THE BATS (MAMMALIA, CHIROPTERA) OF THE UPPER IMBANG-CALIBAN WATERSHED, NORTH NEGROS FOREST RESERVE, NEGROS OCCIDENTAL, PHILIPPINES

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ABSTRACT

Lack of available information about ecological requirements, habitat ranges, and abundance provides continual problems for chiropteran conservation initiatives in the Philippines. Negros Island (Central Visayas, Philippines) represents one of the ten highest-ranking sites globally for megachiropteran diversity yet it is also listed as a priority site for survey work. This paper reports on the first survey on the bat fauna of the Imbang-Caliban watershed of the North Negros Forest Reserve, Negros Island. A total of 13 species of bats from 369 individuals were recorded. These included 9 megachiropterans and 4 microchiropterans. Over 40% of the species recorded were endemic to the Philippines. The most notable species present was *Nyctimene rabori.* These initial results stress the need for more comprehensive surveys in order to implement effective conservation measures for both endemic and threatened species.

Introduction

Members of the order Chiroptera are of particular importance in tropical forest environments. Numerous studies have investigated ecological and evolutionary aspects of the linkages between fruit consumption by vertebrate frugivores and seed dispersal of tropical forest trees (Flemming & Estrada, 1993). Such case studies suggest that regeneration of tree species will suffer if this dispersal capability is lost (Gibson & Wheelwright, 1995). Within the Philippines, few such studies have been completed but Hamann and Curio (1999) suggest that on Negros Island up to 80% of the forest community is dependent on this regeneration mechanism.

This has particular significance for two reasons. Firstly, although in the past the Philippines was almost completely covered in tropical forest, it now has one of the highest rates of tropical forest loss (Collins *et al.*, 1991). The forest coverage of Negros has been reduced from over 90% to just 4% with two thirds of this lost in the last 50 years (Heaney & Regalado, 1998). Secondly, while bats (Chiropterans) often make up a large proportion of the mammalian diversity of forest habitats in the Philippines (Heaney, 1993; Heaney *et al.*, 1997), the Megachiropteran fauna contains a high percentage of threatened taxa as a result of the large-scale deforestation and hunting (Mickleburgh *et al.*, 1992).

The interdependencies of tropical forests and bats are well recognized, and in Philippine montane forests frugivorous bats rather than birds play the dominant role in dispersing early successional species (Ingle, 2003). However, very little data are available in the literature regarding the response by bats to destruction and alteration of their natural habitat (Estrada & Coates-Estrada, 2002). There are at least 15 species of Megachiroptera thought to be present on Negros Island, of which, approximately 20% are known to be endemic to the Philippines, and a high proportion of these species are threatened (Heaney *et al.,* 1998).

However, the status of the Microchiropteran fauna on Negros is still poorly known (Heaney, 1993) and they are recognized as probably the most poorly known mammalian order in the Philippines (Ingle & Heaney, 1992). Nevertheless, there has been notable progress on the ecological understanding of this group, both within specific geographic areas of the Philippines (Sedlock, 2001; Sedlock, 2002), and with particular ecological focus, e.g. seed dispersal (Utzurrum, 1995).

Conversely, the Megachiroptera (particularly the Pteropodidae family) are arguably one of the best-known groups of mammals within the Philippines (Heaney *et al.,* 2000) in terms of the relative distributions. However, it is also acknowledged that sampling effort has been skewed geographically, with many areas that have yet to be sampled. Thus, with little information about this threatened bat species, one can only state that it is believed or known to occur in the North Negros Forest Reserve (Heaney & Mallari, 2000).

Forest habitats have been identified as particularly important for bats and a priority for conservation efforts on a global scale (Mickleburgh *et al.*, 2002). However, an information deficit has been acknowledged (Oliver & Heaney, 1996; Heaney & Regalado, 1998; Turner *et al.*, 2001). With regard to Chiropterans, while new species have recently been discovered, there are concerns that several species may now be threatened and possibly extinct (Ingle & Heaney, 1992). Heaney and Heideman (1987) reported that it has not been possible to estimate the number of species of bats in the Philippines that are extinct or endangered because of a lack of basic surveying information, and they suggested that faunal surveys were needed in nearly all parts of the country. More specifically, Mickleburgh *et al.* (1992) stressed (as one of twenty priority global projects) the urgent need to survey the Negros Island area which is ranked eighth highest in the world for Megachiropteran diversity and has been listed sixteenth globally for requiring the establishment of protected areas for world fruit bat conservation.

