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Report on a Survey of Mammals of the Sierra Madre Range, Luzon Island, Philippines

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Abstract

An inventory of mammals was undertaken at 11 localities along the Sierra Madre range in 2002 to 2005, in areas where few or no data were available previously. The inventory included lowland and montane forest habitats, at elevations from 300 to 1500 m. Thirty-eight species of mammals were recorded, including nine new records for the mountain range. One species, *Kerivoula* cf. *papillosa*, had not been recorded previously from the Philippines, and one, *Coelops hirsutus*, was known previously only from Mindanao and Mindoro Islands. Two species, in the genera *Apomys* and *Chrotomys*, may represent previously unknown species. We captured *Archboldomys musseri* only on Mt. Cetaceo, supporting previous evidence that it is endemic only to that mountain.

A modified mist-netting technique (V-net) for insectivorous bats was effectively used to capture these species. The new records clearly demonstrate that the mammalian fauna of the Sierra Madre is poorly known. Surveys of many additional areas are needed in all known habitat types along the Sierra Madre, especially karst, ultrabasic, and mossy forest, to fully document its diversity.

Keywords: Biodiversity, conservation, endemic, Luzon, mammals, Philippines, Sierra Madre

Introduction

Although the mammals of Luzon Island were among the first in the Philippines to be surveyed, nearly all of the studies were conducted in the Southern Central Cordillera, on or near Mt. Data (Hoogstraal, 1951; Mearns, 1905; Sanborn, 1952; Thomas, 1898). In the 1960s to 1980s, some highly distinctive murid rodents were subsequently recorded in surveys of Mt. Isarog, on the Bicol Peninsula of Southern Luzon (Balete and Heaney, 1997; Heaney et al., 1999; Musser, 1982; Musser and Freeman, 1981; Rickart and Heaney, 1991; Rickart et al., 1991, 1998). Extensive surveys were conducted in Kalinga Province in the northern Central Cordillera (Heaney et al., 2005), and on Mt. Tapulao in Zambales Province (Balete et al., 2007). Several studies of bats have been conducted on Mt. Makiling, Laguna Province (Ingle, 1992; Sedlock, 2001); while other parts of Luzon Island remain poorly documented (Heaney and Mallari, 2002).

The mammals of the Sierra Madre range of Eastern and Northeastern Luzon were almost entirely unknown until the 1980s when surveys were initiated. These include a brief survey of bats along the coast of Isabela and Cagayan provinces (Mudar and Allen, 1986), a brief survey of bats and rodents on Mt. Cetaceo (Danielsen et al., 1994), and a hunter-based survey of cloud rats (Oliver et al., 1993), which provided a majority of the records (Heaney et al., 1998). An assessment of the adequacy of mammalian diversity data in the Philippines showed that little information exists for any portion of the Sierra Madre, and no information at all on the mammals of Quirino and Quezon provinces (Heaney et al., 2002). Given the size and the relatively intact forest of the Sierra Madre and the discovery of a new species of small mammal, *Archboldomys musseri*, that is likely to be endemic to the Sierra Madre (Balete et al., 2006; Rickart et al., 1998), the need for additional information is evident.

Interest in the Sierra Madre as a globally important area for biodiversity conservation increased with its recognition as a conservation priority area during the Philippine Biodiversity Conservation Priorities Program (Ong et al., 2002; see also Heaney and Mallari, 2002). The program focused on building consensus on the location of conservation priority areas in the country (Brooks et al., 2004). In this paper, we present the results of our surveys of mammals of the Sierra Madre in 2002 to 2005.

Materials and Methods

Mist-netting of bats

Mist-nets with an average mesh size of 36 mm and height and length of 2.5 m and 12 m were used to catch bats. Mist-netting stations consisted of a series of 5-10 mist nets (60-120 m long) that were left open for three to four consecutive nights, then transferred to another mist-netting location. Nets were set with the bottom edges of the nets about 0.3 m above the ground. Mist-nets were placed along ridges and streams, and in forest and clearings, especially in possible flyways of bats. Nets were checked in early morning for netted bats and continuously in the evening for two hours (1800-2000 h), and at 30 min to 1 h intervals until 2200 h in the evening. Specimens captured were identified to species level in the field, and we recorded sex, age, individual reproductive condition, mammae size, tail length, forearm, hind foot, ear, total length, and noseleaf width (for relevant bats) as defined in Ingle and Heaney (1992).

