Journal of Environmental Science and Management 17(2): 12-20 (June 2014)
ISSN 0119-1144

Assessment of Fruit Bats and its Food Preferences in Mt. Apo Natural Park, Kidapawan City, North Cotabato, Philippines

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ABSTRACT

Fruit bats are important seed dispersers that aid in natural forest regeneration in degraded areas. This study assessed fruit bat species in a portion of Mt. Apo, Kidapawan City, North Cotabato from September to December 2010 covering six habitat types: human settlement area/residential area, agro-ecosystem/cultivated area, secondary forest/ reforested site, forest edge, riverine/riparian area and montane forest for 1,118 net night hours. The food habits of the bats were also determined based on fecal examination and dropped fruits, which were verified through secondary information using indigenous knowledge interviews. A total of five bat species were noted such as Cynopterus brachyotis (n=83), Haplonycteris fisheri (n=33), Ptenochirus minor (n=25), Macroglossus minimus (n=20) and Ptenochirus jagori (n=12) wherein almost 50% of these are Philippine endemics and could be considered as seed dispersers of diverse trees. This study recommends the protection of Philippine and Mindanao endemic fruit bats such as P. minor, H. fischeri and P. jagori, through the conservation of their staple food (Ficus species) and the remaining primary forest habitat.

Key words: *conservation, food habits, forest, fruit bats, Mt. Apo*

INTRODUCTION

The Philippines has an estimated 180 species of mammals with 115 (57%) of which are endemic. Of these mammals, 77 species are bats with about 22 species considered as country and island endemics (*Heaney at al. 1999*). Among the bat families, frugivorous bats (Pteropodids) have an important role as pollen and seed dispersers that help maintain forest ecosystem and aid natural forest regeneration of degraded areas (*Cox and Elmqvist 1991*; *Rainey et al. 1995*; *Mildstein et al. 2005*). Bats and plants have developed a strong mutualistic relationship that is the result of closely-linked evolutionary association. This is critical for the propagation of plants as supported by the viability of seeds eaten by bats that would be germinated and grown in natural habitats (*Heffner et al. 2007*).

Indeed, bats play an important role in natural forest regeneration in succession areas. Bats are attracted to the fleshy fruits produced by plants (*Ingle 2002*). Most pioneer trees, which contain many small seeds in a single fruit, have the potential to be widely dispersed to invade and colonize denuded areas. Even though bats are highly mobile, reaching 1 to 20 km between roosting and foraging areas (*Fenton 1997*), flying long distances are stressful to them in disturbed habitats (*Cryan 2003*). Seeds are deposited by bats depending largely on the foraging behavior, movement and seed ingestion time (*Tang et al. 2008*).

The highly-threatened lowland dipterocarp forests in the Philippines have diverse fruit trees that are dependent on bats for seed dispersal (*Hodgkison et al. 2003*). However, human activities such as agricultural expansion, human encroachment, logging and mining are proliferating in these lowland habitats affecting the floral and faunal composition of Mt. Apo. With this, fruit bats mainly have critical roles in pollination and seed dispersal of diverse plants (*Agbay et al. 2008*) to restore these areas. Hence, this study aims to identify the species of fruit bats in different habitats with varied degrees of human disturbances along with the analysis of its food preferences.

MATERIALS AND METHODS

Study Area. Mt. Apo is an active strato-volcano (3,143.6 masl), the highest peak occupying 64,053 ha at 6°47 N to 7° 07 N and 125° 09 E to 125° 27 E in the Philippines. It encompasses the municipalities of Magpet, Makilala and the City of Kidapawan (7°00'40" N, 125°05'28" E) (**Figure 1**), of the Province of North Cotabato; Bansalan and Sta. Cruz and City of Digos in the Province of Davao del Sur, and in the City of Davao (*Rivera 2007*). Mt. Apo volcanic complex forms part the Central Mindanao Cordillera and constitute the southern end of a north to south trending belt of Pliocene Quaternary volcanoes. Mt. Apo is a watershed of over 19 river systems in Davao City, Davao del Sur, Bukidnon and Cotabato (*Rivera 2007*).

