites 3, 4, 5 and 6 have an open canopy with less than 50% forest cover in the lower elevation. Sites 7, 8, 9 and 11 have cultivated areas with grasslands and brush lands at the lowest elevation sampled. The coordinates and elevation of each site were obtained using the Global Positioning System (GPS). The sampling was done during the months of Oct.-Nov. 2012 (1st quarter) and Aug.-Sept. 2013 (4th quarter) for the wet season, while Jan.-Feb. (2nd quarter) and April-May 2013 (3rd quarter) for the dry season. Available daily, monthly or yearly temperature, humidity and rainfall data were gathered from the nearest Meteorological Station of PAG-ASA in Malaybalay City. Specific air temperatures per site were also taken for two (2) seasons in a year in Mt. Kitanglad Range.

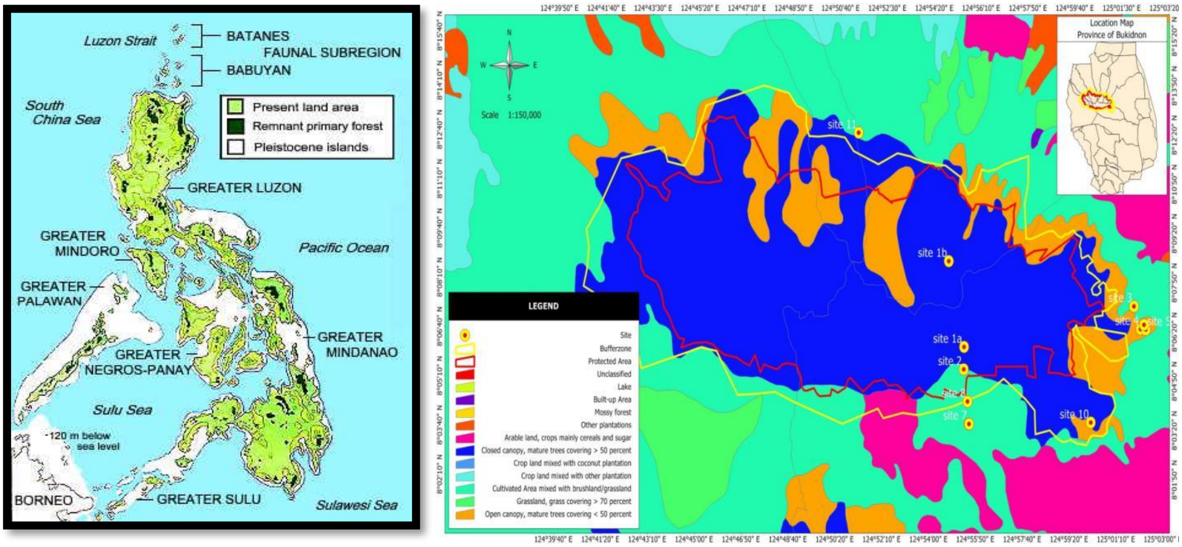

Fig. 1. Location of the selected sampling sites in different representative forest cover along the increasing elevation in Mt. Kitanglad Range, Bukidnon, Mindanao, Philippines (Heaney *et al.*, 1998 and PAMB-MKRNP).

Table 1. Habitat characteristics of each site sampled for wet and dry seasons in Mt. Kitanglad Range on 2012-13.

