A Preliminary study on bats in a Small-scale Mining Site in South central Mindanao, Philippines

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Abstract. Land-use change and its associated activities have been strongly linked to the decline of many bat species populations globally. This study was conducted with a primary goal to document the bat diversity on a small scale mining site in Baranggay Kinayao, Bagumbayan, Sultan, Kudarat, Philippines. A total of 227 individuals were identified, representing two families (Pteropodidae and Hipposideridae), eight genera, and eight species of bats. Three species are endemic to the Philippines namely *Haplonycteris fischeri, Ptenochirus jagori,* and the Vulnerable *Megaerops wetmorei.* Pteropodid *Cynopterus brachyotis* were found to be the most dominant and tolerant species in the area compared to all species combined. In addition, a significant decrease in bat activity was noted during active blasting period, as evidenced by a low capture rate compared to non-blasting period. This preliminary finding suggests the need for further exploration of how human-induced noise increase the effects of the land-use change to bat diversity and population.

Key words: Bat diversity, foraging activity, habitat alteration, small-scale mining area, mine- blasting, non-echolocating bats**.**

1. Introduction

Among keystone species, bats are a best natural candidate for studies on the effects of habitat alterations and land-use changes (Bernard & Fenton, 2007; Jones et al., 2009) because to their high diversity, wide range of distribution, and flight capability to explore various ecosystems (Bernard & Fenton, 2003; Faria, 2006). For these reasons, bats were considered as good indicators of habitat disturbance (Medellín et al., 2000) in many natural and human-modified areas (Gorresen & Willig, 2004) such as mining sites.

In tropical ecosystems, bats play a critical role and when displaced the entire structure and function of the ecosystem is likely to alter affecting other ecosystem provisions (Kunz et al., 2011). With their wide distribution bats have developed different foraging strategies and exploit a wide dietary breadth. Almost a third of the world's bats feed on the fruit or nectar of plants (McNab, 1971). In return for nutrition, these bats are vital pollinators for many high valued tropical plants species (Cox et al., 1992), and additionally essential seed dispersers with major roles in regenerating rainforests (Fleming et al., 1987; Mickleburg et al., 2002; Courts, 1998). Plant populations are influenced by bats that eat fruit, nectar or pollen that helps in pollination and seed rain dispersal that aids in forest habitat regeneration (Mickleburgh et al., 2002; Hodgkison et al., 2003).

Insectivorous bats (i.e. Hipposideridae, Mollosidae, Rhinolopidae, and Vespertilionidae) are major predators of nocturnal insects in many agricultural lands (Whitaker & Kunz, 1988; Kunz & Whitaker, 1983; Avila-Flores

& Fenton, 2005; Williams-Guillén et al., 2008; Wanger et al., 2014). These bat groups are important to the ecosystem for their potential to act as biological pest control agents in farmlands, where they can consume insects up to 30%-100% of their body weight (Leelapaibul et al., 2005). The consumption of pest insects by bats also contributes to the reduction of insecticides used in farm crops leading to a healthier environment (Cleveland et al., 2006; Boyles et al., 2011).

A substantial component of the tropical bat fauna is highly dependent on intact stands of forest for foraging and roosting (Lane et al., 2006; Struebig et al., 2008). However, many bat populations worldwide are threatened by habitat loss intensified by diverse anthropogenic activities (Hutson et al., 2001). In Southeast Asia alone, deforestation occurs as much as 74% in the forested area in the region and may be lost by the end of the century (Sodhi et al., 2004; Miettinen et al., 2011). Additionally, there is a projected significant decrease in species richness of Southeast Asian bats in many regions as a result of changing land-use and climate in the future (Hughes et al., 2012).

The Philippines is one of the diverse countries for bat fauna with 78 species distributed throughout the archipelago in terms of species-area relationship (Ingle & Heaney, 1992; Heaney et al., 1998, 2010). But the unprecedented deforestation rate caused by different land-use change activities (i.e. agriculture and mining) over the country threatens many forest dependent taxa especially bats. Hence, the present study provides information on the diversity, conservation status and endemicity of bats in a small-scale mining area in South Central Mindanao. Further, the findings of this study will serve as a baseline information for effective conservation management for future developments in areas for mining and other land-use change.

2. Materials and methods

2.1. Description of the study site

The study was conducted in the periphery of a small-scale gold mining area in Barangay Kinayao, Bagumbayan, Sultan Kudarat (6° 26' 48.1''N, 124°35' 7.28'' E) (Fig. 1) situated in the southwestern region of Mindanao Island. The mining site is a privately owned by international firms and following a tunnel type mining. We sampled bats more than a kilometer to the North of the mining area (6°26' 24.8''N, 124°34' 41.41''E) within an elevation of 450–600 masl. The nets are generally placed in area dominated by grass species such as cogon (*Imperata cylindrica*), bamboos with presence of *Ficus* species and some fruit trees, were also observed such as Jackfruit (*Artocarphus heterophyllus*), Aratilis (*Muntingia calabura*), Durian (*Durio* sp.), Lanzones (*Lansium domesticum*) and Rambutan (*Nephelium lappaceum*). Cash crops such as corn (*Zea maize*), rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*) are generally cultivated by locals for food and trade.