In addition to the traditional mist-netting technique, we also employed a novel mist-netting technique designed solely for insectivorous bats, which we called the "V-net". We arranged two mist-nets in a V configuration wherein one end of each net is attached to a common secured pole. One arm of the V-net is fixedly positioned and serves as a wall whereas the other arm is mobile. The V-net works along a principle similar to tunnel trap with both arms of the V serving as the opening (Alviola, 2000; Sedlock, 2001). As the V-net is placed along a trail or stream, one person is assigned at the mobile arm of the V and another person stands at its side along the wall. When a bat enters, the mobile arm is shut quickly, causing the bat to be trapped and entangled along the interior of the wall.

Trapping of rodents

A mixture of locally manufactured cage traps and Victor rat traps was used at Sites 2, 3, 5, 7, and 8. Trapping of non-volant mammals was not done at Site 1, as no traps were available at the time, and we used only Victor rat traps at Sites 4, 6, and 9. A mixture of Victor rat traps and Museum Specials was used at Sites 10 and 11. Traps were usually placed on the ground near fallen logs or holes, along suspected runways, and at openings among roots of trees and stumps. Some were placed on the branches of trees above the ground to capture arboreal murids. Traps were spaced at 5-10 m intervals;

each trap line was operated for four to five days. Traps were baited twice each day, during early morning and late afternoon, using thin slices of roasted coconut coated with peanut butter. Live earthworms were also used as bait on some traps at Sites 3, 4, 6, 7, 9, 10, and 11. Animals caught in live traps were released at the site of capture unless voucher specimens were needed. For captured individuals, we recorded the length of tail vertebrae, hind foot, head and body, total length, weight, mammae number, and reproductive condition. Nomenclature was based on Heaney et al. (1998) and Musser and Heaney (1992). Voucher specimens (listed below as "specimens examined") of rodents and bats were prepared for study, cataloged, and identified at the Field Museum, with half to be returned to the National Museum of the Philippines.

Additional methods

Direct observation of snares called *silo* in Tagalog set by local people, footprints, fecal droppings, nests, and animal remains were noted. Animals traded in nearby villages, especially if these animals were taken within the survey site, were also noted. Interviews with local inhabitants (e.g., local guides, hunters, and residents) were conducted using color photos of mammals; we noted local names for animals, perceived abundance and frequency, month and season observed, behavior, and economic importance. Extent of hunting, trapping, and other forms of gathering were noted as well.

Distributions, habitat associations, and English common names are from Heaney et al. (1998) unless noted otherwise. Locations are given in order by elevation, from low to high (Figure 1). Longitude and latitude were determined using a GPS Garmin eTrex Summit. Specimen examined per site were also indicated in the species accounts.

Results and Discussion

Study sites

Site 1. *Blue Waters, Sitio Pallagao, Barangay Sta Margarita, Baggao Municipality, Cagayan Province* (18° 01′ 13″ N, 121° 59′ 26″ E, 4-6 June 2003).

Mist netting was done at the edge of a moderately disturbed limestone forest at 300 m. Several shallow caves located within the vicinity were checked for presence of bat colonies. Only the Blue Water Cave was inhabited by a colony of bats (*Hipposideros diadema*),

