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Responses of fruit bats to habitat quantity and quality of selected forest patches in mt. kitanglad range, Bukidnon, Philippines

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Abstract

Mega chiropterans maintain high quality and quantity of the remaining forest ecosystem in Mt. Kitanglad Range. Hence, this study determined the different species of fruit bats in forest patches with varied quantity and quality influenced by human activities. Mist-netting technique was used comprising a total of 522 net-nights established in selected forest patches in Mt. Kitanglad Range. Results showed three Mindanao Faunal Region endemic species (*Alionycteris paucidentata, Ptenochirus minor* and *Megaerops wetmorei*), three Philippine endemic species (*Haplonycteris fischeri, Ptenochirus jagori* and *Harpyionycteris whiteheadi*), and three non-endemic species (*Rousettus amplexicaudatus, Macroglossus minimus* and *Cynopterus brachyotis*). There were nine species under Family Pteropodidae Order Chiroptera. Endemic species dominated the large, diverse forest areas with minimal human activities while non-endemic species inhabited the small forest areas with high level of human disturbances such as agricultural encroachment and growing population densities. The presence of highly tolerant species despite human disturbances in small forest areas would indicate a relatively degrading forest habitat that in turn, may affect the ecosystem services provided by the forest ecosystem of Mt. Kitanglad Range. Thus, endemic fruit bats were associated to large forested areas rendering high quality ecosystem services. This study suggested urgent reforestation of degraded areas to attain high forest quality and quantity and stable ecosystem services.

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Introduction

The Philippines has high species and habitat diversity as a result of complex geological history, mountain formations, habitat types and climatic factors which contributed to the species that cannot be found elsewhere in the world. A rich terrestrial vertebrates of around 1,084 with almost 50% endemic species per unit area makes the archipelago as one of the megadiverse countries in the world (Heaney *et al.,* 1998). Of which, 74 were bat species, with 22 (30%) country and island endemic species (Heaney *et al.,* 1998). There are 52 species of bats in Mindanao with 42% country and island endemic species (Silvosa *et al.,* 2004).One of the major mountain ranges in Mindanao Faunal Region is Mt. Kitanglad which has rich flora and fauna that are important sources of ecosystem services needed by the people. It was protected by laws, policies and agreements at the local, national and international levels.

However, extensive logging in the past two decades significantly cleared large portions of the original forest covering the mountains leaving patches of forest in the Philippines. Several thousand hectares, particularly in the southwestern slopes of Mt. Kitanglad range, were subjected to commercial logging (Lopez *et al.,* 2014). Some areas were converted to agricultural, residential and industrial areas due to the growing human population and agricultural activities in Lantapan (Opiso *et al.,* 2014; Rola *et al.,* 2014) and other parts of Bukidnon province. As a result, the remnant forests are interspersed by the increasing sizes of grasslands, farms, human settlements and many other uses, even secondary forests have been subjected to further loss decimating endemic wildlife species and ecosystem services. The lowland dipterocarp forest becomes the most threatened habitats which are the main habitats of fruit bats (Relox *et al.,* 2009).

The growing number of threatened endemic species signals the degrading habitats hence the country becomes one of the hottest of the biodiversity hotspots in the world (Myers *et al.,* 2000). The consequent decline of the quality of living of the people indicated the weakening of the ecosystem services such as the occurrence of landslides, soil erosion, siltation, climate change, floods and many others, have threatened lives and properties which emanated from the loss of biodiversity. Indeed, the relationship between the forest habitats and biodiversity is directly proportional and interrelated to the ecosystem services.

The continuing human activities are proliferating around the range such as agricultural expansion, human settlements and lack of human protection which may negatively affect the local composition of wildlife as important part of the ecosystem. Fruit bats are economically beneficial as pollinators of fruit trees, dispersers of seeds of forest trees, and as a source of guano for fertilizer (*Heaney and* Heidemann, 1987). Forest patches as a result of land-use conversion are important habitats of the remaining wildlife species which are often neglected with low protection. The objective of this study is to assess the responses of fruit bat species in selected forest patches of Mt. Kitanglad Range to different forest quantity and quality.

Materials and methods

Habitat Assessment

Mt. Kitanglad Range is geographically locatedat 7° 21' to 8° 35' N and 124° 03' to 125° 16' Ecentral Mindanao of the southern portion of the Philippines with an elevation of 2,938 masl that serves as the major watershed area of the surrounding provinces, Davao, Misamis, Agusan and Cotabato (Figure 1). Mt. Kitanglad has diverse forest ecosystems with varied forest quantity and quality.

Forest quantity was determined using the representative areas and distances of forest patches. Among the sites sampled, large intact old-growth mossy (Site 1) and montane (Site 2) forests are located at the higher elevations enclosed as a protected area. These sites have been utilized for eco-tourism, cultural and communication activities with

minimal amount of disturbance. The lowland dipterocarp forest sampled (Sites 3-11) were outside the protected area of Mt. Kitanglad Range surrounded by the agricultural areas, human settlements and tourism activities with a heavy amount of habitat disturbance. Of which, Site 10 (2,800ha) which is known as the Cinchona Forest Reserve is the largest lowland dipterocarp forest located inside the buffer zone in the lower elevation while the other sites sampled (3, 4, 5, 6, 7, 8, 9 and 11) were outside the buffer zone with the forest area ranging from 1-22ha under the ancestral domains, tenured and untenured migrants around Mt. Kitanglad Range.