2.2. Bat sampling and collection

We divided our sampling into two periods, the first sampling was conducted during active mine blasting activity and the second sampling was conducted 15 days after, during non-blasting activity. Blasting activity usually started at 10:00 in the morning up to late in the afternoon using mine-grade dynamites. Bats were captured using standard-sized monofilament mist nets (12 x 5 m and 10 x 5 m) installed strategically in their flight path such as near fruit trees, cluttered area, open spaces, cliffs, and near water sources roughly 2–3 kilometers from the blasting area. Nets were regularly checked between 17:00 and 23:00 at least every 2 hours interval to prevent stress in trapped bats. These were left opened overnight and checked before 6:00 in the morning.

Captured bats were identified using the taxonomic guide by Ingle and Heaney (1992), updated keys, and photographic guides. Necessary morphometrics such as the total body length, snout-vent length, forearm length, tail length, ear length and hind foot length and other morphological characteristics were noted such as the presence of a tail, markings, tragus/antitragus, nose structures, and interfemoral structure. All captured bats were photographed, marked and released in the sampling site accordingly.

2.3. Data analysis and species diversity

The relative abundance of bat species (%) in two sampling periods was calculated using the equation N_x/n (where: N_x is total number of the individuals of x-th species captured (x=1, 2, 3,…, s) and *n* is the total number of all species (s)). An independent student t-test was used (Statistica 12 statistical software) to compare and determine the significance of the change in bats abundance between two sampling periods. The magnitude of a disturbance from noise (mine blast) or vibration was not measured directly due to limitations on equipment; rather it was determined indirectly based on capture rate during the two sampling periods as the response of bats to the activity. The conservation status and endemicity of the species were assessed using the latest database from the International Union for the Conservation of Nature Redlist version 3.1 (IUCN, 2015).

