Important but not a priority? Conservation concerns and priorities for the Philippine bats in the Anthropocene

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Running title: Conservation threats to the Philippine bats

Abstract

Anthropogenic environmental changes coupled with rapid population growth are altering the Earth's biota at an unprecedented rate, posing an alarming threat to the long-term persistence of many species of both animals and plants. The Philippine archipelago includes over 7000 islands, and of its diverse mammalian biota bats make up a significant proportion, and fulfil vital roles to maintain ecosystem health. Given the high species richness, endemism, vulnerability, and disparity in efforts, the Philippines is a conservation priority for bats. In this study, we aim to determine the vulnerability of Philippine bat species from different threats in order to establish effective conservation decision making and prioritisation in the future. Habitat loss and direct human-driven factors (e.g., hunting) are the main threats to more than half of Philippine bat species. We found that body size and number of threats are important correlates of species vulnerability. While there is no correlation in neither threat levels nor body size with research effort and allocation. We suggest that priorities should consider multiple facets of knowledge gaps, levels of threats and species vulnerability for effective conservation. Carefully looking at the emerging threats, increasing conservation education, and forging equitable partnerships and capacity building to bolster bat conservation in the Philippines.

Keywords: Deforestation, Hunting, Islands, Oil Palm plantations, Southeast Asia

Introduction

Within Island tropical ecosystems, such as the Philippines, bats fulfil unique and crucial roles, and when displaced the entire structure and function of the ecosystem is likely to alter considerably (Cox and Elmquist 2000; Jones et al. 2009; Kunz et al. 2011). Bats provide wide range of essential ecosystem services –from pollination, seed dispersal, pest control to tourism (Wiles et al. 2010; Kunz et al. 2011; Bumrungsri et al. 2013; Wanger et al. 2014) making these taxa good ecosystem health indicators for they respond to changes in habitat conditions (Medellin et al. 2000; Russo and Jones 2015). Regardless of their importance, many bat species and their populations are threatened by diverse anthropogenic threats combined with unprecedented rates of environmental change (Voigt and Kingston 2016). Worldwide, the principal cause of bat mortality and extinction was due to direct anthropogenic factors and unprecedented rates of environmental change (Mickleburgh et al. 2002; Racey 2013; O'Shea et al. 2015; Voigt and Kingston 2016).

In Southeast Asia, a substantial percentage of bat fauna appear to be highly dependent on the intact forest. Whilst, relative deforestation rate may cause a loss of over 74% of the forest by the end of the century (Sodhi et al. 2004; Miettinen et al. 2011; Meyer et al. 2016). This rate coupled with future climatic change is projected to affect and heighten extinction rate of a large proportion of bat fauna in the region as a result of reduced suitable habitats in the future (Lane et al. 2006; Hughes et al. 2012). In addition to environmental changes, direct human impacts from negative perception and lack of knowledge of bat ecosystem services hinder effective conservation implementation and drive the persecution of populations from colonies and hunting for bushmeat (Hutson et al. 2001; Mickleburgh et al. 2009; Mildenstein et al. 2016).

To circumvent the risk of estimated future species loss and habitat reduction it is essential that conservation scientists set achievable conservation targets in multiple dimensions and scales (Rudd et al. 2011; Brum et al. 2017; Connena et al. 2017; Tanalgo and Hughes 2018). Bat Conservation International developed a strategic plan to address present and prevent future threats affecting multiple species at multiple sites, and protection of intact areas with highly diverse bat communities (Bat Conservation International 2014). As conservation actions and protection are typically realised and implemented according to geopolitical territories and threat levels and potential solutions widely vary due to differences in country's capacity and resources availability (Ellison 2005; Trimble and van Aarde 2012; Tuttle 2013; Verde Arregoitia 2016). In the Philippines, for example, the lack of capacity in other facets of bat research influence the focus of bat research diversity in the country in a way which is not completely representative (Tanalgo and Hughes 2018). Thus, the enactment of priorities and conservation management should start in a local or national scale to compliment a large-scale target e.g., regional or global scales (Gärdenfors 2001; Kark et al. 2009; Rudd et al. 2011; Mazor et al. 2013; Beger et al. 2015).

The Philippines hosts around 79 bat species distributed throughout over 7000 Islands of the archipelago, with an estimated >30% endemism and presumably higher once further molecular approaches have been analysed (Heaney et al. 2010; Tanalgo and Hughes 2018). However, many species remain at risk of population declines from a wide range of threats. Tanalgo and Hughes (2018) recently published a comprehensive review of the state of knowledge of the Philippine bats aiming to identify gaps and future targets significant to heighten bat conservation in the country. This review revealed the huge disparity of research allocation across research areas on Philippine bats i.e., there are a few studies on taxonomy and many more on conservation-related studies. In addition, although, research effort toward threatened and endemic species do not differ significantly the 87% of the species were proportionally understudied. In this paper, we aim to (1) identify major threats and vulnerabilities to the Philippine bats, (2) assess their conservation priorities, (3) determine the relationship of threats to the levels of knowledge on Philippine bats, essential to developing effective regional and national conservation prioritisation (Tanalgo and Hughes 2018).