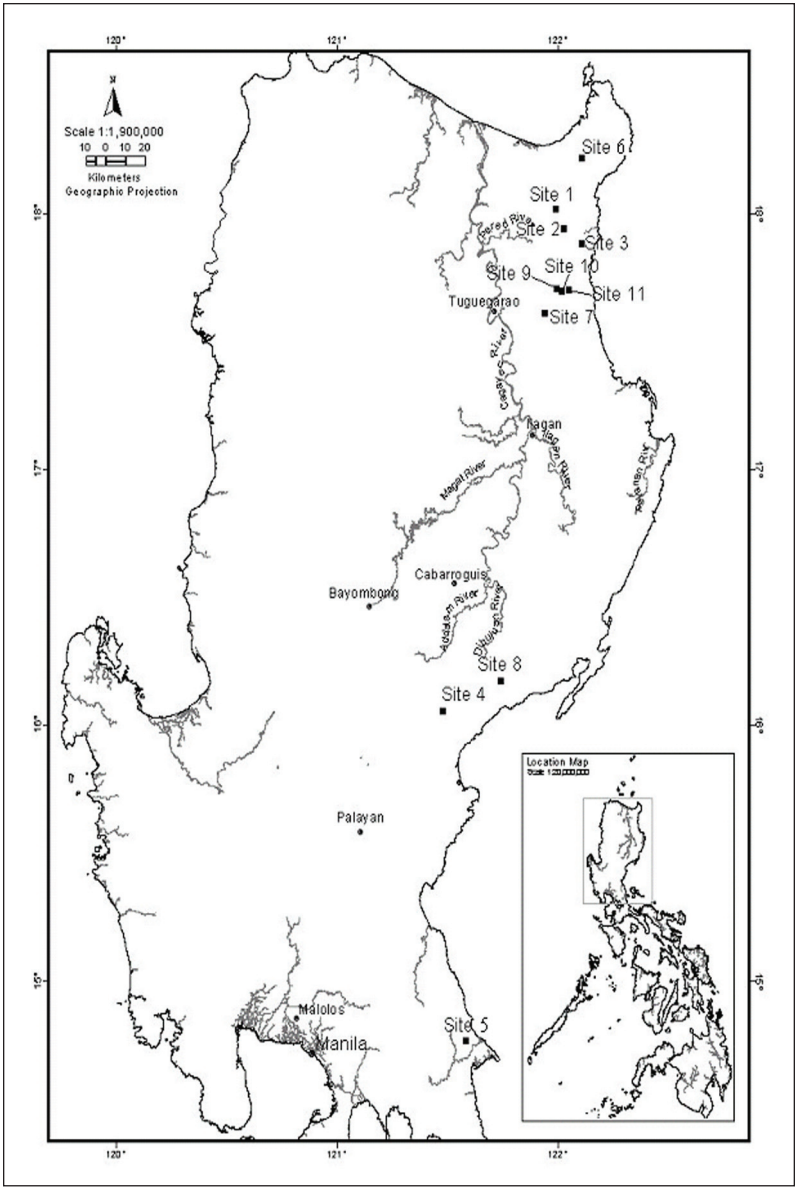

Figure 1. Map showing the location of the different survey sites along the Sierra Madre mountain range

numbering about 150 individuals. Slash and burn farming was common in the area. Commercial logging was cancelled in the area in 1989 but some timber poaching occurred subsequently.

Site 2. *Botanical Garden, Sitio Mansarong, Barangay Sta. Margarita, Baggao Municipality, Cagayan Province* (17° 56′ 24.05″ N, 122° 01′ 29.12″ E, 1-3 June 2003).

Netting and trapping were done in moderately disturbed secondary lowland forest and along the forest edge at 300 m elevation. Forest trees were predominantly Dipterocarpaceae. Shrubs and saplings were mostly Euphorbiaceae, Dipterocarpaceae, Myrsinaceae, Sapindaceae and Rubiaceae. The area was logged 15 years ago and is currently protected by the local community and a small band of *Agta*. The site is adjacent to slash and burn farms maintained by the *Agta* and an old logging road used by the community.

Site 3. *Mt. Twin Peaks, Sitio Matulang, Barangay Sta. Margarita, Baggao Municipality, Cagayan Province* (17° 52′ 53.2″ N, 122° 06′ 34.5″ E, 2-11 May 2003; 18-22 September 2004).

We surveyed 2 sub-sites along the Tabuan river. The first sub-site was in slightly disturbed secondary lowland forest at about 300 m elevation. Forest trees were dominated by Dipterocarpaceae with emergents reaching maximum heights of 35 to 40 m, and the canopy was estimated at 15 to 20 m. Diameter at breast height (DBH) ranged from 35 to 50 cm. Undergrowth consisted mainly of ferns and gingers. Epiphytes were chiefly Araceae and ferns. Lianas consisted mostly of *Freycinetia* spp. and *Ichnocarpus* spp. Shrubs and saplings included Sapotaceae, Dipterocarpaceae, Gutifferae and Euphorbiaceae. At the second sub-site, we conducted only mist-netting along the forest edge at about 300 m elevation. Timber poaching and patches of slash and burn farms were observed at both locations. Logging in the area was cancelled in 1991.

Site 4. *Mt. Mungiao, Sitio Mangitagud, Barangay Matmad, Nagtipunan Municipality, Quirino Province* (16° 03′ 22.5″ N, 121° 28′ 39.7″ E, 1-12 June 2004).