Vegetation cover and estimated size	Coordinates and elevation	Mountain range, brgy. And municipality	Sampling period		Rainfall (mm)		Relative humidity (%)		Temperature on-site and off-site (°c)		Threats
			Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	
Site 1 Upper montane forest (2,000ha)	08° 08' 25.9" N, 124° 54' 54.3" E, 2,172-2,903masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan and Mt. Kitanglad, Sumilao	Oct. 27-31, 2012	Jan. 28-31, 2013	3.9	39.4	86.2	90.5	15.0 (23.7)	09.0 (22.8)	Presence of tourists, forest fire, typhoons, government- owned
Site 2 Lower-middle montane forest (25,000ha)	08° 05' 07.8" N, 124° 55' 27.25" E, 1,915 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	Nov. 23-27, 2012	Feb. 1-2, 2013	4.4	8.8	86	92	18.3 (24)	14.0 (24.5)	Presence of tourists, typhoons, government- owned
Site 3 Secondary forest (28ha)	125° 23' E, 8° 6' 12" N, 1,225 masl	Mt. Kitanglad, Brgy. Imbayao, Malaybalay City	Nov. 3-7, 2013	Feb. 19-22, 2013	19.2	122.6	89.4	84.25	17.0 (23.4)	19.3 (23.8)	Human settlements, farms, typhoons, privately-owned
Site 4 Small riparian forest (1ha)	125.03768 E, 08.10538 N, 1,231 masl	Mt. Kitanglad, Brgy. Imbayao, Malaybalay City	Nov. 10-12, 2013	Feb. 19-22, 2013	0.4	0.8	87.33	84.25	20.0 (24.3)	19.3 (23.8)	Human settlements, farms, typhoons, privately-owned
Site 5 Secondary forest (12ha)	125.04099 E, 08. 10511 N ,1,205 masl	Mt. Kitanglad, Brgy. Imbayao, Malaybalay City	Nov. 12-14, 2012	Feb. 19-22, 2013	7.7	0.8	88.67	84.25	27.5 (24.4)	19.3 (23.8)	Human settlements, farms, typhoons, privately-owned
Site 6 Large riparian forest (5ha)	125.03991 E, 08. 10754 N, 1,219 masl.	Mt. Kitanglad, Brgy. Imbayao, Malaybalay City	Nov. 14-16, 2012	Feb. 19-22, 2013	9.9	0.8	92	84.25	20.5 (22.6)	19.3 (23.8)	Human settlements, farms, typhoons, privately-owned
Site 7 Small riparian forest with agroforestry (8ha)	08° 03' 28.3" N, 124° 55' 38.4" E ,1,332 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	Nov. 17-19, 2012	Feb. 1-3, 2013.	10.5	0	87.67	80	20.5 (24.1)	18.5 (24.6)	Human settlements, farms, typhoons, privately-owned
Site 8 Small riparian forest (3ha)	08° 04' 08.9" N, 124' 55' 36.0" E, 1,505 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	Nov. 19-21, 2012	Feb. 2-4, 2013	68.1	0	90.67	81.25	17.0 (22.7)	16.0 (24.7)	Human settlements, farms, typhoons, privately-owned
Site 9 Large riparian forest (10ha)	08° 03' 28.1" N, 124° 55' 38.9" E, 1,340 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	Nov. 21-23, 2012	Feb. 3-4, 2013	1.6	0	88	83	17.5 (23.5)	18.0 (24.7)	Human settlements, farms, typhoons, privately-owned
Site 10 Cinchona forest reserve (2800ha)	8° 3' 24" N and 125° 00 24" E, 1,266 masl	Mt. Dulang-Dulang, Brgy. Kaatuan, Lantapan	Sept. 19-20, 2013	April 11-13, 2013	0	0.4	87	84.7	19.5 (24.1)	19.5 (24.3)	Human settlements, farms, typhoons, government- owned
Site 11 Remnant secondary forest (15ha)	124° 51.46 E, 08°12.356 N, 1,432 masl	Mt. Kitanglad, Brgy. Dahilayan, Manolo Fortich	Sept. 13-14, 2013	April 13-15, 2013	10.8	18	88	84.7	21 (25.4)	21 (25.3)	Presence of tourists, human settlements, farms, typhoons, privately owned

Collection of Fruit Bats and Data Analysis

The mist-netting method was employed to capture fruit bats (Bennett *et al.*, undated) in each site in one year with 372 net-nights for the wet season and 150 net-nights for the dry season (Table 2). A total of 102 and 75 mist nets for the wet and dry seasons, respectively were placed along the forest edge towards the interior. Mist nets were left open for 38 nights for the wet season and 25 nights for the dry season from 5PM-6AM. The nets were checked every 30 minutes or on a one hour interval from 6:00-10:00PM and from 4:00-6:00AM. All captured bats were retrieved from the mist nets and identified to the species level based on its distinguishing phenotypic characteristics and morphometrics (Ingle and Heaney, 1992). Species composition, abundance, richness, diversity and endemicity were determined and correlated to the physical factors of each habitat sampled such as elevation, temperature, relative humidity and rainfall for wet and dry seasons.

Table 2. Netting efforts of fruit bat collection per site per season in Mt.Kitanglad Range on 2012-13.