Methods

We assessed the threats and vulnerabilities of the 79 species of Philippine bats using the same dataset from Tanalgo and Hughes (2018). We reviewed 142 studies published online (full articles=93, conference proceedings=30, and technical reports=19) between January 25 and April 20, 2017. A dataset was created based on the literature published from 2000-2017 obtained from Web of Science (Thompson Reuters), Google Scholar (https://scholar.google.com), self-archived ResearchGate (https://www.researchgate.net) and personal correspondence to bat scientists based in the Philippines. We used the latest International Union for Conservation of Nature Red List database (http://www.iucnredlist.org/) to supplement our assessment.

We assessed and classified threats and vulnerabilities to 17 'classes' based on standard lexicon (Salafsky et al. 2008) representing direct, indirect, and natural but we omit the intensity and range of threats to each species (e.g., size of population threatened), so, if a threat is recorded to be associated to the species it will be scored 1 (present). We calculated and rank species vulnerability using Species Vulnerability Index ($SVI_{(s)}$), which is the quotient of initial $SVI_{1(s)}$ and maximum $SVI_{max.}$ This can be calculated using the formula:

$$\mathbf{SVI_{(s)} = SVI_{1(s)} / SVI_{max}}$$

$SVI_{1(s)}$ is the initial species (s) vulnerability values based on calculated sums of weighted means of species absolute number of threats ($T_{(s)}$, $T_{dir(s)}$=direct threats, $T_{ind(s)}$=indirect threats, $T_{nat(s)}$=natural threats) multiplied to species biotic potential in terms of conservation status (BP_{cons}) and endemism (BP_E) values based from scoring assigned by Tanalgo et al. (2018). This can be calculated using the mathematical formula:

$$\mathbf{SVI_{1(s)} = \sum [(\bar{x}T_{dir}\,(.50), (\bar{x}T_{ind}\,(.40), (\bar{x}T_{nat}\,(.10)] * \sum (BP_{cons}, BP_E)}$$

$SVI_{(s)}$ values ranges from 1 to 0, species with SVI values near to 1 indicates that the species has higher priority based on the number of known threats compared to species with values near 0, which indicates no known threats but does not guarantee the species is least threatened based on range and population status.

Consequently, we used the non-parametric Kruskal-Wallis Rank Test or Mann-Whitney *U* Test to test the difference of Absolute Number of Threats (*T*) and Species Vulnerability Index (SVI) differ across (i) families or guild, (ii) conservation status, (iii) and endemism. Moreover, we applied Spearman's correlation to test the relationship between Species Vulnerability Index (SVI), (1) the absolute number of threats, and Species-Research Effort Allocation (SREA), which assess the adequacy of research efforts provided to species in a certain period (see supplementary A for the equation and SREA values); and (2) body size (kg) (based on Heaney et al. 2010). We used JASP Statistics v9.01 (JASP Team 2018) for all statistical analyses and visualisations. We set all significance at $P = 0.05$.

Results

Major threats in the Philippine bats

Out of 79 species, 16 (20%) are considered 'Threatened' based on IUCN standards (Vulnerable, Endangered, and Critically Endangered). Majority of studies from 2000-2017 suggest habitat destruction and direct human impacts as the main threat to Philippine bats (Fig. 1 A and B). More than half of the Philippine bats are threatened by deforestation and logging (n=56, 71%). After to deforestation, agriculture conversion is the second the largest threat to 48% of bat species in the Philippines. Hunting for bushmeat is a major direct human threat (n=33, 42%), particularly, 80% of frugivorous species (Fig. 1 B). In cave and underground habitats, cave tourism and visitation threaten almost all known cave-dwelling bats (n=26, 33%) in the country. Apart from tourism and hunting, other threats e.g., guano extractions, vandalism, and bird's nest collection threaten 18% (n=14), 14% (n=11), and 3% (n=2) of cave-dwelling species in the Philippines respectively. Extractive industries chiefly mining and quarrying threaten at least 22 species (27%) of Philippine bats, but this is an underestimated number as many mining areas in the country remains un-assessed due to the difficulty in security access.

Levels and relationship of threats among families and existing knowledge

We found that Absolute Number of Threats (T) do not differ significantly for either conservation status (*Kruskal-Wallis*=6.659, *d.f.*=5, *P*=.247) and endemism (Mann-Whitney *U* Test, *P*=0.573). Whilst, based on Species Vulnerability Index (SVI) as our proxy to gauge the level vulnerability of taxa (species or family) combining a number of threats and conservation status and endemism. Thirty-one (n=31, 39%) species falls above the mean (.201±.0.169) SVI value of overall species (Fig. 2). The highest SVI mean was recorded in Old-World Fruitbats (Pteropodidae) ($\bar{x}_{SVI}$=1.519 ±1.113), although we found that SVI values do not significantly differ among famillies (*Kruskal-Wallis*= 8.880, *d.f.*=6, *P*>.05).