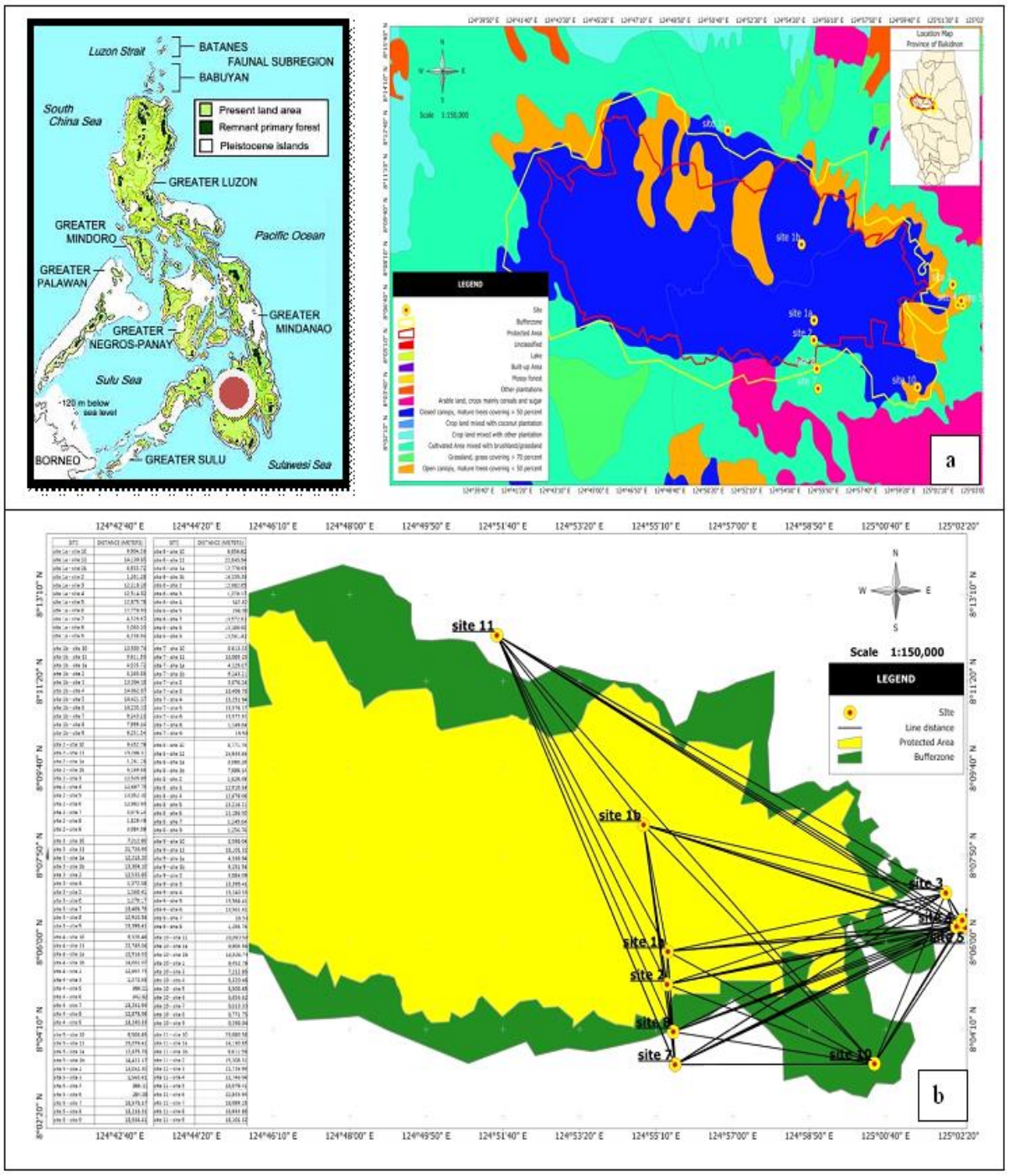

Fig. 1. Location of the selected sampling sites in different representative forest cover (a) and distances (b) in Mt. Kitanglad Range, Bukidnon, Mindanao, Philippines (Heaney *et al.,* 1998; PAMB-MKRNP).

The forest quality was measured based on vegetation analysis and secondary literatures (Table 1). The forest of Mt. Kitanglad is characterized by three (3) major vegetation and habitat types, namely mossy, montane and lowland dipterocarp forests. The lowland dipterocarp forests, with an elevation of up to 1,300 masl, are the most species-rich forest type and structurally the most complex dominated by dipterocarp species, such as *bagtikan, white* and *red lauan* and *yakal*. The higher elevation, composed of lower montane forest (1,300-2,300 masl), covers an approximate area of 25,000 ha and is characterized by a two-layered canopy dominated by Families Fagaceae, Lauraceae, Myrtaceae, Podocarpaceae and Clusiaceae. The highest elevation is composed of upper montane forest (2,300 to 2,900 masl) with abundant oaks, *Lithocarpus* spp. and *Syzigium* spp. are particularly abundant (Fernando *et al.,* 2006). In addition, the species of plants were verified using the point-centered quarter method (Serrano and Lastimosa, 1987). A single 50-m transect line was established in each forest patch in Mt. Kitanglad Range. Species composition, richness, diversity, evenness and food plants were determined per site.