The principal aim of the research was to complete an initial inventory of the Chiropteran species within the different major forest habitats of the Imbang-Caliban watershed of the North Negros Forest Reserve (NNFR).

Study Area

Negros Island forms part of the Negros-Panay Faunal region of the Philippines. The moist forests of the Philippines, including the NNFR, are among the eight most vulnerable forest ecosystems in the world (WWF 2001). It is the largest remaining area of wet evergreen rainforest in Negros and the second largest in the Negros-Panay Faunal region.

Initially the NNFR was established by legislation in 1946 to protect more than 100,000 ha of virgin forest. By 1996, however, only 9,900ha of virgin forest remained in a total area of 16,687ha of forested area (Hamann 2002). The NNFR contains different types of habitats due to its varying degrees of elevation. Lowland dipterocarp forest has been cleared except in a few inaccessible valleys, and 6,600ha of secondary forest grows on areas that have been logged over in the past.

Table 1. Major habitat types within the NNFR in which mist-net surveys were undertaken.

Habitat	Description	Altitudinal Range
Heavily Disturbed Old-growth forest	*Montane forest selectively logged 35 years ago.	1100-1400m
Old-growth forest	*Transitional montane-lowland forest logged legally and illegally for commercial species until 11 years ago.	1200-1600m
Secondary forest	*Transitional montane-lowland forest Legally and illegally logged for commercial species resulting in complete exploitation until 11 years ago.	800-1000m
Forest edge	Forest / non-forest border.	800-1000m

*Classification adapted from Heaney (2001) and history derived from interviews with local community members.

The reserve, however, still contains 4,700ha of mid-elevation old-growth forest and over 5000ha of high-elevation mossy forest. The NNFR is still struggling against illegal logging, hunting, pet traders, rebel activity, and encroachment of the farming populations (Hamann 2002). Further details on the survey areas are also given by Slade and Turner (2003).

The survey work was undertaken within four-hours trek of the village of Campuestohan (10° 39'N, 123° 08'E), on the southwest edge of the NNFR. The surveys were concentrated on four main habitat types (Table 1) within the Municipalities of Talisay and Murcia, Province of Negros Occidental.

Methods

Mist-Net Survey

Mist-nets (38mm mesh, 6m x 2.6m) were used within four habitat types (Table 1), representing both forested and forest edge habitats within the study area of the NNFR. The sites were a minimum of two hours trekking apart. To maximize capture efficiency, nets were established across likely flight-paths such as clearings, along ridges, or by water (Heaney *et al.*, 1989), in a variety of combinations, such as 'Z' and 'T' formations (Kunz *et al.*, 1996), and at heights ranging from 1m to 10m above the ground. High nets were operated on a pulley system and, when possible, were complemented by a low net positioned on the same pulley system (following Ingle, 1993). Generally, nets were opened before dusk and closed anytime up to midnight, depending on weather and personnel. Sampling took place between February 2002 and February 2003 with each site being sampled at regular intervals throughout this period.

The trapping effort is summarized in mist-net hours (calculated as hours per square-meter of net): secondary forest sampled for 224 mist-net hours; disturbed old-growth forest sampled for 213 mist-net hours; old-growth forest sampled for 198 mist-net hours; and forest edge sampled for 189 mist-net hours. Nets were checked every 30 minutes.

For each survey night, the location, weather conditions, and time the nets were operational were noted. As nets were open for variable lengths of time, net-effort for each location was calculated as hours per square-meter of net.

Species Identification

Bats captured were identified using Ingle and Heaney (1992), sexed by observation of genitalia and nipples, and aged (to adult or juvenile) by assessment of the ossification of the joints of the digits of the wing. Forearm length was measured using dial callipers, and weight using spring balances. When new species were encountered, ear, hind-foot, and total length were also recorded. No samples were taken during the survey period and the work was completed under a Gratuitous Permit issued by the Department of the Environment and Natural Resources.