The top species with highest SVI values include globally threatened and rare fruitbat species *viz. Acerodon jubatus* (SVI=1), *Pteropus dasymallus* (SVI=0.679), *Dobsonia chapmani* (SVI=0.597), *Pteropus speciosus* (SVI=0.591), and *Stylonycteris mindorensis* (SVI=0.438) (Supplementary Table I). However, SVI differed significantly across conservation status (*Kruskal-Wallis*=22.811, *d.f.*=5, *P*=.0004) and the levels of threats is highest among Critically Endangered ($\bar{x}_{SVI}$=.597) and Endangered Species ($\bar{x}_{SVI}$=.697). Endemic species also experience higher threats ($\bar{x}_{SVI}$=.297, Mann-Whitney *U* Test, *P*<.001) compared to non-endemic species ($\bar{x}_{SVI}$=.137). We found strong significant positive correlation between SVI and species absolute number of threats (Spearman's Test, ρ=.8572, *P*<.001) (Fig. 3), while there is no significant correlation between Species-Research Effort Allocation Index (SREA) Species Vulnerability Index (SVI) (Spearman's Test, ρ=.0954, *P*>.05) (Fig. 3). Lastly, a positive significant correlation was found between SVI and bat body size (kg) (Spearman's Test, ρ=.430, *P*<.001) while no significant relationship between SREA and body size (kg) of bats (Spearman's Test, ρ=.118, *P*>.05) (Fig. 3).

Discussion

Key threats and conservation concerns to the bats of Philippines

a. Deforestation and logging

Almost 80% of Philippine bats are forest-dependent and forage from intact forest ecosystems (Heaney et al. 2010) at the same time a large proportion of Philippine bats are largely threatened by deforestation. A consolidated results from major studies in different protected areas in the country (e.g., Ingle 2002; Heaney et al. 2003; Gomez et al. 2005; Balete et al. 2006; Heaney et al. 2006; Rickart et al. 2013; Relox et al. 2017) showed a general pattern suggesting intact forests and habitats are important for endemic species (see also Fig. 4). In a study within a protected area in the Philippines, it showed that endemic bat diversity is significantly lower in degraded habitats compared to pristine sites (Relox et al. 2017); and bat species richness and activities are higher in intact forests versus agropastoral sites (Sedlock et al. 2008). The high endemism patterns of bats in forests and pristine ecosystems in the Philippines warrants a more intensive protection of remaining forested areas in the country.

Forest loss is mainly caused by illegal logging and *Kaingin* (slash and burn) for industrialisation and agriculture conversion (Butler, 2014; Global Forest Watch, 2017) and may affect large proportions of bat species especially forest-dependent species roosting and foraging in intact and primary forests (see Fig. 4) (Ingle 2003; Jakosalem et al. 2005; Heaney et al. 2006; Nuneza et al. 2015). Currently, an estimated 90% of lowland forests in the Philippines have disappeared after land use change in the Philippines has reached 20%-70% decline rate over the 20th century, with an estimated 9.8 million ha of forest altered from 1935 to 1988 (Carandang 2005; Suarez and Sajise 2010; Forest Management Bureau 2013; Apan et al. 2017). From 2001 to 2017, the country lost an estimated 1.09Mha of tree cover that is equivalent to 5.9% decrease since 2000 (Global Forest Watch 2017). Nevertheless, only small number of studies explored how different threats interact and potentially exacerbate the impact on species survival and there is no comprehensive understanding of the impacts and dynamics of deforestation and land conversion to bat population and communities in the Philippines. Consequently, with the increasing rate of deforestation in the Philippines, highlighting the need of studies focusing on the impacts of deforestation and other land-uses using different dimensions of bat diversity as surrogate bioindicators is essentially important (Russo and Jones 2015).

b. Agricultural land conversions

Although, agricultural areas support 47% of bat species in the Philippines (Heaney et al. 1998; 2010; and shown here) (see Fig. 4) still a large proportion of bats species are imperilled by expanding agricultural conversions and the understanding of the effects of plantations to bat diversity and ecology remains lacking (Tanalgo and Hughes et al., 2018). Studies in plantations (e.g. rubber and oil palm) in the Philippines, although showed it can support few generalist species (e.g., *Cynopterus brachyotis*), the species richness remains lower compared to forested habitats (Bello et al. 2010; Achondo et al. 2014). It is important to take note that the conversion of intact and secondary forests for agriculture (e.g., plantation) has intensified in the recent years across the globe and particularly in Southeast Asia (Fitzherbert et al. 2008; Meyer et al. 2016; Hughes 2017; Hughes 2018). In the Philippines alone has 620,000 ha (i.e., 8.7% of forest cover, annual change rate 2000-2005=-46,400,000 ha) converted for plantations in 2005 (Butler 2014). Common cash crops such as Oil Palm and Rubber are presently dominating wide land areas in the Philippines and is displacing lowland forests (Villanueva 2011). Although, the Philippines is not a major Oil Palm producer in the Asian region (Sheil et al. 2009) it has consistently produced more than 100 thousand metric ton of palm oil in 2009 to 2012 (Index Mundi 2018). At present, the Philippines has roughly 90 thousand hectares of palm oil producing lands and concentrated in Mindanao Island, south of the Philippines (The Agriculture 2018), with a projection of almost million land area for potential land production (Philippine Bureau of Agricultural Statistics 2012)**.** While Rubber dominates around 222,601 hectares of land areas (as of 2016) (Philippine Statistics Authority 2016). In the first quarter of 2018, rubber production has increased by 4.4% (47.36 metric tons) compared to the same quarter in 2017 (45.37 metric tons) (Philippine Statistics Authority 2018). With this rate and expected expansion in the future in many part of the Philippines especially in lowland pristine ecosystems, spatiotemporal studies (Park 2015) and increasing comparative studies within forest ecosystems and agricultural areas using novel approaches (e.g., mist nettings, harp traps, and echolocation calls) are important step forward to advance deeper understanding on the effects of changing landscapes to bat population that is relevant to implement effective conservation measures (Sedlock et al. 2008; Park 2015; Myer et al. 2016)**.**