Collection of Fruit Bats and Data Analysis

The mist-netting method was employed to capture fruit bats in each forest patch for one year with a total of 522 net-nights in Mt. Kitanglad Range (Table 2). A total of 177 mist nets were installed in each forest patch (Figure 2).Mist nets were left open for 63 nights from 5PM-6AMand were checked every 30 minutes or on a one hour interval from 6:00-10:00PM and from 4:00-6:00AM depending on weather and peace and order condition. All captured bats were retrieved from the mist nets and individually placed in cloth bags. Each individual was identified to the species level based on its distinguishing phenotypic characteristics and morphometrics (Ingle and Heaney, 1992). T-test was used to determine differences of species composition, richness, abundance, diversity, evenness and endemic city among forest patches. Correlation analysis was used to assess the relationship of fruit bats to the richness, diversity, evenness and food plants.

Results and discussion

Species Composition among Forest Patches

A total of nine (9) species of fruit bats under order Chiroptera 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 selected forest patches of Mt. Kitanglad from September 2012 to August 2013 (Figure 3).

As shown in the species effort curve of each site, the number of species increases at an early stage of the sampling period and eventually reached plateau at the later stage of the sampling period. A single species, *A. paucidentata* was the first species captured in the highest elevation from the 1st to 3rd night in all sites sampled in Mt. Kitanglad (Figure 4).

This was followed by the collection of *M. wetmorei* in the 5th night, *C. brachyotis, P. jagori* and *M. minimus* in the 6th night. On the 9th night, *P. minor* and *H. fischeri* were collected. *R. amplexicaudatus* was collected on the 30th night and no new species was recorded on the 31st to 38th night until the 39th night where *H. whiteheadi* was collected.

This means that all species of fruit bats that live in the forest patches were sampled adequately in each site and in Mt. Kitanglad Range. This finding conformed to the study of Struebig *et al.* (2008).

There were three (3) Mindanao faunal region endemic species (*P. minor, M. wetmorei* and *A. paucidentata*), three (3) Philippine endemic species (*P. jagori, H. fischeri* and *H. whiteheadi*) and three non-endemic species (*C. brachyotis, R. amplexicaudatus* and *M. minimus*) recorded

throughout the sampling period. This means that the fruit bats species in the Mt. Kitanglad Range are dominated by the endemic species (6) compared to non-endemic species (3).

Some species are tolerant to habitat disturbances while others are sensitive to habitat disturbances which serve as bio-indicators of the quality and quantity of forest habitats (Relox *et al.*, 2014).

Table 1. Characteristics of each habitat sampled in Mt. Kitanglad Range on 2012-13.

Vegetation cover and estimated size	Coordinates and elevation	Mountain range, brgy. and municipality	Number of plant families (Species)	Plant diversity and evenness	Number of known food items (plants)	THreats
Site 1 Upper montane forest (2,000ha)	08º 08' 25.9" N, 124º 54' 54.3" E, 2,172-2,903masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan and Mt. Kitanglad, Sumilao	8 (8)	0.21 (0.03)	*4 (Lithocarpus, Elaecarpus, Syzygium, Ficus)*	Presence of tourists, forest fire, typhoons, government- owned
Site 2 Lower-middle montane forest (25,000ha)	08º 05' 07.8" N, 124º 55' 27.25" E, 1,915 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	8 (11)	0.45 (0.04)	*5 (Lithocarpus, Syzygium, Fagraea, Syzygium, Elaecarpus)*	Presence of tourists, typhoons, government- owned
Site 3 Secondary forest (28ha)	125º 23' E, 8º 6' 12" N, 1,225 masl	Mt. Kitanglad, Brgy. Imbayao, Malaybalay City	14 (17)	0.77 (0.05)	*4 (Cinnamomum, Castanopsis, Elaecarpus, Syzygium)*	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	8 (14)	0.55 (0.04)	*4 (Cinnamomum, Polyosma, Psidium, Lithocarpus)*	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	5 (6)	0.12 (0.02)	*1 (Lithocarpus)*	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	9 (11)	0.40 (0.04)	*3 (Castanopsis, Zyzygium, Lithocarpus)*	Human settlements, farms, typhoons, privately-owned
Site 7 Small riparian forest with agroforestry (8ha)	08º 03' 28.3" N, 124º 55' 38.4" E ,1,332 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	6 (7)	0.18 (0.03)	*1 (Artocarpus)*	Human settlements, farms, typhoons, privately-owned
Site 8 Small riparian forest (3ha)	08º 04' 08.9" N, 124' 55' 36.0" E, 1,505 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	12 (15)	0.59 (0.04)	*9 (Anisoptera, Lithocarpus, Polyosma, Hymenodyctyon, Syzygium, Maesopsis, Ficus)*	Human settlements, farms, typhoons, privately-owned
Site 9 Large riparian forest (10ha)	08º 03' 28.1" N, 124º 55' 38.9" E, 1,340 masl	Mt. Dulang-Dulang, Brgy. Songco, Lantapan	2 (3)	0.14 (0.05)	*0*	Human settlements, farms, typhoons, privately-owned
Site 10 Cinchona forest reserve (2800ha)	8º 3' 24" N and 125º 00 24" E, 1,266 masl	Mt. Dulang-Dulang, Brgy. Kaatuan, Lantapan	7 (8)	0.15 (0.02)	*1 (Syzygium)*	Human settlements, farms, typhoons, government- owned
Site 11 Remnant secondary forest (15ha)	124º 51.46 E, 08º12.356 N, 1,432 masl	Mt. Kitanglad, Brgy. Dahilayan, ManoloFortich	12 (13)	0.53 (0.04)	*4 (Syzygium, Fagraea, Anisoptera, Lithocarpus)*	Presence of tourists, human settlements, farms, typhoons, privately owned