Data Analysis

Three measures of local diversity were calculated for each survey location and these included: Total number of species (S), Shannon-Weiner diversity $H=å(P_i*Log_e(P_i))$ where P_i is the number of individuals of the *i*th species as a proportion of the total number of all *i*th species, and Pielou's eveness $J=H/Log_eS$ (Carr 1996).

Results

A total of 369 bats representing three Chiropteran families and 13 species were recorded across the survey locations, of which nine were Megachiropteran and four were Microchiropteran species (Table 2). The disturbed old-growth forest had the highest species richness and the greatest number of captured individuals among the habitats sampled, whereas the old-growth forest had the lowest values for both metrics. Over 45% of the species recorded are endemic to the Philippines (Table 2), including the highly endangered *Nyctimene rabori*.

Only three species, *Cynopterus brachyotis, Macroglossus minimus*, and *Rousettus amplexicaudatus* were recorded in all four of the habitat types. Additionally, *Cynopterus brachyotis* and *Haplonycteris fischeri* (a Philippine endemic) were the most abundant species. Of the 369 bats captured during the general mist-net survey, only a small proportion (<5%) were Microchiropterans. Morphological data were recorded for each species (Tables 3-4).

Table 2. Summary of Megachiropteran and Microchiropteran species captured during the surveys within NNFR.

Species	Common name	Forest Edge	Secondary Forest	Disturbed Old-growth	Old-growth forest	Total caught
Cynopterus brachyotis	Common short-nosed fruit bat	48	40	37	7	132
**Haplonycteris fischeri*	Philippine pygmy fruit bat	-	29	55	35	119
**Harpylonycteris whiteheadi*	Harpy fruit bat	-	-	-	1	1
**Nyctimene rabori*	Philippine tube-nosed fruit bat	2	-	3	-	5
Macroglossus minimus	Dagger-toothed flower bat	38	25	4	3	70
**Ptenochirus jagori*	Musky fruit bat	-	3	6	-	9
Pteropus hypomelanus	Common island flying fox	1	-	-	-	1
**Pteropus pumilus*	Little golden mantled flying fox	1	-	-	-	1
Rousettus amplexicaudatus	Common rousette	1	3	3	6	13
Rhinolophus arcuatus	Arcuate horseshoe bat	-	1	1	-	2
**Rhinolophus virgo*	Yellow-faced horseshoe bat	-	1	12	-	13
Myotis macrotarsus	Philippine large-footed myotis	1	-	1	-	2
Pipistrellus spp.	Pipistrelle sp	-	1	-	-	1
Total abundance		92	103	122	52	
Species richness		7	8	9	5	
Shannon-Weiner diversity		1.33	1.51	1.67	1.01	
Pielou's eveness		0.51	0.68	0.67	0.64	

* Endemic species.

Table 3. Megachiropteran adult morphological data.

Species			Adult Female				
		Mass (g)	Body length (mm)	Forearm (mm)	Hind foot (mm)	Tail(mm)	Ear (mm)
Cynopterus brachyotis	range	18-40	65.5-104.7	50-68.5	9.8-15.6	2.2-9	8.8-19.2
	mean (sd)	34.98 (5.25)	91.84 (7.88)	64.23 (3.65)	12.58 (1.38)	5.46 (1.9)	13.717 (2.38)
	n	38	29	39	29	23	30
Haplonycteris fischeri	range	11-22	54.7 -84.5	43.5-52.5	7-14	-	6.3-13
	mean (sd)	23.01	72.25 (5.46)	49.95 (5.33)	9.98 (1.58)	-	10.17 (1.62)
	n	48	45	49	49	-	49
Macroglossus minimus	range	16 -24	55.2- 73.6	41.5 -48	8.2- 14	-	9- 14.6
	mean (sd)	19.27 (2.12)	66.79 (4.95)	44.18 (1.44)	11.15 (1.63)	-	12.56 (1.91)
	n	22	12	22	15	-	15
Nyctimene rabori	range	63-68	132-136	71-79	15.2-16.3	-	18-22
	mean (sd)	65.5 (2.5)	134 (2.0)	75 (4)	15.75 (0.55)	-	20 (2)
	n	2	2	2	2	-	2
Ptenochirus	range	90-107	117.5-150.7	84.1-93	17.4-17.8	6.1-9.1	12.5-18.2
jagori	mean (sd)	98.5 (12.02)	134.1 (23.48)	88.55 (6.29)	17.6 (0.28)	7.6 (2.12)	15.35 (4.03)
	n	2	2	2	2	2	2
Rousettus amplexicaudatus	range	62.1-8-5.2	127.1-141.3	75-82.1	-	14.5-16.3	17.9-19.5
	mean (sd)	76.6 9.19	135.06 (5.28)	78.4 (3.04)	-	15.6 (1.14)	18.64 (0.69)
	n	5	5	5	-	5	5