c. Hunting and human-bat conflicts

Harvesting and bushmeat collection is the main direct threats to Philippine bats. We found that hunting (42%)is high in areas where poverty is relatively high as many locals rely on hunting and consumption of bushmeat to satisfy/compensate limited access to food sources and income i.e., in remote areas where agriculture and livelihood is poorly established (Scheffers et al. 2012; Raymundo and Caballes 2016; Tanalgo et al. 2016; Tanalgo 2017). Large flying foxes (genuses of Acerodon and Pteropus) and fruit bat (e.g., *Cynopterus brachyotis, Ptenochirus jagori, Rousettus amplexicaudatus* and *Eonycteris spelaea*) are often hunted, hence highly vulnerable to hunting pressures for subsistence, medicine, and sports (Scheffer et al. 2012; Nuneza et al. 2015; Mildenstein et al. 2016).

Overhunting has even contributed to declining and local extinction of some narrowly distributed species, for example, *Dobsonia chapmani* in Negros Island (Paguntalan et al. 2008; Raymundo and Caballes 2016). Public misconceptions is also another driver of persecution of large bat colonies. The low awareness and knowledge towards the ecosystem services of bats (i.e., pollination in durian orchards) hence bats are perceived pest and nuisance and this has become an important factor in the execution of bat colonies (Tanalgo et al. 2016). In village localities, locals associate bats to a folklore *Aswang* (a local half human, half bat monster creature) and because of fear many large colonies are exterminated (i.e. cave smoking, shotgun) (Tanalgo et al. 2016).

d. Cave intrusions and exploitations

There is a growing concern on drastic declines of a large population in caves in the Philippines due to hunting, unregulated tourism, and other cave uses (Mould 2012; Sedlock et al. 2014; Tanalgo and Tabora 2015; Phelps et al. 2016). Caves and underground habitats are important for almost half of global bat species (Furey and Racey 2016; Tanalgo and Hughes in. prep.). In the Philippines, around 40 bat species are cave dwelling and dependent from caves for their life histories (Ingle et al. 2011; Sedlock 2014; Phelps et al. 2016; Alviola et al. 2015; Tanalgo and Tabora 2015). Notably, there are 2500 known caves in the Philippines yet only 18% have been classified for protection, tourism, and other uses. Of these, 37% are within Protected Areas (BMB-DENR 2017) and many remain understudied and may be facing diverse anthropogenic threats (Ingle et al. 2011; Sedlock et al. 2014; Alviola et al. 2015; Phelps et al. 2016; Tanalgo et al. 2016). In addition, cement production from karst areas of the country is increasing at 9% with 22 metric tons from 20.1 metric tons in 2013 (Mines and Geosciences Bureau 2015; Fong-Sam 2017).

Regardless of the importance of caves for a large proportions of Philippine bats, most of the country's cave ecosystems lack scientific studies (Ingle et al. 2011; Alviola et al. 2015) at the same time facing great threats due to lack of specific statutory protection, this may be because protecting caves are expensive and time-consuming. The existing policy, National Cave and Cave Resources Management and Protection Act (Republic Act 9072), aims to identify and protect cave biodiversity and geological importance, although important it often focuses on tourism potential and economic values and undermines the protection of cave-dwelling bats and cave biodiversity as a whole (PAWB-DENR 2008). Thus, strategies to effectively conserve and monitor caves in the Philippines using holistic and uniform procedure is an important step forward and to better understand the vulnerability of cave-dwelling bats in the Philippines (Tanalgo et al. 2018).

e. Extractive industries

Mineral mining activities and the establishment of mining road for the survey are prominent in a few protected areas with high bat biodiversity (e.g., documented in Mt. Hamiguitan, Relox et al. 2009). Whilst, information on the effects of mining and associated activities remains poorly understood in Philippine ecosystems due to its accessibility and security. However, preliminary work on bat diversity on small-scale mining sites in Mindanao Island showed low bat diversity this may be because of the extensive removal of potential grounds for bats. Habitat alteration in the area is associated with road construction in the middle of the forested area (Tanalgo et al. 2017). Establishment of road channels in the area destroys many of feasible roosting area for bats and food sources preventing species to interact with each other, also preventing other ecological and biological processes of the species (Palmer et al. 2010; Berthinussen and Altringham 2011).