The mossy forest (Site 1) has been inhabited by Mindanao faunal region endemic species, *A. paucidentata* while the Montane forest (Site 2) by Philippine endemic species, *H. fischeri.*

In the fragmented habitats of lowland dipterocarp forest (Sites 3-11), all nine (9) species were found with varied distribution (Figure 5). It was observed that the largest lowland forest (Site 10) which is a Cinchona Forest Reserve has been dominated by the Philippine endemic species, *P. jagori* as compared to the smallest area sampled (Site 4) which has been

dominated by non-endemic species, *C. brachyotis*. This suggests a negative effect of fragmented habitats on endemic species.

This means that endemic species are sensitive to habitat fragmentation because of their high dependence on large forest as their primary foraging, breeding and roosting sites.

Based on distances of forest patches sampled, Sites 9 and 10 have 100% similar species compositions (Table 3) which have relatively large forest areas with old-growth forest. On the other hand, other sites sampled such as between Site 1 and Sites 2, 4, 5, 6, 8, 9, 10 and 11, between Sites 2 and 5 and 6 and between Sites 6 and 8 do not have similar kind of species due to the high influence of the elevation and vegetation type barriers.

Mossy (Site 1) and montane (Site 2) forests at the higher elevation have species different from those in the lowland dipterocarp forest.

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

Sampling sites	No. of mist nets used	No. of sampling nights	Total/site
Site 1: Upper Montane forest (Brgy. Songco, Lantapan)	20	7	140
Site 2: Lower-Middle Montane forest (Brgy. Songco, Lantapan)	17	5	85
Site 3:Mixed Lowland Forest (Brgy. Imbayao, Malaybalay)	16	7	112
Site 4: Riparian Forest Fragment 1 (Brgy. Imbayao, Malayblay)	13	7	91
Site 5: Remnant Lowland Forest Fragment 2 (Brgy. Imbayao, Malaybalay)	13	7	91
Site 6: Riparian Forest Fragment 3 (Brgy. Imbayao, Malaybalay)	13	7	91
Site 7: Remnant Riparian Forest Fragment 4 (Brgy. Songco, Lantapan)	18	6	108
Site 8: Mixed Secondary Remnant Riparian Forest Fragment 5 (Brgy. Songco, Lantapan)	17	6	102
Site 9: Remnant Riparian Forest Fragment 6 (Brgy. Songco, Lantapan)	18	5	90
Site 10: Secondary Forest Reserve (Brgy. Kaatuan, Lantapan)	16	3	48
Site 11: Remnant Forest (Brgy. Dahilayan, ManoloFortich)	16	3	48
TOTAL/SITE:	75	25	522

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

Table 3. Jaccard's species composition similarity coefficient among forest patches in Mt. Kitanglad Range on 2012-13.

Sites	1	2	3	4	5	6	7	8	9	10	11
1	1.00	0.00	0.17	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00
2		1.00	0.17	0.20	0.00	0.00	0.14	0.50	0.25	0.25	0.20
3			1.00	0.57	0.43	0.43	0.75	0.33	0.67	0.67	0.57
4				1.00	0.80	0.50	0.63	0.40	0.80	0.80	0.67
5					1.00	0.60	0.50	0.20	0.60	0.60	0.50
6						1.00	0.50	0.00	0.33	0.33	0.29
7							1.00	0.25	0.50	0.50	0.44
8								1.00	0.50	0.50	0.40
9									1.00	1.00	0.80
10										1.00	0.80
11											1.00

This shows negative effects of distance over fragmented habitats on endemic fruit bat species distribution, dispersal and migration. The dispersal ability of bats in degraded landscapes is limited to attain secondary forest if the roosting area is too isolated or lack connection to the seed source (Wunderie, 1998).

Fig. 2. Vegetation cover of Site 1 (a and b), Site 2 (c), Site 3 (d), Site 4 (e), Site 5 (f), Site 6 (g), Site 7 (h), Site 8 (i), Site 9 (j), Site 10 (k) and Site 11 (l) in Mt. Kitanglad Range on 2012-13.