Sampling period	Wet Season (1ST AND 4TH QUARTERS) (OCT-NOV. 2012, AUG.-SEPT 2013)			DRY SEASON (2ND AND 3RD Quarters) (JAN-FEB., APRIL-MAY, 2013)		
Sampling sites	No. of mist nets used	No. of sampling nights	Total Netting Nights	No. of mist nets used	No. of sampling nights	Total Netting Nights
Site 1: Upper Montane forest (Brgy. Songco, Lantapan)	10	4	40	10	3	30
Site 2: Lower-Middle Montane forest (Brgy. Songco, Lantapan)	10	4	40	7	1	7
Site 3:Mixed Lowland Forest (Brgy. Imbayao, Malaybalay)	10	4	40	6	3	18
Site 4: Riparian Forest Fragment 1 (Brgy. Imbayao, Malayblay)	10	4	40	3	3	9
Site 5: Remnant Lowland Forest Fragment 2 (Brgy. Imbayao, Malaybalay)	10	4	40	3	3	9
Site 6: Riparian Forest Fragment 3 (Brgy. Imbayao, Malaybalay)	10	4	40	3	3	9
Site 7: Remnant Riparian Forest Fragment 4 (Brgy. Songco, Lantapan)	10	4	40	8	2	16
Site 8: Mixed Secondary Remnant Riparian Forest Fragment 5 (Brgy. Songco, Lantapan)	10	4	40	7	2	14
Site 9: Remnant Riparian Forest Fragment 6 (Brgy. Songco, Lantapan)	10	4	40	8	1	8
Site 10: Secondary Forest Reserve (Brgy. Kaatuan, Lantapan)	6	1	6	10	2	20
Site 11: Remnant Forest (Brgy. Dahilayan, Manolo Fortich)	6	1	6	10	2	20
Total/season/site:	102	38	372	75	25	150

Legend: netting nights=no. of mistnets used x no. of sampling nights

Results and discussions

Species Composition per Season Among Forest Patches

A total of nine (9) species of fruit bats such as *Ptenochirus jagori* (Greater Musky Fruit Bat), *Ptenochirus minor* (Lesser Musky Fruit Bat), *Alionycteris paucidentata* (Mindanao Pygmy Fruit Bat), *Haplonycteris fischeri* (Philippine Pygmy Fruit Bat), *Cynopterus brachyotis* (Common Short-Nosed Fruit Bat), *Rousettus amplexicaudatus* (Geoffroy's Rousette), *Macroglossus minimus* (Long-Tongue Nectar Bat), *Harpyionycteris whiteheadi* (Harpy Fruit Bat) and *Megaerops wetmorei* (White-Collared Fruit Bat) of family Pteropodidae were recorded in all forest patches of Mt. Kitanglad for all seasons (Table 3). These species make up 28.1% of the total bat species in Mt. Kitanglad (Heaney *et al.*, 2006), 17.3% of the total species recorded in the Mindanao Faunal Region (Silvosa *et al.*, 2004) and 11.7% of the total species in the Philippines (Heaney *et al.*, 2006). There were five (5) species such as (*P. jagori, P.minor, C. brachyotis, H. fischeri* and *M. minimus*) documented on both seasons. *R. amplexicaudatus* and *H. whiteadi* were not documented during the wet season while *M. wetmorei* and *A. paucidentata* were absent during the dry season (Table 3). This meant that there were equal numbers of species found in per season but species composition differed depending on their tolerances to disturbance and presence of food items. According to Bonaccorso *et al.*, 2002, fruit bats are able to consume five (5) to 20 fruits per night of the *Ficus* which produce tens to thousands of fruits every seven (7) to ten (10) days all year around.

Table 3. Taxonomic classification, geographical distribution and conservation status of fruit bats species documented in forest patches per season in Mt. Kitanglad Range on 2012-13.