We surveyed 2 sites at 400 m and 700 m elevation. Netting was done at 400 m and trapping was done at 400 m and 700 m. The area was a selectively logged primary lowland forest. Emergent trees were predominantly dipterocarp species reaching maximum height of about 30 m with DBH reaching about 110 cm. Height of canopy tree species was estimated at about 20 to 25 m with DBH

about 32-40 cm. Understory vegetation was minimal, mostly ferns, rattans, ginger, and *Begonia* species. Vines were uncommon. The forest floor was rocky, with large rocks and boulders common, especially near the creek. The site is the hunting ground of the *Bugkalot*. Timber poaching, mainly for the premium species (such as *narra* and *kamagong*) was common. Hunting and some previous forest clearings were observed near our study area.

Site 5. *Mt. Binuang, Barangay Minahan, General Nakar Municipality, Quezon Province* (14° 45′ 52″ N, 121° 35′ 03″ E, 24 June – 1 July 2003).

Mt. Binuang rises a little over 1000 m. Trapping and netting was done in a highly disturbed secondary lowland forest between 500 and 700 m. Emergent and canopy trees are predominantly Dipterocarpaceae and Dilleniaceae. Emergent trees reached a maximum height of 25 m and canopy trees reached 20 to 25 m, with DBH of about 30 to 40 cm. The herb layer consisted mainly of pteridophytes. Epiphytes were mostly aroids and lianas, mainly *Freycinetia* spp. and *Ficus* spp. Shrubs and saplings consisted mostly of Dipterocarpaceae, Euphorbiaceae, Proteaceae, and Celastraceae. Slash and burn farming was common below our study area. Commercial logging was cancelled in the area in the early 1990s, but timber poaching was rampant with freshly cut trees observed along the trail and along the slopes.

Site 6. *Mt. Cagua, Barangay Magrafil, Gonzaga Municipality, Cagayan Province* (18° 13.12′ N, 122° 06.66′ E, 6-14 August 2004).

Netting and trapping was done in a slightly disturbed secondary lowland forest at 730 m. Emergent and canopy trees were predominantly Myrtaceae, Melastomataceae and Dipterocarpaceae reaching a maximum height of 18 m and canopy height of 14 m with DBH ranging from 30 to 40 cm. Epiphytes were ferns and lianas, mostly *Freycinetia* spp. Understory plants were mostly saplings, most belonging to Dipterocarpaceae, Sapindaceae and Lauraceae. Terrain was moderately flat. Mt. Cagua is a dormant volcano; its last eruption, in 1860, created a circular summit crater about 1.5 km in diameter, with steep, 60 m high walls; the highest peak reaches 1133 m (http://www.volcano.si.edu/world/volcano). Hunting was observed in the area and timber poaching was evident outside the crater at 800 m due to the presence of newly cut trees and tree stumps. Commercial logging in the area was cancelled in 1991.

Site 7. *Sitio Lowak, Barangay Minanga, Peñablanca Municipality, Cagayan Province* (17° 36′ 49.1″ N, 121° 56′ 23.8″ E, 11-19 November 2002).

Mist netting and trapping were conducted between 960 and 1200 m. The vegetation was transitional lowland to montane forest, with typical lowland plant species (e.g. Dipterocarpaceae) uncommon relative to montane tree species. Most emergent trees were *Shorea polysperma*. Canopy trees were predominantly *Lithocarpus* and *Syzygium* species. The subcanopy included laurels (Lauraceae), oil fruits (*Elaeocarpus* spp.), and tea (Theaceae). Common understory plants included *Discocalyx*, *Symplocos*, *Olea*, *Macaranga* and *Canthium* species. Trees were predominantly low-branching and multi-stemmed. Emergent trees reached a maximum of 25 m. Prevailing canopy species reached heights of about 12 to 18 m. Terrain consisted of moderate to rather steeply ascending ridges. We observed about 150 snares for wild pigs and deer in the area. Commercial logging was cancelled in late 1990s, but timber poaching was apparent as we often encountered people with their carabao pulling freshly cut timber near our study area.

Site 8. *Mt. Lataan, Barangay Disimungal, Nagtipunan Municipality, Quirino Province* (16° 10′ 20.6″ N, 121° 44′ 22.7″ E, 5-14 March 2003).