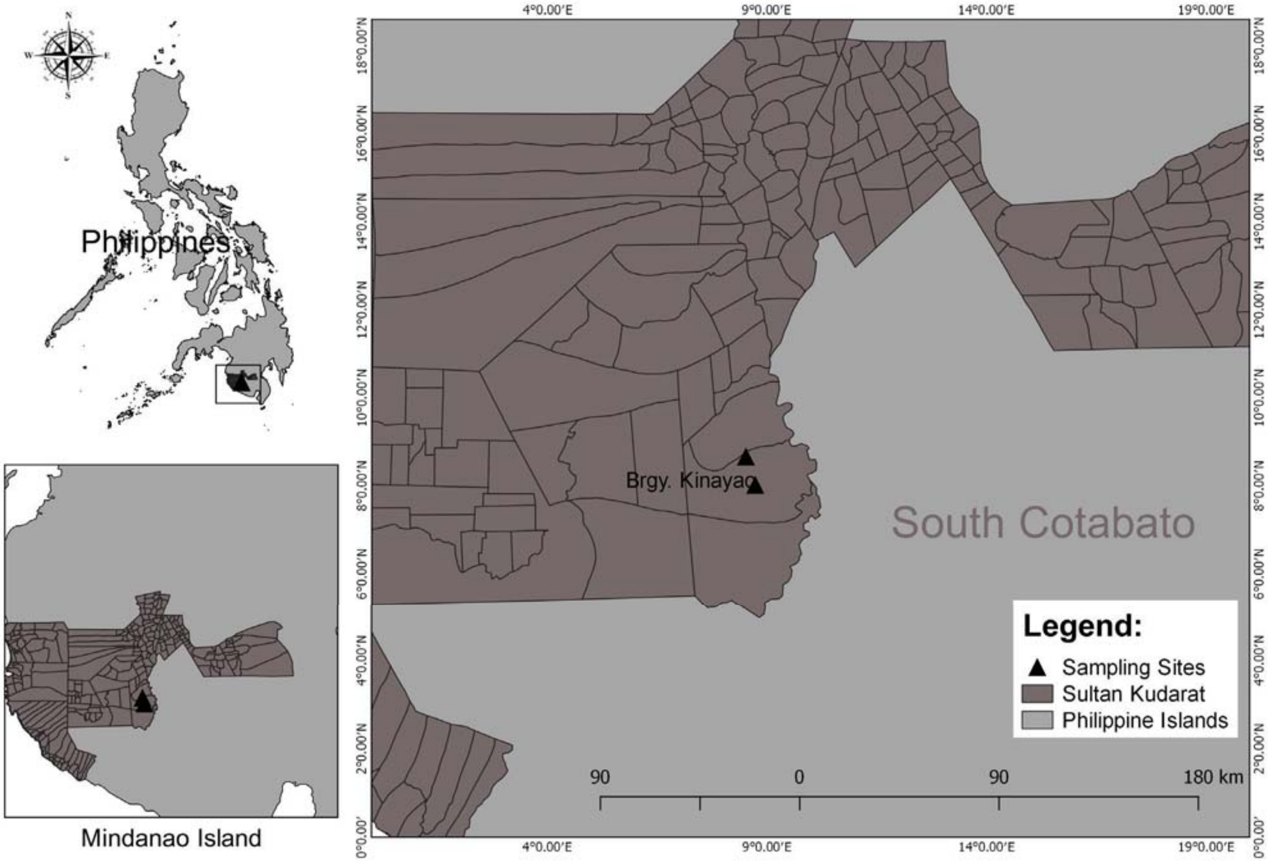

Figure 1. Map of Kinayao, Bagumbayan, Sultan Kudarat showing the location of sampling sites at the periphery of the mining area

3. Results and discussion

3.1. Species richness, composition, and conservation status

A total of 227 (blasting (n= 51); non blasting (n=176)) individuals representing two families, eight genera, and eight species were identified from the study site (Table 1). Of the eight species recorded, seven are under the family Pteropodidae (fruit bats) namely *Cynopterus brachyotis, Eonycteris spelaea, Haplonycteris fischeri, Macroglossus minimus, Megaerops wetmorei, Ptenochirus jagori,* and *Rousettus amplexicaudatus* and one species undler Hipposideridae (insect bats), *Hipposideros ater*. These captured species represent 10.25% and 15% of the Philippine and Mindanao bat species respectively.

The endemic fruit bats *Ptenochirus jagori* and *M. wetmorei* were captured during the two sampling periods while *H. fischeri* was caught only in the first sampling. Heaney et al. (1998) documented *P. jagori* as a tree and cave roosting species which occurs from sea level to at least 1,950 masl. It is abundant in primary forest and common in the secondary forest but occasionally present in agricultural areas near the forest. This species also has been reported in degraded habitats of Cebu and Negros. Similarly, *H. fischeri* is one of the most common endemic fruit bats in primary forest, especially at middle elevations. This species is often moderately common in secondary forest and is also present in mixed agricultural habitats and second-growth forest (Heaney et al., 1998). On the other hand, *M. wetmorei* is known only from primary and lightly disturbed lowland forest from 800 to 1,200 masl. This species is probably absent from montane and mossy forest above 1,500 masl (Heaney et al., 2010). Few individuals of this species is also recorded roosting from caves (Tanalgo & Tabora, 2015).

Only a single individual of insect bat, *Hipposideros ater* was captured in the area during the first sampling period. This species according to Heaney et al. (2010), is rarely found in agricultural areas close to the forest but has been recorded from lowland and montane primary to the secondary forest in Southeast Asia including the Phil-

Table 1. Species of bats identified from mining adjacent area in Brgy. Kinayao, Bagumbayan, Sultan Kudarat, Philippines

Species Name	Common Name	Conservation status	Endemicity
Cynopterus brachyotis (Müller, 1838)	Lesser Dog-faced Fruit Bat	LC	NE
Eonycteris spelaea (Dobson, 1871)	Lesser Dawn Bat	LC	NE
Haplonycteris fischeri Lawrence, 1939	Fischer's Pygmy Fruit Bat	LC	E
Hipposideros ater Templeton, 1848	Dusky roundleaf Bat	LC	NE
Macroglossus minimus (É. Geoffroy, 1810)	Lesser Long-tongued Fruit Bat	LC	NE
Megaerops wetmorei Taylor, 1934	Mindanao Pygmy Fruit Bat	VU	IE
Ptenochirus jagori (Peters, 1861)	Greater Musky Fruit Bat	LC	E
Rousettus amplexicaudatus (É. Geoffroy, 1810)	Geoffrey's Fruit bat	LC	NE

Legend: LC- Least Concern, VU-Vulnerable, NE-Non-endemic, E-Endemic, IE-Island Endemic

ippines. Individuals of this species were also recorded from caves in south central Mindanao (Tanalgo & Tabora, 2015). In contrary to *H. ater*, *Cynopterus brachyotis* was the most abundant and common species accounted from the study site for both periods. Figure 3 shows the comparative relative abundance of bats after the two sampling period. The sum of *C. brachyotis* captured in two sampling periods totaled 191 individuals, comprising the 84.1% of the total capture of the whole sampling duration. Several studies showed that this fruit bat species is common in almost all habitats throughout Southeast Asia including the Philippines (Heaney et al., 1998; Campbell et al., 2006). They are observed to be abundant in agricultural areas and common in the secondary forest but are usually uncommon or absent in primary forest (Campbell et al., 2006, Bumrungsri et al., 2007; Achondo et al., 2014). They are also known as one of the most abundant bats in disturbed lowland habitats, including residential, agricultural, and urban areas (Heaney, 2010; Kunz et al., 2011).