Scientific Name	Common Name	Geographical Distribution (Heaney *et. al.*, 2010)	Conservation Status (IUCN Red List 2014 and DENR- DAO 2014-15)	Sampling Sites Documented	Wet season	Dry season
P. jagori	Greater Musky Fruit Bat	Philippine Endemic	Least Concern	3,4,5,7,8,9,10	Present	Present
H. whiteheadi	Harpy Fruit Bat	Philippine Endemic	Least Concern	11	Absent	Present
H. fischeri	Philippine Pygmy Fruit Bat	Philippine Endemic	Least Concern	2,3,4,7,8,9,10,11	Present	Present
A. paucidentata	Mindanao Pygmy Fruit Bat	Mindanao Faunal Region Endemic	Least Concern	1,3,7	Present	Absent
P. minor	Lesser Musky Fruit Bat	Mindanao Faunal Region Endemic	Least Concern	4,5,6,7	Present	Present
M.wetmorei	White-Collared Fruit Bat	Mindanao Faunal Region Endemic	Vulnerable	3,6,7	Present	Absent
M. minimus	Long-Tongue Nectar Bat	Non-Endemic	Least Concern	3,4,5,6,7,9,10,11	Present	Present
R.amplexicaudatus	Geoffroy's Rousette	Non-Endemic	Least Concern	7	Absent	Present
C.brachyotis	Common Short-Nosed Fruit Bat	Non-Endemic	Least Concern	3,4,5,6,7,9,10,11	Present	Present

Species Richness, Abundance, Diversity and Endemicity per Season among Forest Patches

Based on the netting effort, there were more species documented during the dry season (1.75) than during the wet season (1.47) (Fig. 3). The highest number of species was recorded in Site 4 (0.25) while none in Site 10 (0) during the wet season. During the dry season, Site 5 (0.33) had also the richest species while none in Sites 1 and 2 (0). Fruit bats were more abundant during the wet season (4.89) than during the dry season (4.32). Fruit bats were most abundant in Site 4 (1.6) while scarce in Site 2 (0.05) during the wet season. On the other hand, fruit bats were most abundant (1.75) in Site 10 while lowest (0.14) in Site 8 during the dry season. There was no significant difference (p>0.05) of the abundance and richness of fruit bats between seasons. This result meant that species richness and abundance are not affected by seasonal variation in which suggested a continuous food and roosting sites throughout the year in Mt. Kitanglad Range.

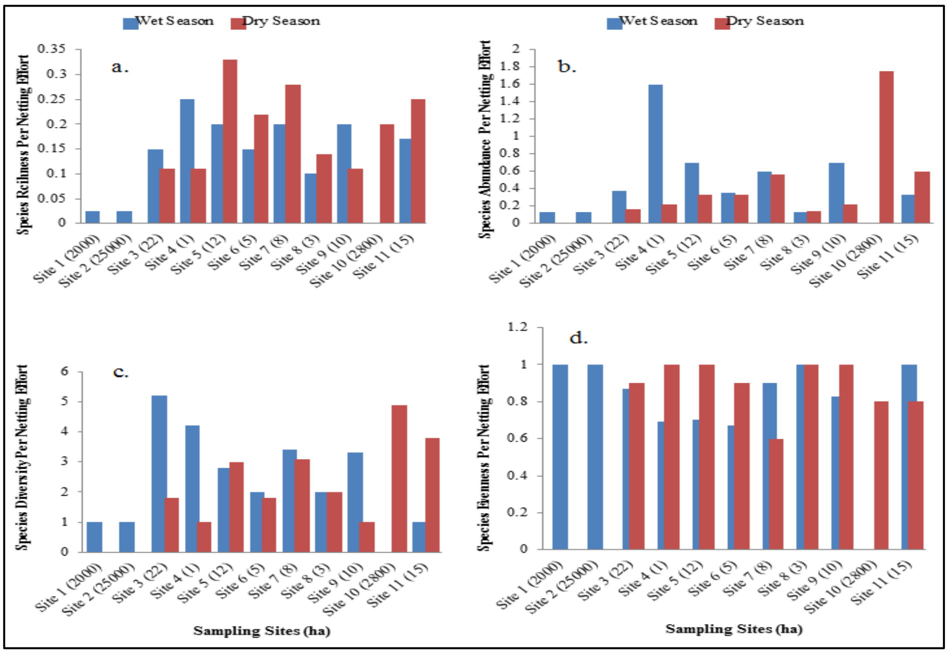

Fig. 2. Species richness (a), abundance (b), diversity (c) and evenness (d) per netting effort per forest patch per season in Mt. Kitanglad Range on 2012-13.