As of August 2018, 703,846.67 hectares (2.35% of Philippine land area) has been covered by mining tenements with 9 million hectare land area for potential mineral mining (Mines and Geosciences Bureau 2018). Currently, there are 48 metallic mines and 61 non-metallic mines (e.g., limestone/shale quarries) and 3389 small quarries (Mines and Geosciences Bureau 2018). While, metallic mining operations are higher CARAGA and Central Visayas region, which may imperil a large proportion of forested areas (Mines and Geosciences Bureau 2018).While cement production extracted from karst areas of the country has increased around 9% to 22 metric tons from 20.1 metric tons in 2013 (Mines and Geosciences Bureau 2015; Fong-Sam 2017). Although, the Department of Environment and Natural Resources legislated the Philippine Extractive Industries Transparencies Initiative (PH-EITI) to improve the accountability and transparency in the Philippine mining sector (Agub 2013; Jamasmie 2014), however, this do not mainstream biodiversity conservation. In response, at present, the government's new strict environmental policy that considers biodiversity conservation prior to mining project implementation and mandating mining companies to restore, possibly to near-original condition, mining-destructed forest covers in the Philippines (Villanueva 2017). Nevertheless, given that mining and quarrying create nuclear impacts on the ecosystem, hence, an all-encompassing biodiversity monitoring not only for bats but also for all natural resources, as a whole and total restriction of the activity in biodiversity hotspots is needed.

f. Scientific (over) collections for disease research and public perception: an emerging threat for Philippine bats?

Scientific collection and disease surveillance are not currently but may emerge as a threat in the future due to an increasing trend of bat-associated diseases studies in the Philippines over the past 2 decades (Tanalgo and Hughes, 2018). We found thirty-five species (n=35, 44%; 7 endemic species) of Philippine bats have been subjected for disease research in the recent 17 years. Most of these studies have euthanised numerous individuals, for example, single nationwide studies have sampled 1047 individuals (brain of 821 individuals were collected) from 14 bat species to examine for the associated virus, and other studies may have even executed 21 species (see Tanalgo and Hughes 2018 for a list of studies). Most of the species collected (and killed) for disease surveillance in the Philippines are not classified threatened based on the global red list.

Despite numerous surveillance on their diseases, no clear evidence on the incident of bat mortality, transmission to human or livestock that associated bat-microbes (e.g., virus, bacteria, and fungi) (Tanalgo and Hughes 2018). Globally, around 13% of 222 recent studies collected bats for disease surveillance and dominantly coming from the tropics (Russo et al. 2018). Although only a small number of species are currently at risk of the scientific collection in the Philippines, the number of species and individuals collected for disease research if not regulated may pose a significant threat. In addition to over collection of bats, disease-related studies have significantly contributed to the negative image of bats and undermine lifelong efforts to conserve and protect many bat populations (López-Baucells et al. 2017; Tuttle 2017; Racey et al. 2018). Therefore, disease studies that deals with collecting bats should essentially consider the conservation implications of their collections and surveillance, and should clearly enforce educational progress and the conservation importance of such studies.

g. Changing climate: an unknown threat to the Philippine bats

Large-scale studies suggest that changing climate will certainly threaten bat species (Sherwin et al. 2012; O'Shea et al. 2016); however, the knowledge on the projected impacts of global changing climate to the Philippine bats remains lacking (Tanalgo and Hughes 2018). Although, Hughes et al. (2012) projected the impact of climate change and land-use change on bat species diversity in mainland Southeast Asia. The study has projected the effects of future climate scenarios on bat diversity and predicted changes in range size for 171 bat species throughout mainland Southeast Asia. Chiefly, it is a significant reduction in species richness in all regions with current high species richness between 2050-2090 it is the severe scenario of continuously increasing human population size, regional changes in economic growth and the greenest scenario, global population peaking mid-century. In 2050 and 2080, those scenarios set by the IPCC together with the climate change factors have predicted that 3-9 % of the species would lose its niche, 2-6 % of species may have no suitable niche space in 2050-2080. Synergistically, vegetation loss and climate changes combined results to only 1 % of species showed no variability in 2050 predictions. Expansion of ranges was also projected in some species however due to barriers to dispersal especially species with poor dispersal capacity expansion is impossible. Under bioclimatic scenarios, 1-13% of species showed no projections in their current range. To circumvent expected biodiversity loss in the future efficient and effective facilitation of range shifting for dispersal-limited species it through landscape connectivity improvement (Hughes et al. 2012). Synergistically, land-use and climate change have led to substantial range contraction and increase extinction probability in the decades (Root and Schneider 2002; Thomas et al. 2004). Apart from monitoring, it is imperative to have a robust measure of climate and land-use change impacts to Philippine bats and to identify areas where highest conservation protection is required to evade future species loss.

Conservation priorities and future directions for Philippine bat conservation

The levels of threats and vulnerabilities and research efforts largely varies across Philippine bats. In this study, we found that neither threat levels nor body size correlate with research efforts among Philippine bats. While the absolute number of threats and body size are found to be an important determinant of species vulnerability. In projecting extinction rates, body size correlates with higher extinction risk (Cardillo and Bromham 2001; Cardillo et al. 2005; Harris and Pimm 2008; Fritz et al. 2009).

With the wide range of disparity in research allocation and threats in Philippine bats, it is essential to develop a holistic conservation framework. Reyers (2004) stated that recent attempts to streamline the identification of priorities requiring immediate conservation management (e.g., Connena et al. 2017) have urged the development of procedures for identifying species or population and regions for biodiversity importance that faces the largest threats in the near future (e.g., Hughes et al. 2012; Struebig et al. 2015; Tanalgo et al. 2018). In the Philippines, conservation should not solely focus on threatened or rare species. Brum et al. (2017) highlighted that integrative biodiversity conservation encompassing not only species distribution, endemism, and vulnerability but also functional and evolutionary traits, to guarantee holistic priorities based on broad and multi-dimensions of diversity, hence, future studies in Philippine bats should be directed towards multiple facets of consideration to address gaps and disparities.