Fruit Bats Relative Vegetation Quantity

In terms of richness, Site 5 (0.53) had the highest based on netting effort while Sites 1 and 2 (0.025) had the lowest which are significant different ($p<0.05$) among sites (Figure 6). Based on abundance of fruit bats, Site 4 had the most abundant bats (1.82) while Site 2 had the least abundant bats (0.05). There was a significant difference ($p<0.05$) of the abundance of fruit bats among sites per netting effort. Based on the netting effort, Site 7 had the highest species diversity (6.5) compared to Site 1 (1) that differed significantly ($p<0.05$) among sites sampled.

Fig. 3. Species of fruit bats (a. *A. paucidentata*, b. *P. jagori,* c. *P. minor*, d. *H. fischeri*, e. *M. wetmorei*, f. *C. brachyotis*, g. *M. minimus, h. R. amplexicaudatus* and *i. H. whiteheadi*) captured in the forest patches ofMt. Kitanglad Range on 2012-13.

Site 8 had the highest evenness (2) as compared to Site 2 (1). There was a significant difference ($p<0.05$) of species evenness among sites.

But, the large forest patches serve as habitats of more endemic species of fruit bats and exhibited strong site fidelity (Winkelmann *et al.,* 1999). However, most individuals of fruit bats collected were dominated by non-endemics (*C. brachyotis*) in the small forest fragments which are highly disturbed areas as compared to the dominance of endemic species in large forested areas sampled at the same elevations (*P. jagori*) and at the higher elevations (*A. paucidentata*) which are slightly disturbed given the presence of food items such as *Ficus* (Relox *et al.,* 2014).

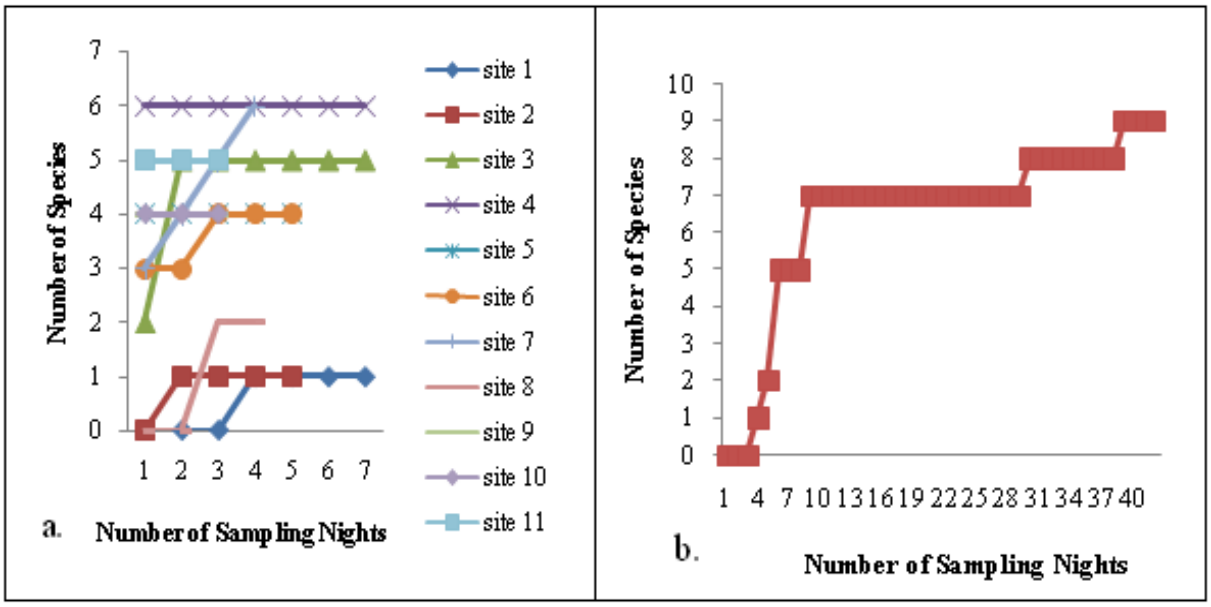

Fig. 4. Cumulative species effort curve per site (a) and all sites (b) in Mt. Kitanglad Range on 2012-13.