Mist netting and trapping was done from 900 to 1000 m in lower montane forest. Emergent and canopy trees were predominantly Fagaceae, Dilleniaceae, Myrtaceae and Sapotaceae. Canopy height was estimated at 8 m, and emergents reached a maximum of 15 m. Trees were predominantly low branching and multi-stemmed, 30 to 35 cm diameter. Shrubs and saplings consisted of Rubiaceae, Cornaceae, Myrtaceae, Rubiaceae species. The herb layer commonly consisted mostly of ferns and gingers. Epiphytic plants were mostly seen on tree boles, dominated by orchids, ferns and bryophytes. Lianas were mostly *Freycinetia* spp. The slope was moderately ascending to flat. According to our local guides, commercial logging did not reach the area. Timber poaching and hunting were observed.

Site 9. *Mt. Cetaceo, Sitio Baua, Barangay Lapi, Peñablanca Municipality, Cagayan Province* (17° 42′ 28.8″ N, 121° 59′ 49″ E, 5-19 May 2004).

We conducted netting and trapping in old-growth montane forest at 1300 m dominated by *Tristaniopsis* spp. and *Lithocarpus* spp. Tree trunks were covered with moss. Emergent trees were approximately

20 m (*Agathis philippinensis*) and average height of dominants was approximately 10 to 12 m. Undergrowth plants included rattans, ferns, and Cyperaceae. Forest litter was about 3 to 5 cm deep. Exposed rocks were common measuring about half a meter to a meter in diameter and were mostly covered with thick moss.

Site 10. *Mt. Cetaceo, Sitio Baua, Barangay Lapi, Peñablanca Municipality, Cagayan Province* (3.5 km SW of Mt. Cetaceo Peak, 17° 41′ 52″ N, 122° 01′ 08.9″ E, 9-18 June 2005).

We conducted netting and trapping in montane forest at 1400 m. Emergent trees were *Agathis philippinensis* approximately 17 m in height. Height of canopy species was approximately 12 to 15 m. Average height of dominant trees species was approximately 10 to 15 m dominated by *Syzygium* and *Lithocarpus* species. Ground cover was mainly composed of ferns and mosses.

Site 11. *Mt. Cetaceo, Sitio Baua, Barangay Lapi, Peñablanca Municipality, Cagayan Province.* (1.5 km SW of Mt Cetaceo peak, 17° 42′21.80″ N, 122° 35.80′ E, 14-17 June 2005).

We conducted trapping at 1500 m in mossy forest dominated by *Leptospermum* species. Emergent trees were approximately 6 to 7 m and average height of canopy tree species was 5 m. DBH of canopy cover was 5 to 15 cm. Canopy epiphytes included orchids and vines. Pitcher plants were relatively common. Pandan and *Ficus* species were rare. Understory plants were dominated by *Drymis piperata* and ground cover plants were dominated by ferns and mosses.

Accounts of species

Order Insectivora

1. Family Soricidae – Shrews
   a. *Crocidura grayi* (Dobson, 1890). The Luzon shrew is endemic to the Philippines and has been recorded in Catanduanes, Aurora, Camarines Sur, Laguna, and Rizal Provinces and on Mindoro (Heaney et al., 1998). We captured this species only in montane forest at 1400 m and mossy forest at 1500 m (Table 1). Specimens examined: Site 10; 1; Site 11, 1.

Order Chiroptera

1. Family Pteropodidae – Fruit bats
   a. *Acerodon jubatus* (Eschscholtz, 1831). The golden-crowned flying fox, a Philippine endemic, has been documented in the Sierra Madre, in Divilacan and Dinapigue, Isabela Province (Danielsen et al., 1994; Mudar and Allen, 1986). We did

Table 1. Number of individuals captured by trap or net (+ number caught by hand) during the biological surveys conducted along the Sierra Madre in 2002, 2003, and 2004. Scientific name in bold face indicates species endemic to the Philippines