In addition, conservation allocation i.e., monetary budget to implement research or protection of habitat should carefully balance between threatened and non-threatened species. Lesser threatened species in the Philippines may have the tendency to experience ‘Passenger Pigeon Fiasco’ effects, where a lesser threatened or commonly abundant species may go extinct (or decrease in population and range) due to human-driven activities such as hunting for bushmeat and trade (Tanalgo and Hughes 2018). Lastly, the improvement of Philippine IUCN red list assessment, especially of data deficient species, is also crucial to advance the understanding the extent of threats and vulnerabilities across species and habitats.

Take-home message

Along with the increasing number of bat studies relevant to Philippine bat conservation, yet there is clear disparity on the priorities persisting on research needs and species vulnerabilities. The understanding of Philippine bats in terms of its provision of different ecosystem services provisions and the impacts of a wide range of threats remains unknown. Essentially, it is a call to intensify diverse inclusive research through capacity building of geographically lacking regions, support next generations of scientists in the Philippines, promote equitable collaboration and partnerships, transparency, and open-data sharing and accessibility. We hope this ought not to hinder progress in Philippine bat conservation but instead be a challenge and opportunity especially for young and emerging bat scientists in the Philippines.

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Figures

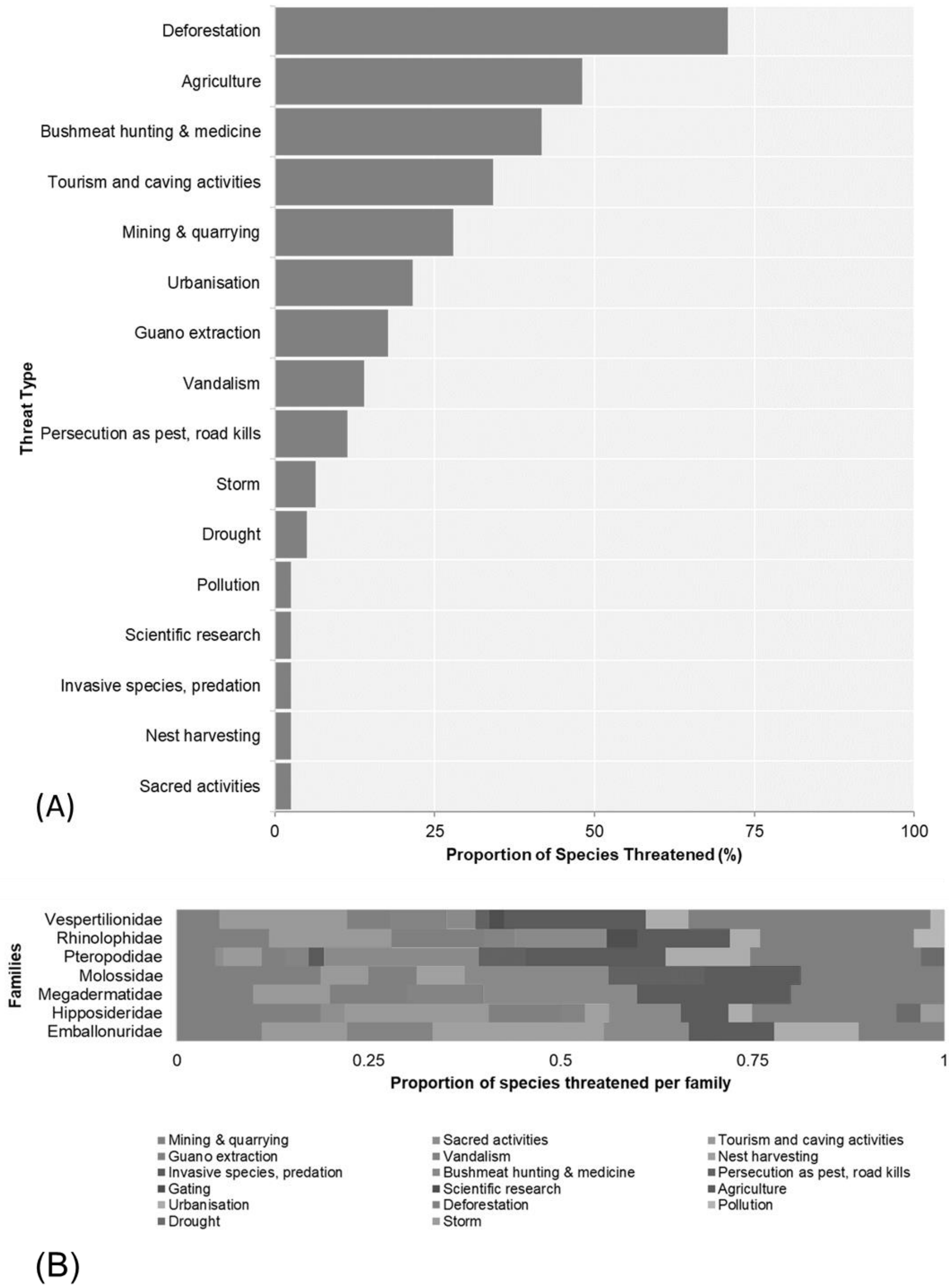

Figure 1. (A) Proportions of bats species on different threats and vulnerabilities in the Philippines; (B). Distribution of threats across different bat families in the Philippines.