Mt. Apo has generally a tropical rainy climate. It falls under the Type IV of the modified Corona's classification wherein precipitation is relatively evenly distributed throughout the year. Mean monthly temperature ranges from

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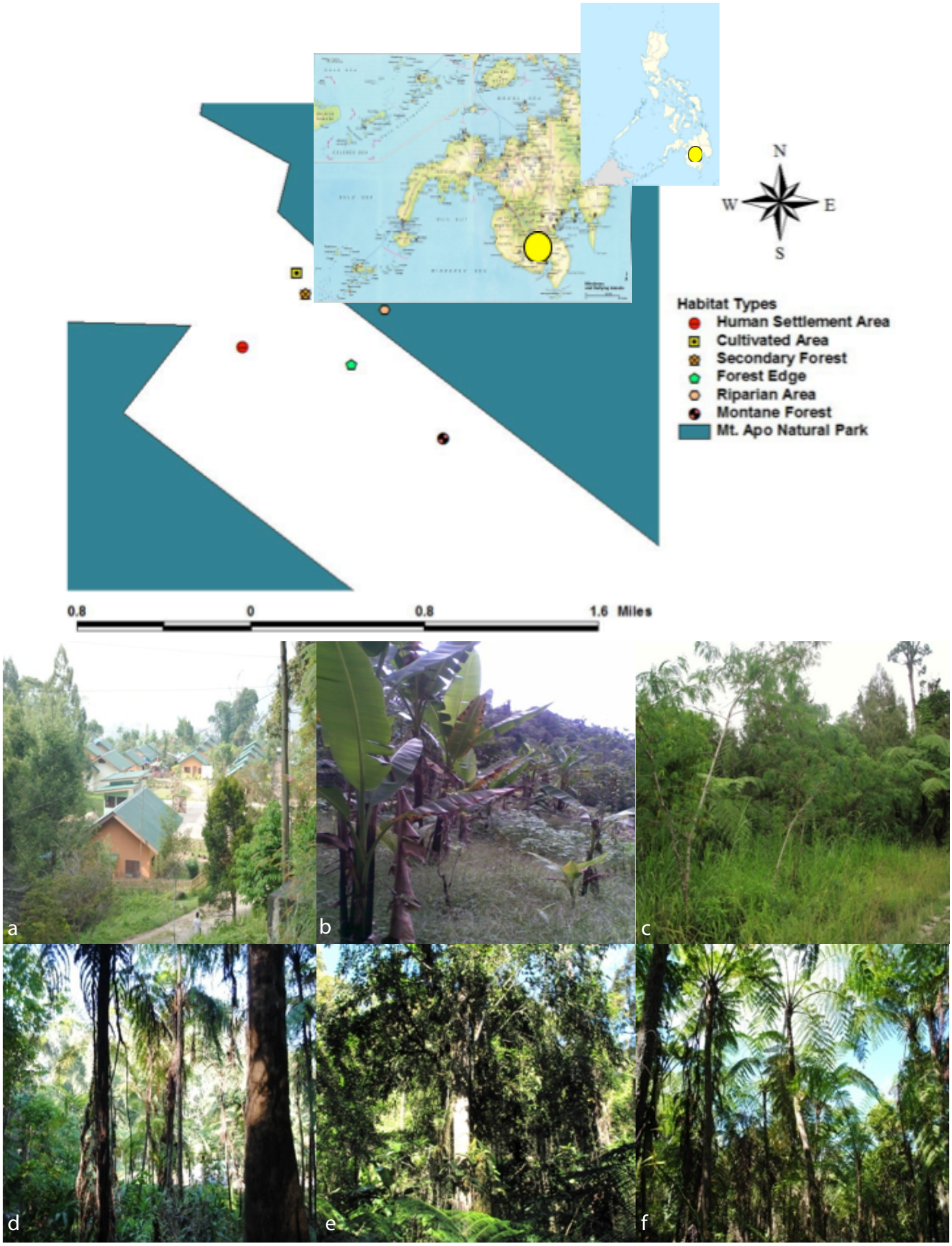

Figure 1. Maps of the Philippines, Mindanao and the types of habitats sampled in this study: settlement area (a), cultivated area (b), secondary forest (c), forest edge (d), riparian area (e) and montane forest (f) in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to October 2010.