The low elevation of the study site may have contributed to the abundance of fruit bats observed. Heaney and Utzurrum (1991) documented that bat activity and abundance is highest in lowlands and decreases with increasing elevation. Also, the presence of several fruit trees (i.e. *Muntingia* sp.) in the area may have also contributed to the abundance of this pteropodid groups. According to Reis et al. (2000) vegetal diversity, structure, the size of forest remnants, and quality of the area influence the distribution and abundance of bats. In addition, the abundance of fruit bats could be due to their flight performance, which shows tolerance to degraded and open areas. Most of the species especially *C. brachyotis* are known to cross open areas with less to no obstacles (Tanalgo et al., 2011), an area similar to the study site. Law et al. (1999) and Schulze et al. (2000) emphasized that bats tolerance to habitat loss and fragmentation are attributed to their ability to traverse open areas to reach other forest fragments or other vegetation types and to use resources within the matrix.

On the other hand, the low count of insectivorous bats may be attributed to their ability to evade mist nets using echolocation (Sedlock et al., 2011). Fruit bats lack this ability except for *Rousettus* groups (Korine et al. 1999). A study conducted by Dai et al. (2001) in the boreal broadleaved forest in Japan revealed that the use of harp traps improves the efficiency of the capture rate of bats especially echolocating species compared to the use of mistnets in sampling. Conversely, a low diversity of bats was recorded in the area. This result may have been affected by the on-going forest destruction due to mining.

In terms of conservation status, seven species are of Least Concern and single species, *Megaerops wetmorei* is categorized as Vulnerable because of the rapid decline of its population which may even continue in the future (Rosell-Ambal et al., 2008 in IUCN, 2015) (Table 1). The decline is estimated to be more than 30% over the three generations, inferred from habitat destruction and degradation (Rosell-Ambal, *l.c.*). *M. wetmorei* is a poorly known bat species whose distribution is restricted in Mindanao faunal region in the Philippines and in some part of Borneo (Heaney et al., 1998, Heaney et al., 2010). In Mindanao Island, Gomez et al. (2005) recorded this species in Arakan valley conservation area, in Mt. Kitanglad (Heaney et al., 2006), in Mt. Malindang Mountain range (Nuneza et al., 2006) and in Mt. Apo National Park (Achondo et al., 2014; Tanalgo per.obs.). Likewise, Tanalgo and Tabora (2015) reported its occurrence in caves in south Central Mindanao roosting together with other fruit bat species.

Although most of the species assessed are of Least Concern, impending habitat modifications in the area due to mining have the potential to cause declines in species of conservation significance. This consequence will further result to unbalanced ecosystem functioning. For instance, the study of Quesada et al. (2003) demonstrated the negative effect of habitat disruption to bat-plant mutualism in the dry forest ecosystem. As observed, greater visitation rate and a greater number of pollen grains deposited on flowers from trees in undisturbed forest resulted in a significantly greater fruit set for trees in the area. Apart from habitat destruction, Whitmore (1997) added that habitat fragmentation caused by different human activities such as mining is one the primary proximate causes of present day species extinction.

3.2. Mining-induced noise and bat activity

Globally, bat populations are imperiled by various threats which include habitat alteration. Habitat destruction is considered as the most important driver of species extinction worldwide (Pimm & Raven, 2000). In the tropics, habitat loss and forest fragmentation are two of the main costs of extreme anthropogenic pressures, this includes mining and industrial developments (Myers, 1992; Whitmore, 1997; Kelly, 1998; Antwi et al., 2008). There are two sampling periods carried out in the mining site. The first sampling was during the active dynamite blasting is present, the blasting lasted for 11 hours between 7 am and 6 pm in a day. The second sampling is without dynamite blasting in the mining area. The gap between two sampling periods was 15 days only to reduce pronounced changes in the habitat. We noted that there is a low capture rate of bats in terms of the number of individuals during the first sampling period when mine blasting is active (Fig. 2). We found out that there was a significant difference in the number of individuals during blasting (M=15.75, SD=3.8) and non-blasting (M=43.75, SD=18.46) periods; t (6) =-2.96, p=0.025. These findings suggest that noise from produced during blasting period have an effect on the activity of bats.