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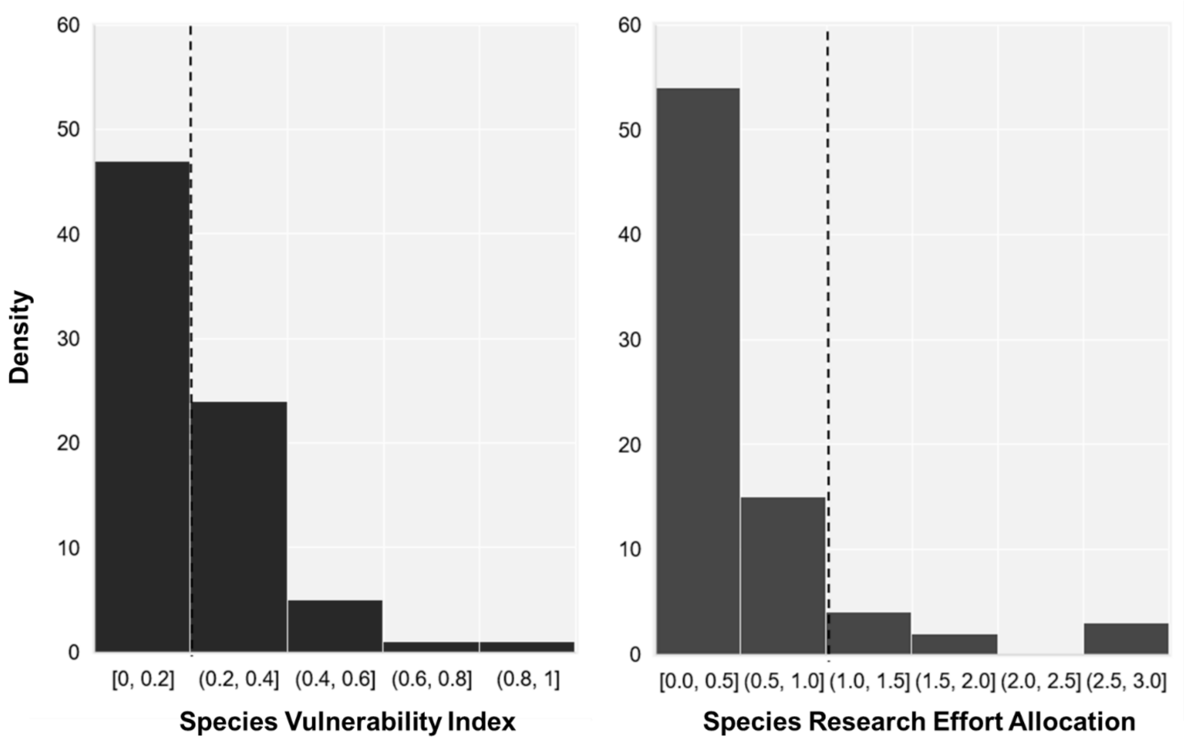

Figure 2. Density and distribution of Species Vulnerability Index (SVI) among Philippine bats (in red bars). This analysis shows that thirty-nine percent (n=39, 49%) of Philippine bats are above-average values (dash line in red bars) vulnerability level based on combined threats, conservation status, and endemism under the scenario where direct threats (Tdir=50%) are given high emphasis. While, majority of species remains below the average (in dash lines) Species-Research Effort Allocation (in blue bars) (SREA figure is adapted from Tanalgo and Hughes, 2018).