26.4 °C during January to 27.9 °C during April, and relatively wetter during the rest of the year. Monthly relative humidity ranges from 78 % during March and April while at 82 % during June and July. Mt. Apo has clay-loam fertile volcanic soil and Miral type classification (*Rivera 2007*).

Six sampling sites namely: human settlement area/ residential area, agro-ecosystem/cultivated area, secondary forest/reforested site, forest edge, riverine/riparian area and montane forest were established in a portion of Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, Southern Mindanao (**Table 1**). Each habitat type was characterized based on vegetation cover and human activities (*Heaney et al. 1998*; *Gonzalez et al. 1999*). Each area was sampled in four consecutive months from September to December 2010 encompassing the wet season only.

Field Collection of Bats and their Diets. Sampling efforts consisting of three to six consecutive 12 active dark hours (6 PM-6 AM) using five to nine standard nets (12-m long, 2.6-m high, 33-mm) were allotted per site from September to December 2010 with a total of 1,118 net-night hours. To maximize capture efficiency, nets were established across likely flight paths, such as clearings, along ridges or by the water (*Heaney et al. 1999*) on approximately 500-m transect line depending on the terrain, slope or topography. Mist nets were checked every 30 minutes to one hour from dusk to dawn depending on the weather condition and number of personnel (*Malley et al. 2006*). Captures were retrieved from tangling in the mist nets and placed individually inside the cloth bags for identification following the Key to the Bats of Philippine Island (*Ingle and Heaney 1992*).

Fecal samples, droppings and fruits dispersed were collected using 10 modified empty sacks on the 500-m transect line following mist nets with approximately 100-m interval depending on the terrain. This method was employed for three to six 12 active night hours (*Tang et al. 2008*). Feces of each capture were collected from cloth bags after they were retrieved from nets and allowed to defecate for 30 minutes to two hours and then freed (*Thomas 1988*). Seeds in the feces were scattered on the tissue paper, counted and identified to species or local names with confirmation from the Indigenous People (IP) and surveyed fruit trees in the area. Representative seed samples from each plant were preserved in vials with 70% alcohol.

Vegetative (fruits, flowers and leaves) parts of plants of the known food preference of bats were collected, examined and identified to the species level, whenever possible. Supplementary information on the diet of bats was taken using interviews and informal Focus Group Discussions (FGDs) with the IPs who have significant duration of residency and who were hunters and gatherers in the forested area. Brief ocular observations on the plants fruiting in the site were also done to trace the likely fruits eaten by bats.

The number of plant seeds present in the feces of each capture was determined and compared to other species of bats. The bat species and their preference for a particular species of plant were noted. Percentage of seeds relative to other plants was calculated. The mean number of seeds dispersed per bat species was determined and compared. Secondary data on the trees dispersed by bats was obtained from literature and compared with the present data.

RESULTS AND DISCUSSIONS

Species Composition and Abundance. A total of 172 individuals from five species of bats such as *Cynopterus brachyotis* (n=83), *Haplonycteris fischeri* (n=32), *Ptenochirus minor* (n=25), *Macroglossus minimus* (n=20) and *Ptenochirus jagori* (n=12) belonging to a single Order Chiroptera under family Pteropodidae were found in the six different habitats sampled (**Table 2**). The highest number of species (n=5) was recorded in the forest edge while the lowest number of species (n=2) was found in riparian area (**Figure 2**). The most abundant species are *C. brachyotis* (n=83) while the least is *P. jagori* (n=12) One species of bats, *P. minor*, *i*s Mindanao endemic while *P. jagori* and *H. fischeri* are Philippine endemics. All captures belong to least concern status under the *IUCN* (*2010*).