Based on the netting effort, Site 3 had the highest species diversity (5.2) while Site 10 had the lowest (0) during the wet season. Site 10 had the highest species diversity (4.9) while Sites 1 and 2 had the lowest (0) during the dry season. Sites 1, 2, 8 and 11 had the highest evenness (1.0) during the wet season while Site 10 had the lowest (0) among the sites sampled per netting effort. Sites 4, 5, 8 and 9 had the highest evenness (1.0) while Sites 1 and 2 had zero have the lowest (0) during the dry season. There was no significant difference (p>0.05) of species diversity and evenness between seasons. This result showed that small forest habitats have diverse and even fruit bats that are highly tolerant to anthropogenic disturbances than to large and continuous forest with more endemic species that are sensitive to disturbances.

Among the forest patches, Sites 3, 6 and 7 had the highest Mindanao endemics (0.05) while absent in Sites 2, 8, 9, 10 and 11 during the wet season based on the netting effort (Table 13). Sites 4 and 6 had the highest Mindanao endemics (0.11) while absent in Sites 1, 2, 3, 5, 8 and 9 during the dry season (Fig. 3). Site 11 had the highest endemic species to the Philippines (0.17) while Sites 1, 6 and 10 did not have any during the wet season. Similarly, Site 11 had also the highest Philippine endemics (0.15) while Sites 1, 2, 3, 4 and 6 did not have these species during the dry season. Non-endemic species were dominant in Sites 4, 5 and 9 (0.05) while none occurred in Sites 1, 2, 8, 10 and 11 during the wet season. Site 5 had also the highest non-endemics (0.22) during the dry season while Sites 1, 2, 4, 8 and 9 did not have any.

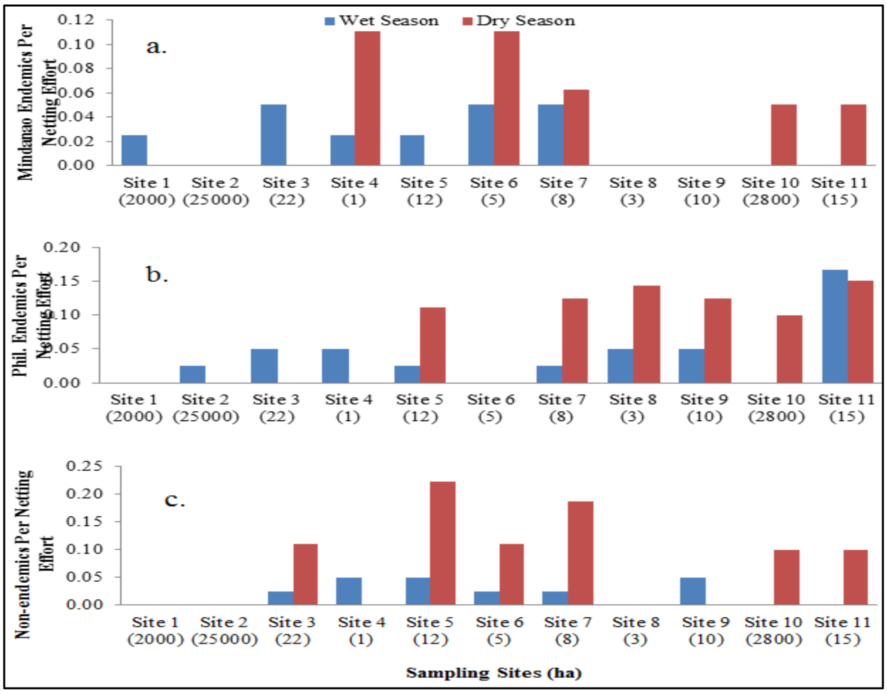

Fig. 3. Mindanao faunal region (a) and Philippine (b) endemics and non-endemics (c) per netting effort per forest patch per season in Mt. Kitanglad Range on 2012-13.

There was no significant difference (p>0.05) of endemic species between seasons. These meant that endemic species were not affected by seasonal variation and live in the forest patches sampled. However, there was a significant difference (p<0.05) of nonendemic species between seasons and among sites. This implied that small forest patches harbor lesser endemic fruit bats and more non-endemic species.

Forest interior or dependent species are sensitive to forest edges (Juliani *et al.*, undated) unlike edge species (Kays *et al.*, 1999). Rich assemblages of large number of forest-dependent, disturbance-sensitive species were found in areas with greater forest cover (Faria *et al.*, 2007).