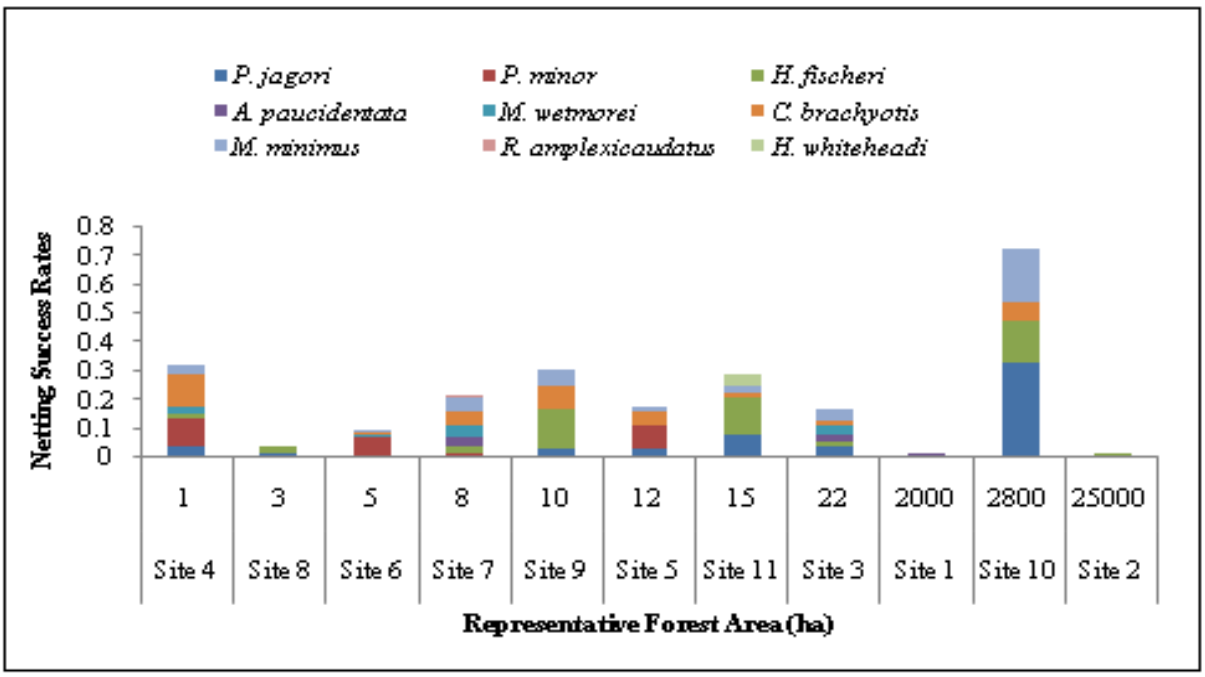

Fig. 5. Abundance per netting effort of each fruit bat species found in selected forest patches in Mt. Kitanglad Range on 2012-13.

This result showed that fragmented habitats have diverse and even fruit bats that are highly tolerant to anthropogenic disturbances as compared to large and continuous forest with more endemic species that are sensitive to disturbances.

In the study of Struebig *et al.* (2008), the forest area is positively correlated with the species abundance and richness of bats consequently the diversity of endemic foliage inhabitants.