These findings are supported by looking into the abundance of a dominant species, *Cynopterus brachyotis,* which have a noticeable increase in abundance during the second sampling period when blasting was absent (Fig. 3). Interestingly, most of the published reports on the effect of human-induced noise to bats have mainly dealt with echolocating species (i.e. *Myotis myotis, Tadarida brasiliensis*) (see Schaub et al., 2008; Russo et al., 2007; Bunkley et al., 2015) and none has reported about non-echolocating species such as *C. brachyotis*. These preliminary findings suggest a hypothesis that commonly occurring bats species can

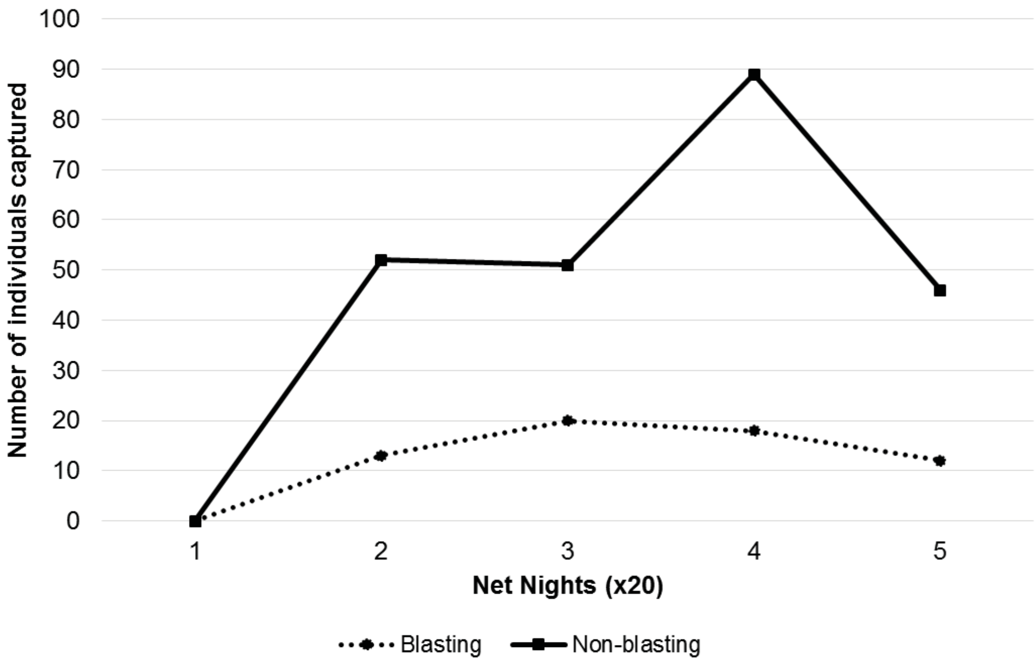

Figure 2. The capture rate of bats noted within the two sampling periods with presence and absence of mine blasting in the study area

be a useful tool as an indicator species to detect effects of land-use and induced noise especially in heavily impacted areas such as mining areas.

According to Francis and Barber (2013), most noise-related impacts appear to involve behavioral responses in a species. These responses include changes in temporal patterns, changes in spatial distributions or movements, decreases in foraging or provisioning efficiency coupled with increased vigilance and anti-predator behavior, and changes in mate attraction and territorial defense. In this study, behavioral response of bats to mining blast was only based on their foraging activity as determined by the capture rate. Schaub et al. (2008) mentioned that bats have the unique acoustic capacity that enables them to traverse in different habitats without clearly seeing. However, ambient noise influences the availability and use of this acoustic information in animals in many ways. Additionally, they also observed that foraging areas very close to highways and other intense noise sources have an effect on the physiological activities of bats. In echolocating bats, the intensive sound could possibly affect their capacity to echolocate which in turn affects foraging. Jones (2008) presumed that high levels of noise masks acoustic signals, potentially making it more difficult for animals to defend territories, attract mates or attend to other important communication signals such as begging, alarm or distress calls. In bats, it was clearly demonstrated that based on experiments that anthropogenic noise can affect their foraging activities and predatory capacity (Siemers & Schaub, 2011).

4. Conclusion

The research was the first to document bat species and activity in a mining area in the Southern Mindanao region, Philippines. In general, despite the presence of forest dependent and endemic species in the area we found low species diversity of bats in the adjacent area of the small-scale mining site. A commonly occurring species, *Cynopterus brachyotis* was found to be the most dominant species in both sampling period. Furthermore, our findings and observation from the field survey draw another hypothesis that bats in mining areas are not solely affected by land-use change but may also affect by extreme noise produced in mining sites.

It is therefore recommended that long-term studies on bat population in mining areas be conducted to assess other impacts of mining that could be utilized as a framework for conservation to attain sustainable mining in the country. Comparing non-echolocating and echolocating species and using harp traps and sonar detectors in sampling is also recommended to document more species that possibly were undocumented.