The most abundant number of individuals was recorded in montane forest (n=70) and the least in riparian site (n=8). Of the total captures from five (5) species of bats found within 1,118 netting night hours, only 17 individuals defecated with an estimated 658 known seeds in the different habitats in Mt. Apo. These results conform with the studies of *Rickart et al. 1993*, *Relox et al. 1999* and *Alviola et al.*, *2008* that species richness and abundance of small fruit bats are decreasing as elevation increases since most sites sampled are at lower elevations (1,200 masl).

Thus, habitat selection of most bats tend to be the lowland dipterocarp forest (*Gomez 2005*). Despite its high ecological importance, Mt. Apo suffers from many forms of human interventions especially at the lower elevations. Deforestation accounted for 50% of forest cover loss due to the conversion of forest areas to agricultural lands (*Carandang 2010*) in the area. Significant forest reduction of lowland dipterocarp forest that harbors the rich and abundant bat species along with human encroachment in montane forest may contribute to the eventual decline of bat population and diverse floral composition in Mt. Apo.

Food Items of Fruit Bats. Approximately six known plant species composed mainly of *Ficus* species (basicong, luhimit and balete), *Musa* sp. (abaca/banana), *Calamus adspersus*

Table 1. Anthropogenic disturbances, coordinates and plant species per site in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

Sampling Site	General Characteristics	Coordinates/ Elevation (masl)	Plant Species
Human Settlement/ Residential (Relocation Site)	Populated, ecotourism area, less vegetated, many houses and establishments, roads, highly disturbed	7°01'16" N 125°13'28" E/ 1,286	*Musa sp.* (banana), *Artocarpus sp.* (marang), *Thysanolaena sp.* (tiger grass), *Phaseolus sp.* (beans)
Agro-ecosystem/ Cultivated Area (Lower Mandarangan)	Planted dominantly with abaca, intercropped with vegetables, very steep, adjacent to forest, small and few houses built, moderately disturbed	7°01'16" N 125°13'27" E/ 1,263	*Asplenium sp.* (giant fern), *Juniperus sp.* (cedar), *Mimosa pudica* (makahiya)
Secondary Forest/ Reforested (EDC-Geothermal Plant)	Previously a kaingin area, controlled human encroachment, adjacent to establishments, highly reforested	7°00'58" N 125°13'15" E/ 1,362	*Cyathea* spp. (Giant fern), *Cedrus* spp. (cedar), *Mimosa pudica* (makahiya)
Forest Edge (Upper Mandarangan)	Primary intact forest, adjacent to clearing, large trees predominate, highly controlled human entry, minimal disturbance	7°01'11" N 125°13'30" E/ 1,318	*Calamus sp*. (rattan), *Ficus* sp. (hagimit/luhimit) and *Cyathea* sp., *Ficus* sp. (basicong), *Dicongpteris* (fern),
Riparian Area (Marble River)	Besides climbing trail, located along the Marble river bank, frequently flooded, highly protected, reforested, dams were built	7°00'36" N 125°14'03" E/ 1,381	*Bambusa sp.* (bamboo), *Ficus sp., Calamus sp.* (rattan), *Asplenium sp.* (fern)
Montane Forest (EDC- Nursery Area)	Located inside the EDC premises, highly protected and reforested, controlled human presence, intact primary forest	7°00'54" N 125°13'41" E/ 1,424	*Asplenium sp.* (fern), *Medinella magnifica* (Medinella), *Ficus* sp. (balete)

(uway), *Piper aduncum* (buyo-buyo), *Coffea arabica* (kape) and *Psidium guajava* (bayabas), were documented as food choices of bats based on indigenous knowledge, fecal examination and dropped fruits in the sampling areas in Mt. Apo (**Figure 3**).

The known food items such as *Ficus* species, *Musa* sp., *P. aduncum* and *P. guajava* in tropical forest (*Mildenstein et al. 2005*; *Nathan et al. 2005*) were also preferred by bats in the sampling areas in Mt. Apo. High diversity of *Ficus* species known to bear thousands of fruits all year round (*Silvosa et al. 2004*; *Rivera 2007*) could be found in Mt. Apo. During the survey, these were observed fruiting in riparian area, montane and forest edges. Only a few trees remained in the cultivated area, human settlement and in secondary forest because of forest clearing.