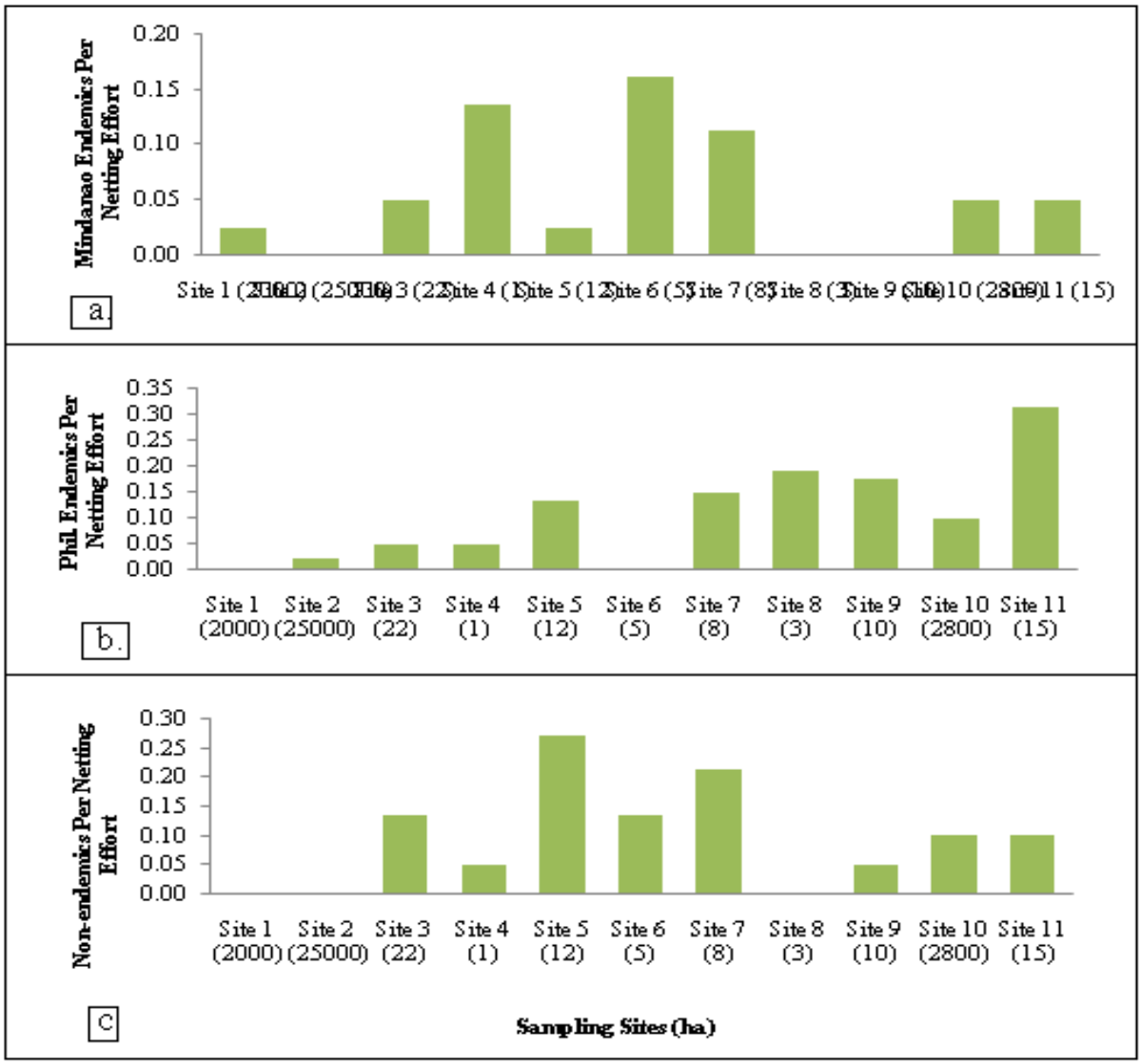

Fig. 6. Mindanao faunal region (a) and Philippine (b) endemics and non-endemics (c) per netting effort per site in Mt. Kitanglad Range on 2012-13.

Mindanao endemics were highest in Site 6 (0.16) compared to zero (0) in Sites 7 and 8. Site 11 had the highest Philippine endemic species (0.32) while none in Sites 1 and 6. Non-endemics lead in Site 5 (0.27) while zero (0) in Sites 1, 2 and 8.

Endemic species were significantly different ($p<0.05$) among sites. However, there was a significant difference ($p<0.05$) of non endemic species among sites. This implied that small forest patches harbor lesser endemic fruit bats and more non-endemic species.

This suggested a change of community structure in large forest by endemic species to non-endemic fruit bats in the fragmented habitats.

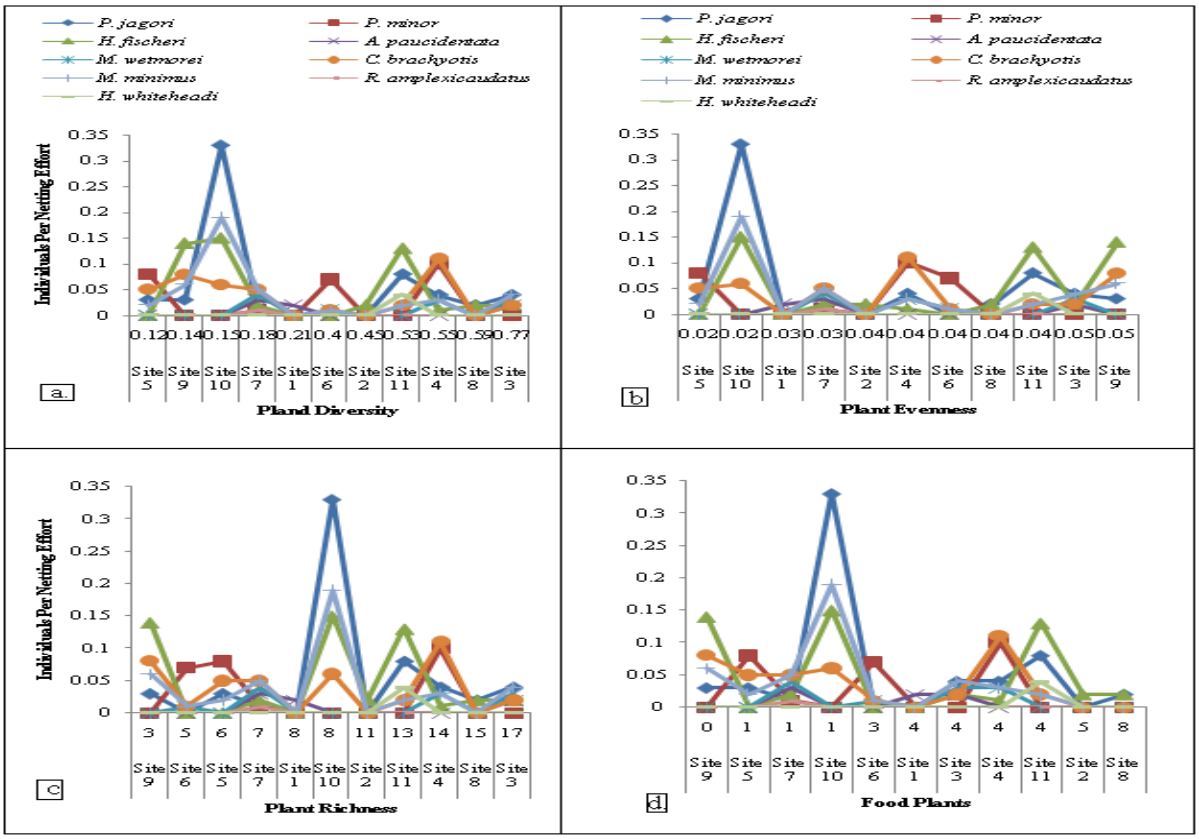

Fig. 7. Increasing diversity (a), evenness (b), richness (c) and food plants (d) against different species of fruit bats in Mt. Kitanglad Range on 2012-13.