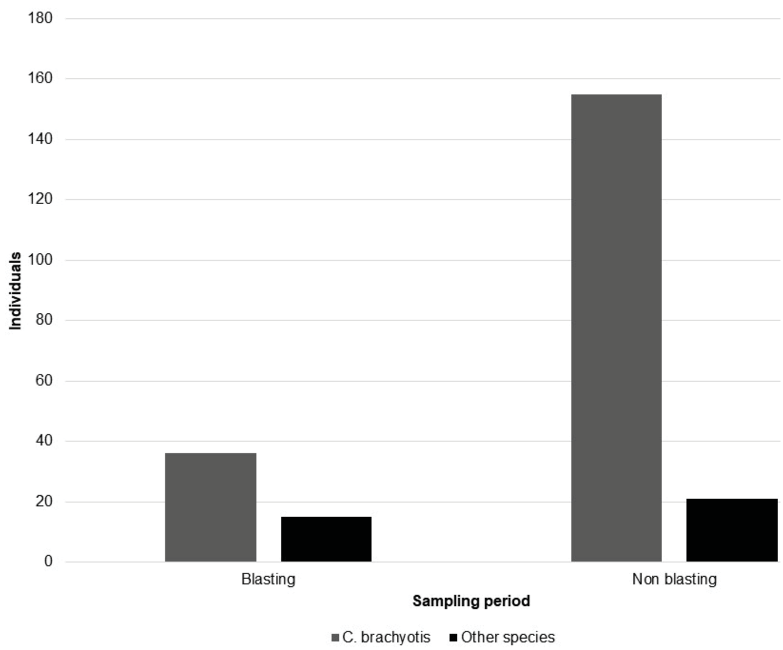

Figure 3. The abundance of *Cynopterus brachyotis* during two sampling periods in mining adjacent area

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References

Achondo M.J.M., Casim L.F., Tanalgo K.C., Agduma A.R., Bretaña B.L.P., Mancao L.S., Salem J.G.S., Supremo J.P. & Bello V.P., 2014, Occurrence and Abundance of Fruit Bats in Some Conservation Areas of North Cotabato. Asian Journal of Conservation Biology 3: 3–20.

Antwi E.K., Krawczynski R.& Wiegleb G., 2008, Detecting the effect of disturbance on habitat diversity and land cover change in a post-mining area using GIS. Landscape and Urban Planning 87: 22–32.

Avila-Flores R. & Fenton M.B., 2005, Use of spatial features by foraging insectivorous bats in a large urban landscape. Journal of Mammalogy 86: 1193–1204.

Bernard E. & Fenton M.B., 2003, Bat mobility and roosts in a fragmented landscape in central Amazonia, Brazil. Biotropica, 35(2): 262–277.

Bernard E. & Fenton M.B., 2007, Bats in a fragmented landscape: species composition, diversity and habitat interactions in savannas of Santarém, Central Amazonia, Brazil. Biological Conservation, 134(3): 332–343.

Boyles J.G., Cryan P.M., McCracken G.F. & Kunz T.H., 2011, Economic importance of bats in agriculture. Science 332: 41–42.

Bumrungsri S., Leelapaibul W. & Racey P.A., 2007, Resource partitioning in sympatric Cynopterus bats in lowland tropical rain forest, Thailand. Biotropica, 39(2): 241–248.

Bunkley J.P., McClure C.J., Kleist N.J., Francis C.D., & Barber J.R., 2015, Anthropogenic noise alters bat activity levels and echolocation calls. Global Ecology and Conservation, 3: 62–71.

Campbell P., Reid N.M., Zubaid A., Adnan A.M. & Kunz T.H., 2006, Comparative Roosting Ecology of *Cynopterus* (Chiroptera: Pteropodidae) Fruit Bats in Peninsular Malaysia. Biotropica, 38: 725–734.

Cleveland C.J., Betke M., Federico P., Frank J.D., Hallam T.G., Horn J., Lopez J.D., McCracken G.F., Medellin R.A., Valdez A.M., Sansone C.G., Westbrook J.K. & Kunz T.H., 2006, Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas. Frontier Ecology Environment 4:238–243.

Courts S.E., 1998, Dietary strategies of Old World fruit bats (Megachiroptera, Pteropodidae): how do they obtain sufficient protein?. Mammal Review 28: 185–194.

Cox P.A. Elmqvist T., Pierson E.D. & Rainey W.E., 1992, Flying Fox as Pollinators and Seed Dispersers in Pacific Island Ecosystem, [in:] D.E. Wilson, G.L. Graham (eds), Pacific islands Flying Foxes: Proceedings of an International Conservation Conference, Biological Report 90: 18–23. US Department of the Interior, Fish and Wildlife Service, Washington DC.

Dai F., Ishii T., Agetsuma N. & Toshiki A., 2001, Efficiency of harp Traps for Capturing Bats in Boreal Broad-Leaved Forest in Japan. Eurasian Journal of Forest Restoration 3: 23–26.

Faria D., 2006, Phyllostomid bats of a fragmented landscape in the north-eastern Atlantic forest, Brazil. Journal of Tropical Ecology 22: 531–542.