Responses of Fruit Bats to Elevation and Climatic Factors per Season among Forest Patches

Mt. Kitanglad has the second highest elevation (2,938 masl) in the Philippines characterized by a Massenerhebung (mountain mass) effect wherein vegetation zones move upwards on large high mountain ranges (Heaney *et al*., 2006).

The sampling areas were located at the lower to higher elevations which ranged from 1163 (Site 11) to 2538 masl (Site 1) with dipterocarp, montane and mossy forests. All species except *A. paucidentata* and ecological measures of fruit bats showed negative correlation to elevation similar to the study of Rickart *et al*. (1993) and Relox *et al*. (2009) that species richness and abundance were decreasing with elevation (Fig. 4). These results showed that the lower elevation with small forest patches harbored more species and individuals. But, Mindanao endemic bats were confined in the higher elevation while Philippine endemics were at the relatively lower elevation. Mindanao and Philippine endemic species co-existed with the non-endemic species at the lower elevation with small forest habitats. Diversity and evenness of bats were remarkably higher in the lower elevation with small forest patches but lower at higher elevation with intact forest in the presence of foraging and roosting sites despite the habitat disturbances.

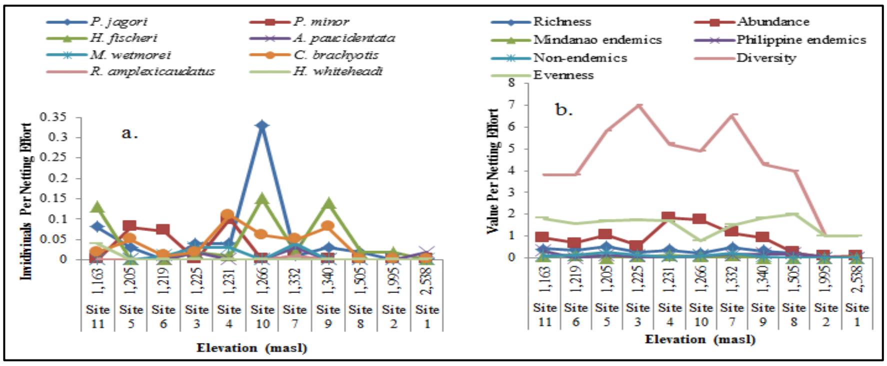

Fig. 4. Species (a) and ecological (b) responses of fruit bats per netting effort to increasing elevation in Mt. Kitanglad Range on 2012-13.

The highest temperature was recorded in Site 5 with 27.5°C while the lowest in Site 1 with 15°C during the wet season. The highest temperature was also recorded in Site 11 with 21°C while lowest in Site 1 with 9°C during the dry season. There was no significant difference (p>0.05) of temperature readings between seasons. The average temperature ranged from 12 (Site 1) to 23.4°C (Site 5) for both seasons. The temperature was significantly different (p<0.05) among sites. This meant that there was a low temperature in the highest elevation sampled with mossy forest while there was a high temperature in the lower elevation with small forest patches (Fig. 5).

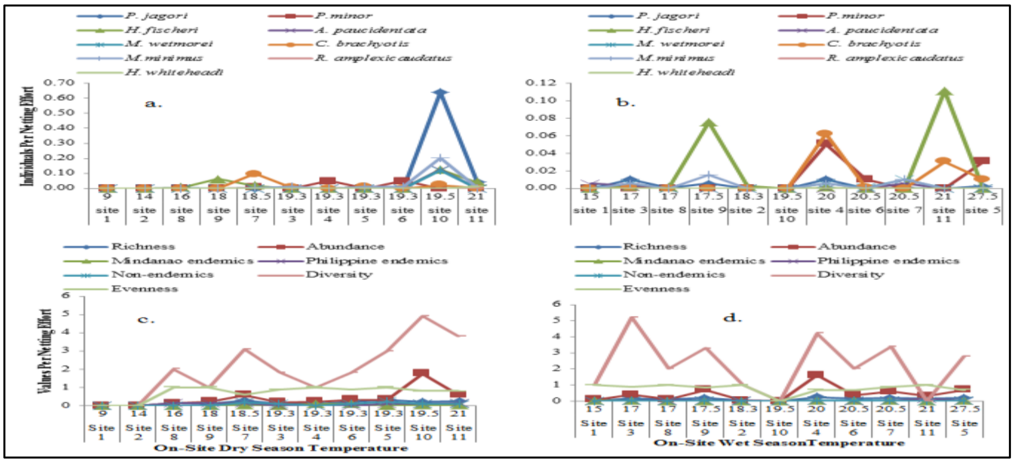

Fig. 5. Species (a and b) and ecological (c and d) responses of fruit bats per netting effort per season to increasing temperature in Mt. Kitanglad Range on 2012-13.