Adult Male					
Mass (g)	Body Length (mm)	Forearm (mm)	Hind foot (mm)	Tail (mm)	Ear (mm
17-45	78.4-103.9	50.1-68.8	8.5-16.2	1.5-7.4	8.1-24
33.93 (6.13)	88.66	62.45 (3.3)	12.48 (1.61)	5.15 (1.89)	13.83 (2.89)
47	37	50	46	23	46
17-25	6.9-13.4	56.1-61.2	31 -52.1		7.9-12.9
23.61 (18.3)	69.50 (3.51)	48.64 (3.48)	10.34 (1.57)	-	10.18 (1.25)
33	33	33	33		33
17.5- 24	65.2 -85.4	42-64.6	11.1 - 14.7	0-6.5	9.1-14.6
21.7 (3.55)	70.87 (6.42)	46.3 (4.62)	11.28 (1.32)	2.167 (3.75)	12.88 (1.52)
20	13	20	14	3	14
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
80-93	109.5-135.4	82-89.3	15.2-19.9	3.7-12.3	16.5-17.6
88.92 (6.53)	122.08 (8.74)	86.40 (2.87)	18.38 (2.07)	8.93 (3.51)	17.02 (0.38)
6	6	6	6	6	6
65-88	129.1-146.2	77.7-83.1	-	14.9-17.2	18.1-21.2
78.6 (9.23)	137.8 (6.3)	80.7 (2.22)	-	15.78 (0.95)	19.4 (1.28)
6	6	6	-	6	6

Species listed in Table 2 but not in Table 3 were juveniles.

Table 4. Microchiropteran adult morphological data.

Species		Adult Female					
		Mass (g)	Body length (mm)	Forearm (mm)	Hind foot (mm)	Tail(mm)	Ear (mm)
Hipposideros	range						
Ater	mean (sd)	-	-	-	-	-	-
	n						
Rhinolophus	range	6-13	49.2-51.8	45.1-50	6.3-9.3	13-23	15-17
arcuatus	mean (sd)	10.5 (3.11)	50.33 (1.33)	47.73 (2.01)	7.83 (1.23)	18.48 (4.14)	16.13 (0.94)
	n	4	3	4	4	4	4
Rhinolophus	range	6-18	33.9-52.8	37.8-41.3	4.4-8	9-29.9	9-16.8
virgo	mean (sd)	12.88	42.63 (6.55)	39.83 (1.25)	6.63 (1.09)	17.16 (4.18)	12.45 (2.79)
	n	8	6	8	8	8	8
Pipistrellus	range						
sp.	mean (sd)	-	-	-	-	-	-
	n						

Adult Male					
Mass (g)	Body Length (mm)	Forearm (mm)	Hind foot (mm)	Tail (mm)	Ear (mm
6	40.9	40.9	7	29.7	15.5
1	1	1	1	1	1
8-15	46.9-50	47-50.4	6.8-17.8	3.7-24.6	9.9-21.5
11.19 (2.53)	50.34 (2.42)	49.05 (1.49)	10.08 (3.4)	17.48 (6.73)	16.85 (4.17)
8	6	8	8	8	8
6-14	30.5-63	37.2-40.5	6-7.2	16-21	10-16.4
8.71 (3.04)	42.09 (9.73)	38.9 (1.09)	6.63 (0.41)	19 (2.16)	14.81 (1.95)
7	8	9	9	9	9
4	49.5	32.5	6.3	30.9	12.1
1	1	1	1	1	1

Species listed in Table 2 but not in Table 4 were juveniles.