Fleming T.H., Breitwisch R. & Whitesides G.H., 1987, Patterns of tropical vertebrate frugivore diversity. Annual Review of Ecology and Systematics 18: 91–109.

Francis C.D., & Barber J.R., 2013, A framework for understanding noise impacts on wildlife: an urgent conservation priority. Frontiers in Ecology and the Environment 11: 305–313.

Gomez R.K., Ibañez J.C. & Bastian S.T., Jr, 2005, Diversity and community similarity of Pteropodids and notes on insectivorous bats in the Arakan Valley Conservation Area, Mindanao. Sylvatrop 15: 87–102.

Gorresen P.M. & Willig M.R., 2004, Landscape responses of bats to habitat fragmentation in Atlantic forest of Paraguay, Journal of Mammalogy 85: 688–697.

Heaney L.R. & Utzurrum R.C.B., 1991, A review of the conservation status of Philippine land mammals. Association of Systematic Biologists of the Philippines, Communications 3: 1–13.

Heaney L.R., Tabaranza B.R., Jr., E.A. Rickart, D.S. Balete & Ingle N.R., 2006, The Mammals of Mt. Kitanglad Nature Park, Mindanao, Philippines. Fieldiana: Zoology 112 :1–63.

Heaney L.R., Balete D.S., Dolar M.L., Alcala A.C., Dans A.T.L., Gonzales P.C., Ingle N.R., Lepiten M.V., Oliver W.L.R., Ong P.S., Rickart E.A., Tabaranza B.R., Jr. & Utzurrum R.C.B., 1998, A synopsis of the mammalian fauna of the Philippine Islands. Fieldiana: Zoology 88: 1–66

Heaney L.R., Dolar M.L., Balete D.S., Esselstyn J.A., Rickart E.A. & Sedlock J.L., 2010, Synopsis of Philippine Mammals. The Field Museum of Natural History in cooperation with the Philippine Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau, Manila, Philippines. http://archive.fieldmuseum.org/philippine_mammals

Hodgkison R., Balding S.T., Zubaid A. & Kunz T.H., 2003, Fruit Bats (Chiroptera: Pteropodidae) as seed dispersers and pollinators in a lowland malaysian rain Forest. Biotropica 35: 491–502.

Hughes A.C., Satasook C., Bates P.J., Bumrungsri S. & Jones. G., 2012, The projected effects of climatic and vegetation changes on the distribution and diversity of Southeast Asian bats. Global Change Biology 18: 1854–1865.

Hutson A.M., Mickleburgh S.P. & Racey P.A., 2001, Microchiropteran bats: global status survey and conservation action plan, IUCN/SSC Chiroptera Specialist Group. IUCN Gland, Switzerland and Cambridge, England

Ingle N.R. & Heaney L.R., 1992, A key to the Bats of the Philippine Islands, Fieldiana: Zoology. New Series 69: 1–44.

IUCN, 2015, the International Union for the Conservation of Nature Redlist version 3.1. <www.iucnredlist.org> [Accessed on 16th January 2015].

Jones G., 2008, Sensory ecology: noise annoys foraging bats. Current Biology, 18: R1098–R1100.

Jones G., Jacobs D.S., Kunz T.H., Willig M.R. & Racey P.A., 2009, *Carpe Noctem*: the importance of bats as bioindicators. Endangered Species Research 8: 93–115.

Kelly M., 1998, Mining and the Freshwater Environment. Elsevier Applied Science/ British Petroleum, London.

Korine C., Izhaki I. & Arad Z., 1999, Is the Egyptian fruit-bat *Rousettus aegyptiacus* a pest in Israel? An analysis of the bat's diet and implications for its conservation. Biological Conservation 88: 301–306.

Kunz T.H. & Whitaker J.O., Jr., 1983, An evaluation of fecal analysis for determining food habits of insectivorous bats. Canadian Journal of Zoology 61: 1317-1321.

Kunz T.H., Braun de Torrez E., Bauer D., Lobova T. & Fleming T.H., 2011, Ecosystem services provided by bats. Annals of the New York Academy of Sciences 1223: 1–38.

Lane D.J., Kingston T. & Lee B.P.H., 2006, Dramatic decline in Bat Species Richness in Singapore, with implications for Southeast Asia. Biological Conservation 131: 584–593.

Law B. S., Anderson J. & Chidel M., 1999, Bat communities in a fragmented forest landscape on the southwest slopes of New South Wales, Australia. Biological Conservation 88: 333–345.

Leelapaibul W., Bumrungsri S. & Pattanawiboon A., 2005, Diet of Wrinkled-lipped free-tailed Bat (*Tadarida plicata*, Buchannan, 1800) in Central Thailand: Insectivorous Bats Potentially Act as Biological Pest Control Agents. Acta Chiropterologica 7: 111–119

McNab B.K., 1971, The structure of tropical bat faunas. Ecology 52: 352–358.