Species	Site 1	Site 2	Site 3	Site 4
	Moderately disturbed limestone forest	Moderately disturbed secondary lowland forest	Lightly disturbed secondary lowland forest	Selectively logged lowland forest
	300 m	300 m	300 m	400 m
1. *Crocidura grayi*	0	0	0	0
2. *Acerodon jubatus*	R	0	0	0
3. *Cynopterus brachyotis*	2	9	3	1
4. *Haplonycteris fischeri*	1	3	13	0
5. *Macroglossus minimus*	1	1	12	0
6. *Otopteropus cartilagonodus*	0	0	4	0
7. *Ptenochirus jagori*	0	1	3	2
8. *Pteropus hypomelanus*	0	0	S	0
9. *Pteropus leucopterus*	0	0	0	0
10. *Pteropus vampyrus*	0	0	S	0
11. *Rousettus amplexicaudatus*	1	1	0	0
12. *Coelops hirsutus*[2]	0	0	0	0
13. *Hipposideros ater*	0	0	0	3
14. *Hipposideros diadema*	3	0	1	1 (+1)
15. *Hipposideros obscurus*[2]	0	0	0	2
16. *Rhinolophus arcuatus*	0	0	0	7
17. *Rhinolophus inops*[2]	0	0	0	0
18. *Rhinolophus philippinensis*[2]	0	0	0	0
19. *Rhinolophus virgo*	0	0	0	3
20. *Harpiocephalus harpia*[2]	0	0	1	0
21. *Kerivoula* cf. *papillosa*[2,3]	0	0	0	1
22. *Murina cyclotis*[2]	0	0	1	1
23. *Myotis horsfieldi*	0	0	0	1
24. *Myotis muricola*	0	0	0	0
25. *Pipistrellus javanicus*	0	0	0	3
26. *Chaerophon plicata*[1]	0	0	0	0
27. *Macaca fascicularis*	R	R	R	S
28. *Apomys* sp.	0	0	0	9
29. *Apomys* cf *microdon*	0	0	0	0
30. *Bullimus* sp.	0	1	3	16
31. *Archboldomys musseri*	0	0	0	0
32. *Chrotomys* sp.	0	0	+1	9
33. *Phloeomys pallidus*	S	R	R	R
34. *Rattus everetti*	0	3	5	23
35. *Rattus exulans*	0	0	0	1
36. *Paradoxurus hermaphroditus*	0	0	0	0
37. *Sus philippensis*	R	R	S	S
38. *Cervus marianmus*	R	R	R	S
Total trap-nights (Cage traps)	0	6	510[4]	0
Total trap nights (Victor Rat Traps)	0	0	104[4]	1388
Total trap nights (Museum specials)	0	0	0	0
Total net nights	3.5	3.5	12	33
Total V-nets (2 hours/night)	0	0	0	40

S = sighted; R = reliable reports; 0 = absent, [1] = Specimen given by a local spelunker; [2] = new record for Sierra Madre; [3] = new country record; [4] = locally made snap traps; x = no data were kept.

Table 1. contd.

Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
Highly logged secondary lowland forest	Lightly logged secondary lowland forest	Transition secondary lowland to montane forest	Old growth montane forest	Old growth montane forest	Old growth montane forest	Mossy forest
500-700 m	730 m	960-1200 m	900-1000 m	1300 m	1400 m	1500 m
0	0	0	0	0	1	1
0	0	0	0	0	0	0
1	1	20	0	0	0	0
8	1	10	0	0	0	0
1	1	2	0	0	0	0
4	1	1	18	11	0	0
6	0	29	12	1	0	0
0	0	0	0	0	0	0
S	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	0	0	0	0	0
0	1	0	0	1	0	0
3 (+1)	0	0	0	0	0	0
2	5	0	0	0	1	0
0	3	9	0	2	1	0
0	0	5	0	0	0	0
0	1	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	1	0	0	0	0	0
0	0	0	0	5	3	0
0	0	0	0	0	0	0
R	R	R	R	R	0	0
0	19	8	3	67	54	85
0	0	0	0	0	2	1
18	14	1	4	13	14	8
0	0	0	0	0	0	4
0	0	0	0	0	0	0
0	R	R	S	R	0	0
19	7	5	4	4	8	1
0	0	0	0	0	0	0
0	S	0	S	0	0	0
R	S	R	R	S	R	0
R	R	S	R	S	S	0
245	0	501	x	0	0	0
145[4]	255	174[4]	x	734	913	681
0	0	0	0	0	76	93
64	37	78	x	98	12	0
2	8	0	0	0	0	0

not capture this species, but at Site 9 local people reported a roost of very large bats that we were not able to verify; these might have been this species or *Pteropus vampyrus*, or both together (Mildenstein et al., 2005). The large bats are frequently hunted in the area.

b. *Cynopterus brachyotis* (Mueller, 1838). We captured the common short-nosed fruit bat in lowland agricultural areas and secondary forest from 300 to 730 m, and in transitional lowland-montane forest at 960 m (Table 1). Despite extensive netting, we did not capture them in montane forest between 900 to 1300 m at Sites 8 and 9 and 1400 m at Site 10. Specimens examined: Site 4, 1; Site 6, 1.