Discussion

Thirteen of the 73 species known to exist in the Philippines (Heaney *et al.*, 1998) have been recorded, representing over 17% of the Philippine bat fauna. However, this only represents 31% of the 41 species known to occur on Negros (Heaney *et al.*, 1998). The comparatively low numbers of species encountered may be explained by the limited number of areas (habitat types) surveyed and by the survey techniques employed. The combination of effort and techniques used may also partly explain the observed differences in the community metrics calculated.

The majority of the recordings consist of fruit bats, in particular, the Common short-nosed fruit bat (*Cynopterus brachyotis),* Dagger-toothed flower bat *(Macroglossus minimus),* and Philippine pygmy fruit bat (*Haplonycteris fischeri)*. The prevalence of megachiropterans is probably a facet of the survey method employed since microchiropterans are known to be able to detect and avoid mist-nets and thus tunnel trap methodologies are recommended for sampling this group (Sedlock, 2001).

Perhaps the most important record is the Philippine tube-nosed fruit bat (*Nyctimene rabori*) which is not only endemic to the Philippines but is only known to exist on three islands, Cebu, Sibuyan, and Negros (Heaney *et al.*, 1998). Discovered only in 1984, this species is currently classified as Critically Endangered by the World Conservation Union (IUCN Red List). It is thought that numbers of this species are now reduced to about one percent of the original population size. Such a decline is due to their dependency on lowland tropical forest where they feed and roost.

The capture of the Philippine pygmy fruit bat (*Haplonycteris fischeri)* is potentially very important since this species has declined in recent years and is listed as vulnerable (Heaney *et al.*, 1998). It is also known to prefer primary (old-growth) forest and rarely found in secondary forest, as confirmed by the results presented.

Other species encountered included both threatened and endemic species. The Little golden-mantled flying fox *(Pteropus pumilus)* is rare and endemic to the Philippines and well known to frequent islands where it is usually associated with primary and well-developed secondary forest (Heaney *et al.*, 1989), and uncommon to rare on larger islands (Heideman & Heaney, 1989; Utzurrum, 1992). Catch data suggest that densities are quite low although it has been hypothesized that this species forages high in the canopy and therefore it may be more abundant than current catch data suggest (Mickleburgh, *et al.,* 1992). The presence of this species within the reserve is very encouraging as it is considered globally vulnerable by the IUCN and is fourth on the conservation priority list for Philippine fruit bats (Mickleburgh, *et al.,* 1992).

Another species captured in low numbers was the Common island flying fox (*Pteropus hypomelanus)* which is also endemic to the Philippines. However, the species is known to fly high above normal netting reach and thus it may be more abundant than the catch-rates suggest. Of the microchiropterans, the Pallid Large-footed myotis (*Myotis macrotarsus)* is an uncommon species that is dependent upon caves to roost in (Heaney *et al.,* 1998) and is currently listed as near-threatened (Mickleburgh *et al.*, 1992).

We acknowledge that the reported data may represent a biased portrait of the bat community present in the area since we only sampled one level of the habitats studied during part of the night and because species of bats may be caught unequally by mis-nets. Since Microchiropterans are known to be able to detect and avoid mist-nets, tunnel trap methodologies are recommended for sampling this group (Sedlock, 2001).

Conclusion

The overall results demonstrate that even within the restricted geographic area surveyed, the forest habitats of the NNFR support a comparatively diverse and important bat fauna both on local and national scales. The records for the Philippine tube-nosed fruit bat even suggest this is a globally important site.

Further surveys employing a range of methods and over a greater number of habitat types (e.g. riparian forest; high-elevation mossy forest) are required for a comprehensive assessment. In addition, social and ecological assessments of the relevant threats posed to the bat fauna within the surveyed area of the NNFR should be made in order that appropriate conservation recommendations can be proposed.

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