Through IK on the dietary habit of fruit bats, plants listed as food items expanded the primary information. In this study, fruit bats maybe responsible in the distribution of majority of the *Ficus* and other plant species seeds to propagate naturally in different areas that could have contributed to the diverse flora and stable habitat in Mt. Apo. In addition, the food items found in the feces, roosting site and IK were similar except for *Ficus* (balete), *P. guajava* (bayabas) and *C. arabica* (kape).

Fruit Bat Dispersers. The *P. minor* dispersed the highest number of known seeds (n=343) followed by *C. brachyotis* (n=279) of various plants such as *Ficus* and *Musa* species and the least by *P. jagori* (36) from *Ficus* species and *C. adspersus* across sampled sites in Mt. Apo. This result shows that *C. brachyotis* appear to prefer *Ficus* species as documented by studies in tropical forest (*Albayrak et al. 2006, Hodgkison et al. 2007; Lopez and Vaughan 2007*) (**Table 3**). The diet of Philippine (*P. jagori*) and Mindanao (*P. minor*) endemics are still poorly studied. Hence, this data at least provides primary information on their food preference particularly in Mt. Apo.

Human settlement areas, agro-ecosystem and montane forest have the greatest number of bat dispersers while the least is in secondary forest. This finding implies that fruit bats may forage at night for fruiting trees grown and planted at the human settlement and agricultural areas. These bats may also disperse seeds in degraded areas and may find refuge by returning to montane forest with least human disturbances during the day. This means high energy cost in finding for food especially for endemic species (*Albayrak et al. 2006*) that have highly narrow and specialized food items than the non-endemic species with broad food items.

In tropical forest, fruit bats highly use odor to distinguish ripe and unripe fruits. This shows that old world fruit bats like *Cynopterus brachyotis* chiefly use chemical cues to locate and obtain fruits especially of *Ficus* sp. (**Figure 4**). There is little food overlap between bats and birds in terms of food acquisition (*Hodgkison et al. 2007*) because bats forage at night while birds

Table 2. Species composition, abundance, endemicity and conservation status of fruit bats per sampling effort per site in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

Scientific name	Common name	Geographic Distribution *(Heaney et. Al., 2010)*	Conservation Status *(IUCN, 2010)*	HS	CA	SF	FE	RS	MF	TOTAL
M. minimus	Lesser Long-Tongued Fruit Bat	Southeast Asia	Least Concern	8	7	-	5	-	-	20
C. brachyotis	Common Short-Nosed Fruit Bat	Southeast Asia	Least Concern	9	5	13	14	5	37	83
P. jagori	Musky Fruit Bat	Philippine Endemic	Least Concern	4	2	-	1	-	5	12
H. fischeri	Philippine Pygmy Fruit Bat	Philippine Endemic	Least Concern	-	4	2	5	3	18	32
P. minor	Lesser Musky Fruit Bat	Mindanao Endemic	Least Concern	4	-	4	7	-	10	25
			Number of Species:	4	4	3	5	2	4	
			Number of Individuals:	25	18	19	32	8	70	
			Netting-night hours:	86	204	144	252	144	288	

Legend: HS- Human Settlement, CA- Cultivated Area, SF-Secondary Forest, FE- Forest Edge, RA- Riparian Area, MF- Montane Forest, - undocumented

Figure 2. Species of fruit bats: *P. jagori* (a), *M. minimus* (b), *H. fischeri* (c) and *C. brachyotis* (d) found in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

Table 3. Estimated number of seeds consumed by fruit bats per site in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