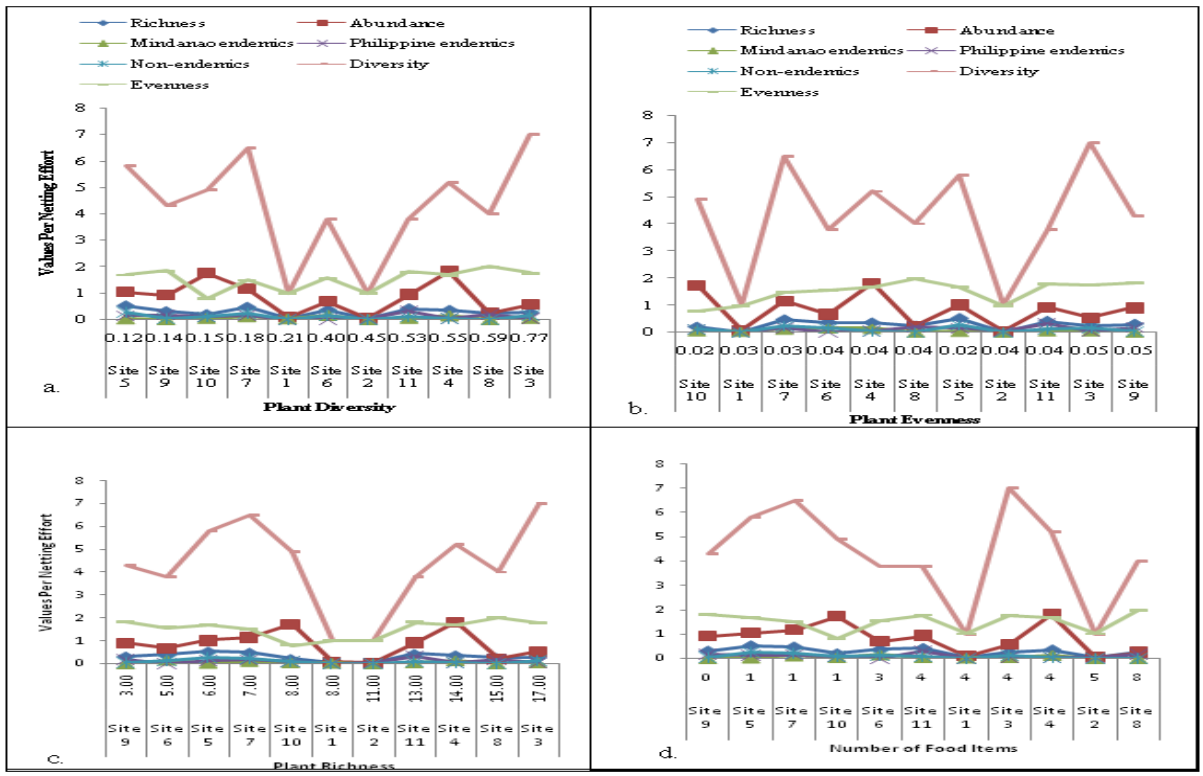

Fig. 8. Increasing diversity (a), evenness (b), richness (c) and food plants (d) against ecological measures of fruit bats in Mt. Kitanglad Range on 2012-13.

This means that as anthropogenic disturbances increase, the endemic species may decrease and non-endemic species may increase. Smaller fragments lose a given proportion of species more quickly than larger ones which suggest that fragmentation would have had more drastic effects *(Ferraz et al.,* 2003) especially endemic species.

Among the fruit bats species, *H. whiteheadi* was positively correlated to plant diversity (0.24), evenness (0.16), richness (0.24) and number of food items (0.12). *M. wetmorei* was also positively correlated to diversity (0.29), evenness (0.30) and richness of plants (0.27) while *A. paucidentata* was positively correlated to evenness (0.13) and richness (0.06). *P. minor* (0.03), *H. fischeri* (0.14) and *C. brachyotis* (0.22) were positively correlated only to evenness of plants (Figure 7).

Ecological measures of fruit bats such as richness, abundance, diversity, evenness and endemic city were positively correlated to plant evenness (0.25) but negatively correlated to the number of food plants (0.25). Mindanao and Philippine endemics were positively correlated to diversity (0.10) and richness of plants (0.07), respectively. Diversity and evenness of fruit bats were positively correlated to diversity and richness of plants (Figure 8). The quality of the area, vegetation and size of forest fragments are important factors in the distribution and abundance of bats (Gallo *et al.,* 2010).

Conclusion

Indeed, endemic fruit bats are good bio-indicators of a healthy of forest ecosystem in the Mt. Kitanglad Range with high quality and quantity rendering high ecosystem services to the people. The lowland dipterocarp forests with fragmented habitats surrounded by growing population and agricultural expansion despite high protection level by the stakeholders have been dominated by non-endemic non-threatened species, while those large forests were dominated by threatened endemic species. Highly endemic species are selective to high forest quality with rich, diverse and even food plants as the foraging, roosting and breeding areas of fruit bats in their habitats. This study would like to recommend regular monitoring of fruit bats, habitat protection and management in the Mt. Kitanglad Range.

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