All species, except *A. paucidentata* (-0.323), and ecological measures of fruit bats showed positive correlation with temperature. This meant that majority of the fruit bat species tolerated high temperature except for the Mindanao endemic species, *A. paucidentata* that was observed to inhabit higher elevation with low temperature through thermoregulation or roosting in colonies (Heideman and Utzurrum, 2003). The lower elevation with tolerable temperature had been preferred by most species of bats, both endemic and non-endemic species. The high temperature in the forest patches may have large impacts to endemic fruit bats as compared to the low temperature in the large forest areas. Fruit bats could be affected by the increasing temperature by aggravating the microclimate changes in the small forest patches brought about by the edge effects affecting the tolerable limits of fruit bats.Among the sites sampled, Site 6 had the highest relative humidity (92%) while Sites 1 and 2 have the lowest (86%) during the wet season based on the relative humidity data from the nearest meteorological station, PAG-ASA, Malaybalay City, Bukidnon (Fig.s 6). On the other hand, Site 2 had the highest relative humidity (92%) while Site 7 had the lowest (80%) during the dry season. The average relative humidity ranged from 84 (Site 7) to 89% (Site 2) for both seasons.

There was a significant difference ($p<0.05$) of relative humidity between seasons and among sites.

Results showed that relative humidity was higher at the higher elevation than the lower elevation and also higher during the wet season than the dry season. All species and ecological measures of fruit bats exhibited negative correlation against the relative humidity. This showed that all species of fruit bats cannot tolerate high relative humidity at the higher elevation and during the wet season. This climatic condition may limit their distribution to the lowland dipterocarp forest with low amount of moisture attributed to the high evaporation rate relative to high temperature. As the temperature increased, the relative humidity also increased which may affect the tolerable range of fruit bats.Based on the rainfall data obtained from the nearest meteorological station of PAG-ASA, Malaybalay City, Bukidnon, the highest rainfall (68.1mm) occurred in Site 8 while the lowest (0.4mm) was in Site 4 during the wet season (Fig. 7). During the dry season, Site 3 had the highest rainfall (122.6mm) while none in Sites 7 to 9. There was no significant difference ($p>0.05$) between seasons on the amount of rainfall. The average rainfall ranged from 0.2 (Site 10) to 70.9mm (Site 3) for both seasons. There was a significant difference ($p<0.05$) of the average rainfall among sites.