c. *Haplonycteris fischeri* (Lawrence, 1939). We caught the endemic Philippine pygmy fruit bat in secondary lowland forest from 300 to 730 m, and in transitional lowland-montane forest at 960 to 1200 m. Despite extensive netting at Site 8, 9 and 10 in montane forest between 900 to 1300 m, we captured none. All individuals were released (Table 1).

d. *Macroglossus minimus* (E. Goeffroy, 1810). We captured the dagger-toothed flower bat, a widespread Southeast Asian species, in agricultural areas, forest edge and secondary lowland forest from 300 to 730 m, and in transitional lowland-montane forest at 960 m. They apparently were absent in montane forest between 900 to 1400 m at Sites 8, 9 and 10, and mossy forest at Site 11 at 1500 m (Table 1). Specimens examined: Site 6, 1.

e. *Otopteropus cartilagonodus* (Kock, 1969). The Luzon pygmy fruit bat is a monotypic genus endemic to Luzon Island (Heaney et al., 1998); previous records were from secondary and primary lowland, montane, and mossy forest at 200 to 1900 m (Mudar and Allen, 1986; Ruedas et al., 1994). We captured this species in secondary lowland forest from 300 to 730 m, in transitional lowland-montane forest at 960 to 1200 m, and in old-growth montane forest at 900, 1300 and 1400 m. As seen on Mt. Isarog (Heaney et al., 1999), *O. cartilagonodus* overlapped with *H. fischeri* at some sites, but *O. cartilagonodus* was less common than *H. fischeri* in lowland forest, and *H. fischeri* was absent at the montane forest sites where *O. cartilagonodus* was common (Table 1). Specimens examined: Site 9, 3.

f. *Ptenochirus jagori* (Peters, 1861). The musky fruit bat is a widespread endemic within the Philippines, often common in primary and secondary forest and agricultural areas

adjacent to forest (Heaney et al., 1999; Heideman and Heaney, 1989; Ingle, 1992; Mudar and Allen, 1986; Lepiten, 1995). We found it to be common in secondary lowland forest from 300 to 500 m and in transitional lowland-montane forest at 960 m; it was uncommon in old-growth montane forest at 900 and 1300 m (Table 1). Specimens examined: Site 4, 2; Site 9, 1.

g. *Pteropus hypomelanus* (Temminck, 1853). The common island flying fox is distributed throughout much of Indo-Australia, including the Philippines, where it is common in agricultural areas and absent in primary forest (Rickart et al., 1993; Utzurrum, 1992). We captured none, but observed the island flying fox feeding in groups on a fig tree (*tangisang bayawak*, *Ficus variegata*) at Site 3, together with the larger *Pteropus vampyrus*. Groups of flying foxes were also seen high in the sky at dusk (1800 h) and consistently observed for the duration of the survey period. Local people call this species *bayakan* in Tagalog, and report that they regularly observed this species visiting their orchards.

h. *Pteropus leucopterus* (Temminck, 1853). The mottled-winged flying fox is endemic to the Luzon faunal region and Dinagat Island (Heaney et al., 1998). In the Sierra Madre, it was reported in Dinapigue, Isabela Province (M. Van Weird, personal communication). We did not capture this species at our sites, but we used binoculars to observe one individual (with distinctive white spots on its wings) flying over our camp at Site 5. Local people at all of our sites reported the presence of this species, but further survey is needed to verify these reports.

i. *Pteropus vampyrus* (Linnaeus, 1758). This species is found from Indochina to the Lesser Sundas and is widespread within the Philippines, in lowland forest up to 1250 m (Heaney et al., 1998; Rabor, 1955, 1986; Rickart et al., 1993). We did not catch this species, but saw them feeding on figs (*tangisang bayawak*, *Ficus variegata*) at Site 3 together with *P. hypomelanus*. Some individuals were observed to have a large reddish brown "cape" from the head to the nape of the bat that typifies *P. vampyrus*. Local people call this species *bayakan* in Tagalog, and reported that they regularly observed this species visiting their orchards. We also observed several individuals over our camp at Site 1; the identification was not certain.

j. *Rousettus amplexicaudatus* (É. Geoffroy, 1810). The common rousette occurs from Thailand to Solomon Island and the Philippines, usually in open, heavily disturbed habitats (Heaney et al., 1998). We netted the species in open and agricultural areas at Sites 1 and 2 at 300 m elevation; they were absent at other sites, where all of the netting was done in the forest. All individuals were released.