Habitat (month)	Family	Plant species	PJ	CB	PM	MM	Total	Mean
Human Settlement (Sept. 2010)	Moraceae	*Ficus* sp. (basicong)	3^{+}	66^{+}	26^{+}	-	95$^{\#*}$	31.7
	Musaceae -	*Musa* sp. (abaca/banana)	-	40^{+}, 81^{+}	17^{+}	-	138$^{+\#}$	46
	Arecaceae	*Calamus adspersus* (uway)	33^{+}	-	-	- -	33^{+}	33
		Total:	36	187	43	-	266	-
		Mean:	18	62.3	21.5	-	-	-
Riparian Area (Oct. 2010)	Moraceae	*Ficus* sp. (luhimit)	-	42^{+}	-	-	42$^{+\#}$	42
	Piperaceae	*Piper* sp. (buyo-buyo)	-	$^{+}$	-	-	$^{+\#}$	-
	-	Total:	-	42	-	-	42	
		Mean:	-	42	-	-	-	
Montane Forest (Nov. 2010)	Moraceae	*Ficus* sp. (basicong)	-	-	-	-	*	-
	Piperaceae	*Piper* sp. (buyo-buyo)	-	-	-	-	*	-
	Moraceae	*Ficus* sp. (luhimit)	-	~50^{+}	~300^{+}	-	~350^{+}	200
		Total:	-	~50	~300^{+}	-	~350^{+}	
		Mean:	-	~50	~300^{+}	-	-	
Forest Edge (Dec. 2010)	Moraceae	*Ficus* sp. (luhimit)	-	-	-	$^{+\#}$	$^{+\#}$	-
	Piperaceae	*Piper* sp. (buyo-buyo)	-	$^{+\#}$	-	-	$^{+\#}$	-
		Total:	-	-	-	-	-	-
		Mean:	-	-	-	-	-	-
		Total seeds:	36	279	~343	-	~658	-

Legend: *Dropped fruits, $^{+}$Found in Feces, $^{\#}$Identified and confirmed by IPs, $^{-}$Undocumented; PJ- *P. major*, HF- *H. fischeri*, CB- *C. brachyotis*, PM- *P. minor*, MM- *M. minimus*

Figure 3. Some of the food items such as *Ficus* sp. (basicong) (a), *Mus*a sp. (banana/abaca) (b) and *Ficus* sp. (luhimit) (c) of bats in a portion of Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

are during the day. The breadth of feeding niche differs between species, which implies resource partitioning of fruit bats (*Lopez and Vaughan 2007*). Frugivorous bats disperse more seeds from green fruits directed to open areas and abandoned sites, thus making them potential agents in forest regeneration (*Stashko and Kunz 1987*).

Food Preferences. *Ficus* sp. (luhimit) (74%) is the most preferred food item of bats in the sampling areas in Mt. Apo where it was found to be widely distributed (**Figure 5**). Fruit bats usually prefer to congregate when feeding in plants such as *Musa* sp. and *Ficus* sp. that was likewise documented by *Garcia* (*2007*). The consumptiion capacity of the bats will be met if the fruits available are abundant. However during scarcity, bats choose other food items that are present in the area to survive (*Soule 1986*).

Ficus species are considered as keystone species because many species of bats and other wildlife depends on it for survival and at the same time for the widespread dispersal of the fruits colonizing habitats. Bats prefer to feed on figs and other fruit trees that produce fruits at different times and are good sources of calcium, amino acids and fiber (*Ratcliffe and Hofstede 2005*). Fig trees produce tens to thousands of fruits every seven to ten days at different times in primary and secondary forest. Bats consume five to 20 fruits of *Ficus* species each foraging night throughout a year (*Bonaccorso et al. 2002*).

Montane forest contains the highest number fruit bats able to disperse seeds while none in secondary forest and cultivated areas. In Mt. Apo, the presence of fruit bats in montane forest could have contributed to great diversity of trees in primary forest with least disturbance to ensure survival while aiding forest regeneration in degraded and disturbed areas. Large numbers and highly diversified species of fruit bats are needed to maintain the balance in the forest ecosystem. Generalist fruit bats with the highest density are those with the broadest food preference in areas

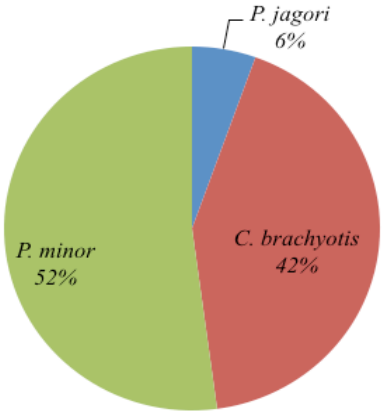

Figure 4. Percentage of fruit bat dispersers in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