Medellín R.A., Equihua M. & Amin M.A., 2000, Bat diversity and abundance as indicators of disturbance in Neotropical rainforests. Conservation Biology 14: 1666–1675.

Mickleburgh S.P., Hutson A.M. & Racey P.A., 2002, A review of the global conservation status of bats. Oryx 36: 18–34.

Miettinen J., Shi C. & Liew S.C., 2011, Deforestation rates in insular Southeast Asia between 2000 and 2010. Global Change Biology 17: 2261–2270.

Myers N, 1992, Tropical forests: present status and future outlook, [in:] N. Myers (ed.), Tropical Forests and Climate: 3–32, Springer Netherlands.

Nuneza O.M., Ates F.B., Alicante A.A., Calizo-Enguito M.R., Toledo-Bruno A.G., Labajo Y.I. & Dejarme S.M., 2006, Vertebrate Faunal Diversity and Relevant Interrelationships of Critical Resources in Mt. Malindang, [in:] G.D. Rivera (ed.), The Mount Malindang Experience: Society, Environment, and Development. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) and Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs, Los Banos, Laguna, Manila: 37–65.

Pimm S.L. & Raven P., 2000, Biodiversity: Extinction by numbers. Nature 403: 843–845.

Quesada M., Stoner K.E., Rosas-Guerrero V., Palacios-Guevara C. & Lobo J.A., 2003, Effects of habitat disruption on the activity of nectarivorous bats (Chiroptera: Phyllostomidae) in a dry tropical forest: implications for the reproductive success of the neotropical tree *Ceiba grandiflora.* Oecologia 135: 400–406.

Reis N.R., Peracchi A.L., Sekiama M.L. & Lima I.P., 2000, Diversidade de morcegos (Chiroptera, Mammalia) em fragmentos florestais do estado do Paraná, Brasil. Rev. Bras. Zool. 17: 697–704.

Rosell-Ambal G., Tabaranza B. & Ramayla S., 2008, *Megaerops wetmorei*. The IUCN Red List of Threatened Species. Version 2015.1. <www.iucnredlist.org> [Accessed on 16th January 2015].

Russo D., Jones G. & Arlettaz R., 2007, Echolocation and passive listening by foraging mouse-eared bats *Myotis myotis* and *M. blythii*. Journal of Experimental Biology 210: 166–176.

Schaub A., Ostwald J. & Siemers B.M., 2008, Foraging bats avoid noise. Journal of Experimental Biology 211: 3174–3180.

Schulze M.D., Seavy N.E. & Whitacre D.F., 2000, A comparison of phyllostomid bat assemblages in undisturbed Neotropical forest and in forest fragments of a slash-and burn farming mosaic in Pete´n, Guatemala. Biotropica 32: 174–184

Sedlock J.L., Ingle N.R. & Balete D.S., 2011, Chapter 5: Enhanced Sampling of Bat Assemblages: A Field Test on Mount Banahaw, Luzon. Fieldiana Life and Earth Sciences 2: 96–102.

Siemers B.M. & Schaub A., 2011, Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. Proceedings of the Royal Society of London B: Biological Sciences 278: 1646–1652.

Sodhi N.S., Koh L.P., Brook B.W. & Ng P.K., 2004, Southeast Asian Biodiversity: an Impending Disaster. Trends in Ecology & Evolution 19: 654–660.

Struebig M.J., Kingston T., Zubaid A., Mohd-Adnan A. & Rossiter S.J., 2008, Conservation value of forest fragments to Palaeotropical bats. Biological Conservation 141: 2112–2126.

Tanalgo K.C., Achondo M.J.M.M., Bretaňa B.L.P., Fernadez-Casim L. & Tabora J.A.G., 2011, Wing Ecomorphology and Flight Performance of Bats in Pisan Caves, Kabacan, North Cotabato, Philippines. Asian Journal of Biodiversity 3: 113–125.

Tanalgo K. C. & Tabora J.A.G., 2015, Cave-dwelling bats (Mammalia: Chiroptera) and conservation concerns in South central Mindanao. Philippines, Journal of Threatened Taxa 7: 8185–8194.

Wanger T.C., Darras K., Bumrungsri S., Tscharntke T. & Klein A. M., 2014, Bat pest control contributes to food security in Thailand. Biological Conservation 171: 220–223.

Whitaker J.O., Jr, & Kunz T.H., 1988, Food habits analysis of insectivorous bats. Ecological and behavioral methods for the study of bats: 171–189.

Whitmore T.C., 1997, Tropical Forest Disturbance, Disappearance and Spices Loss, [in:] W.F. Laurance, R.O. Bierregaard, Jr, (eds), Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. University of Chicago Press, Chicago, Illinois: 3–12.

Williams-Guillén K., Perfecto I. & Vandermeer J., 2008, Bats limit insects in a neotropical agroforestry system. Science 320: 70.