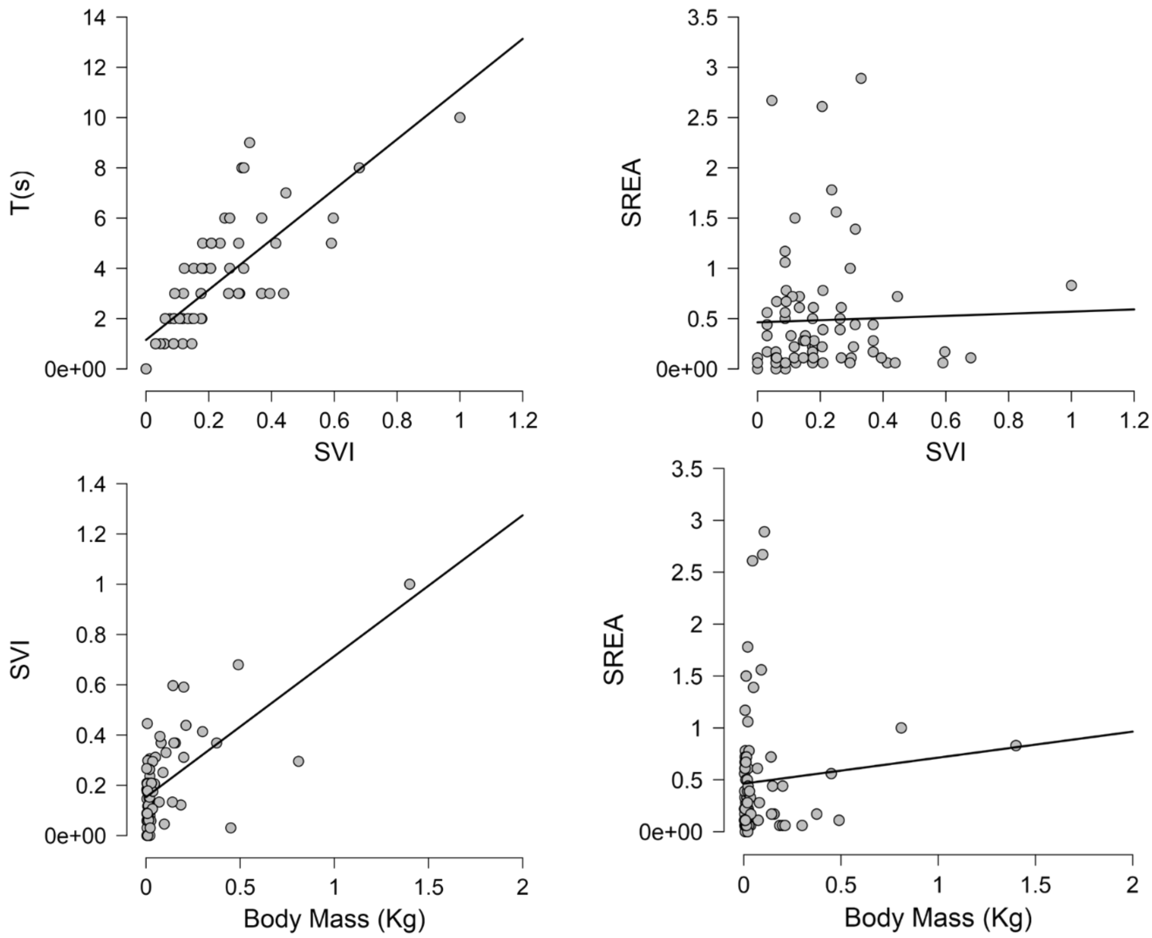

Figure 3. Relationship between Species Vulnerability Index (SVI), Absolute number of threats (T), Species Research Effort Allocation (SREA), and body mass (kg).

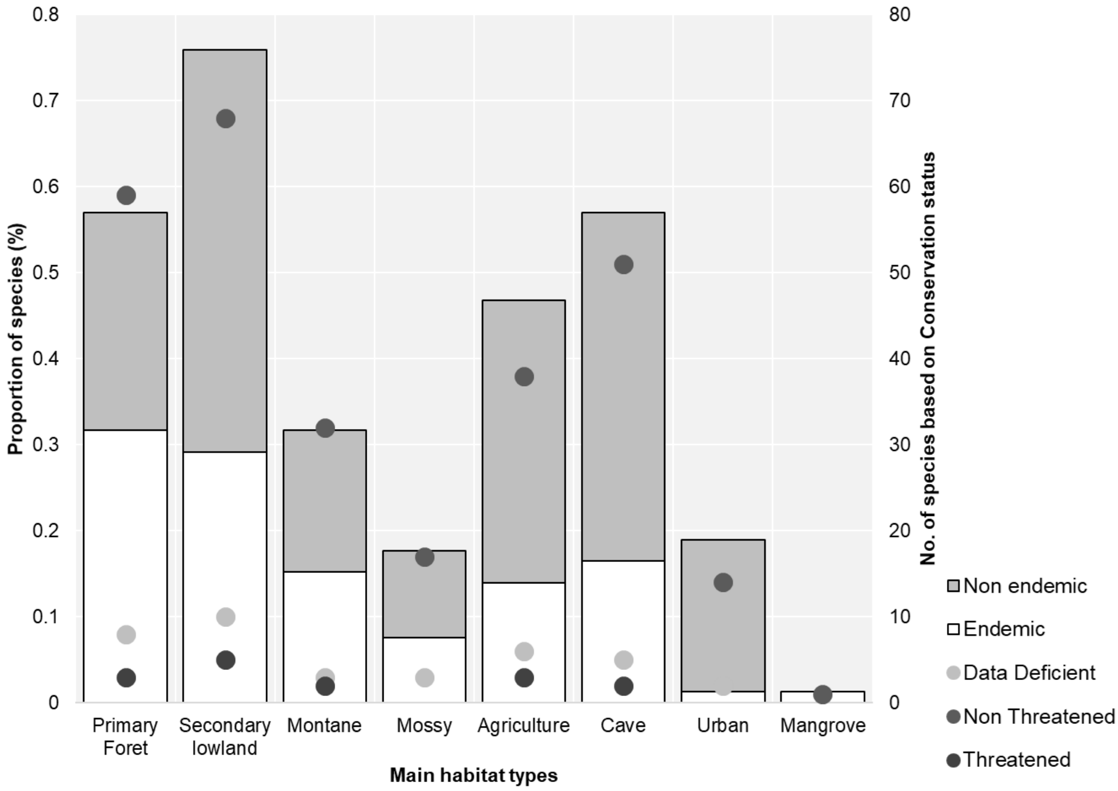

Figure 4. Estimated distribution of Philippine bats across different major habitat types in the Philippines. Based from accounts of Heaney et al. (2010), Tanalgo, and Hughes (2018).