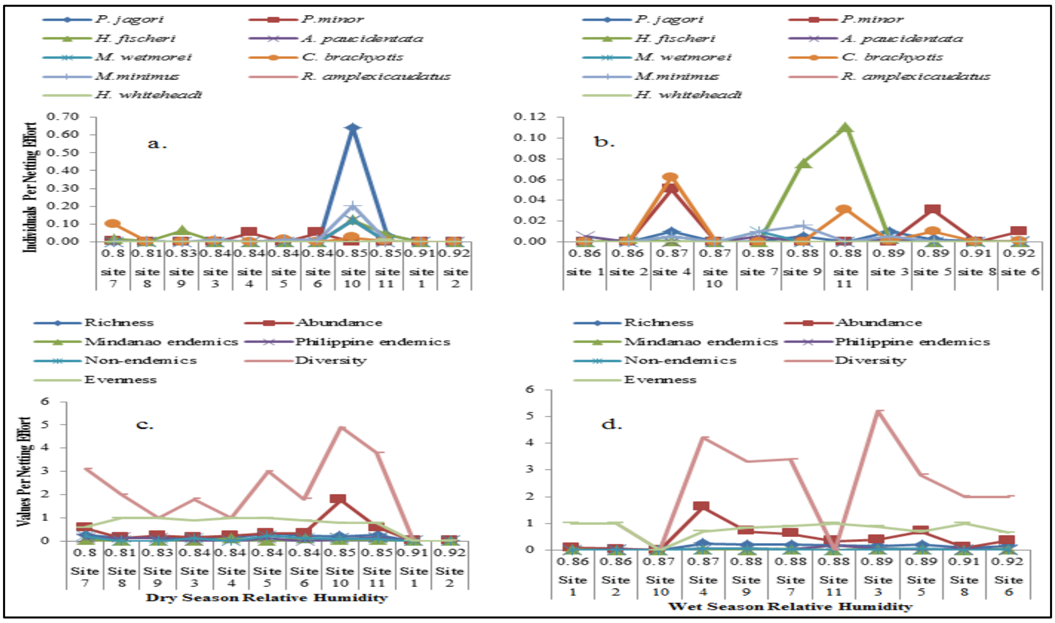

Fig. 6. Species (a and b) and ecological (c and d) responses of fruit bats per netting effort per season to increasing relative humidity in Mt. Kitanglad Range on 2012-13.

Heavy rains mostly occurred at the higher elevations than in the lowlands during the wet season than the dry season. All species except *A. paucidentata* (0.40) and *M. wetmorei* (0.23), and ecological measures of fruit bats, except diversity and evenness, had a negative correlation to rainfall.

Mindanao endemic species, diverse and even fruit bats tolerated rainy nights. Species richness and abundance decrease as rainfall increased. This could be enhanced by the higher precipitation, strong wind speed and frequent storms which may reduce this bat population.

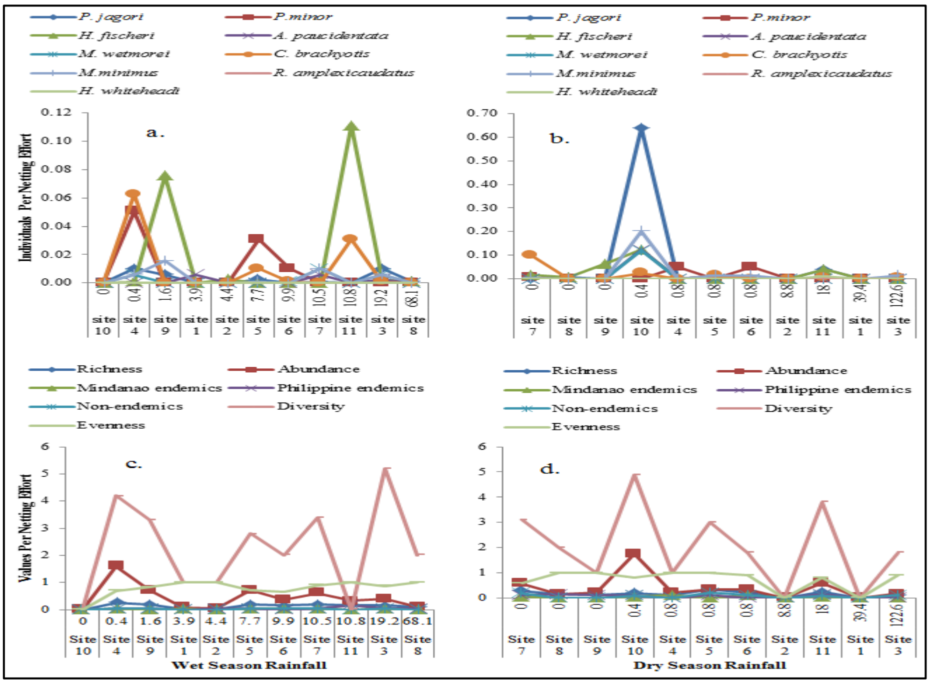

Fig. 7. Species (a and b) and ecological (c and d) responses of fruit bats per netting effort per season to increasing rainfall in Mt. Kitanglad Range on 2012-13.

Conclusions and recommendations

Therefore, forest patches support fruit bat species not affected by seasonal variation in the presence of continuous food supply, lesser roosting disturbances and available breeding areas at all elevations throughout the year. The endemic fruit bats lived in forest patches with favourable climatic conditions along the elevational gradient in Mt. Kitanglad Range. This study would like to recommend protection of forest patches in the higher elevation and reforestation of degraded lowland forest such as carbon sequestration projects with the cooperation of the local residents to attain favourable climatic conditions for fruit bats in the advent of climate change.

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