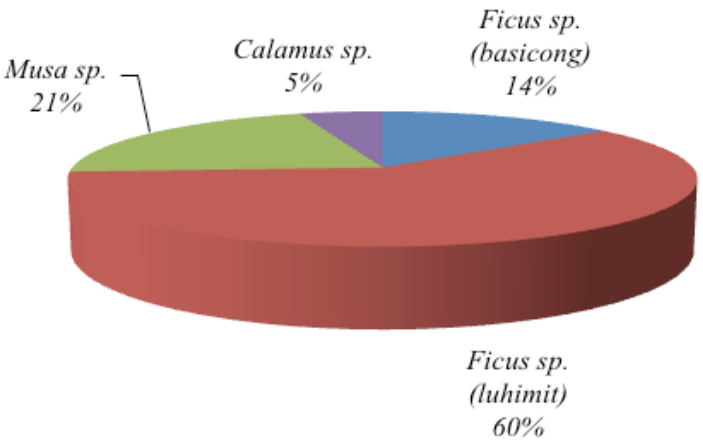

Figure 5. Food items (%) of bats in Mt. Apo, Sitio Agko, Brgy. Ilomavis, Kidapawan City, North Cotabato from September to December 2010.

sampled, although most of them often forage in large groups in flowering or fruiting trees (*Altringham 1996*).

Implications to Bat Conservation. Ficus species serve as staple food of fruit bats making up more than 50 % of their diet. *Musa* species and *C. adspersus* were the dominant plant species in the agricultural area and primary forest, respectively. Other food choices were rarely eaten by bats and were located outside the habitat sampled, that limit the identification of food items of bats only to the mist-netted areas.

This finding signifies that bats prefer *Ficus* species as it produce numerous fruits as confirmed by earlier study of *Fleming* (*1988*). Although there is a difference in the plant species preferred, bats largely depends on the kind of habitat present that provides different food items. In the long-term, if the population of preferred plant species of bats declines, their counterpart would also likely decrease in numbers. Without the existence of bats, the flora composition of the area would be reduced. The stability of the forest ecosystem would be jeopardized that can have serious environmental and economic consequences (*Ducummon 2000*), such as the extinction of endemic plants and proliferation of exotic species even in the protected areas, among others.

CONCLUSIONS AND RECOMMENDATIONS

Mt. Apo harbors endemic fruit bats capable of dispersing seeds of different plant species that could help maintain the ecological balance and aid in forest regeneration in degraded and disturbed areas. Fruit bats exhibited high preference on *Ficus* species over other plant species. While the endemic species such as *P. jagori*, *P. minor* and *H. fisheri* make up most of the fruit dispersers, these species are threatened by forest clearing and fragmentation especially that they have limited distribution and are highly specialized in terms of food item preferences.

This study recommends the preservation of the remaining habitats of fruit bats especially the montane forest of Mt. Apo by controlling human encroachment and further development in the area. In this way, a minimum viable population of fruit bats would be achieved to help maintain the rich and abundant endemic bats in Mt. Apo. The fruit bats must be conserved and their forest habitats must be protected particularly from agricultural expansion that could intentionally reduce primary forest. Thus, the agricultural activities and developments must be regulated in the area to provide enough suitable habitats for fruit bats. Nearby communities must also be informed and educated about the importance of fruit bats and their role in maintaining the forest ecosystem in Mt. Apo.

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ACKNOWLEDGMENT

We would like to acknowledge the Southeast Asian Research in Agriculture (SEARCA) University Consortium and the Department of Science and Technology Science Education Institute (DOST-SEI) for the financial support. We would also like to thank the Indigenous People, LGUs, CENRO and DENR-11 for the issuance of Gratuitous/ Collection Permit in Mt. Apo. Our appreciation also to the Energy Development Corporation (EDC) for the security provided to the researchers within the premises of the geothermal plant. Lastly, for UP Mindanao for the logistical support.