2. Family Rhinolophidae - Horseshoe bats
   a. *Coelops hirsutus* (Miller, 1911). The Philippine tailless roundleaf bat occurs only in the Philippines (Heaney et al., 1998). We captured one individual of this poorly known species at Site 2 in secondary lowland dipterocarp forest at about 900 m. The species was known previously from Mindoro and Mindanao (Heaney et al., 2006). The species has also been captured on Mt. Makiling, Laguna Province (J. Sedlock, personal communication). Specimens examined: Site 8, 1.
   b. *Hipposideros ater* (Templeton, 1848). The dusky roundleaf bat occurs from India to Australia, including the Philippines (Heaney et al., 1998). We captured the species in secondary lowland forest at about 400 m at Site 4 using a V-net. Specimens examined: Site 4, 3.
   c. *Hipposideros diadema* (E. Goeffroy, 1813). The diadem roundleaf bat occurs from Burma to the Solomon Islands and common throughout the Philippines (Heaney et al., 1998). We caught the species in almost all of the habitat types we sampled from 300 to 1300 m (Table 1). A colony of about 150 individuals was observed inside a large cave near Site 1 and we observed the species emerging from tree hollows at Site 1. One individual roosting under a large fern at Site 4 was caught by hand. Specimens examined: Site 1, 1; Site 3, 1; Site 4, 2; Site 6, 1; Site 9, 1.
   d. *Hipposideros obscurus* (Peters, 1861). The Philippine forest roundleaf bat is endemic to the Philippines and occurs in primary and disturbed forest up to 1100 m (Heaney et al., 1998, 2006; Sedlock, 2001). We captured two individuals using a V-net set across a creek at Site 4 and three individuals by mist nets and one by hand in an abandoned mineshaft at Site 5 at 400 and 500 m elevation, respectively. Specimens examined: Site 4, 2; Site 5, 3.

e. *Rhinolophus cf. arcuatus* (Peters, 1871). The arcuate horseshoe bat is a widespread endemic within the Philippines (Esselstyn et al., 2004; Heaney et al., 1998; Sedlock, 2001). The species currently referred to as *Rhinolophus arcuatus* in the Philippines may consist of two or more species (Heaney et al., 1991, 1999, 2006; Ingle and Heaney, 1992). We captured the species in lightly disturbed lowland forest at Sites 4 and 6, and highly disturbed secondary lowland forest at Site 5 (Table 1). Initial examination of our specimens suggests two different species, corresponding to the "large" and "small" morphs (Ingle and Heaney, 1992). Further taxonomic study is needed. Specimens examined: Site 4, 10; Site 5, 2; Site 6, 5; Site 10, 1.

f. *Rhinolophus inops* (K. Andersen, 1905). The Philippine forest horseshoe bat is endemic to the Philippines; it is often abundant in primary lowland and montane forest up to 2250 m (Heaney et al., 1998, 2006). We captured this species in secondary lowland forest and old growth montane forest between 730 and 1300 m (Table 1). Specimens examined: Site 6, 2; Site 7, 9; Site 9, 2; Site 10, 1.

g. *Rhinolophus philippinensis* (Waterhouse, 1843). The enormous-eared horseshoe bat is widely distributed from Borneo to Australia and has been captured only in primary and secondary forest (Heaney et al., 1998; Lepiten, 1995; Ruedas et al., 1994). We captured this species only in transitional lowland forest and montane forest between 960 and 1200 m (Table1). Specimens examined: Site 7, 5.

h. *Rhinolophus virgo* (K. Andersen, 1905). The yellow-faced horseshoe bat is endemic to the Philippines and inhabits secondary and primary lowland forest from 250 to 1100 m (Heaney et al., 1991, 1998, 2006; Ingle, 1992; Rickart et al., 1993; Sedlock, 2001). We captured this species in selectively logged lowland forest and slightly disturbed secondary lowland forest using a V-net at 400 m and 730 m (Table 1). Our specimens appear to represent two different morphs; the specimen from Site 6 (FMNH 176548) is substantially smaller than the others, which appear to represent typical *R. virgo*, and some cranial features differ. Further taxonomic study is needed. Specimens examined: Site 4, 3; Site 6, 1.

3. Family Vespertilionidae - Common bats
   a. *Harpiocephalus harpia* (Temminck, 1840). The hairy-winged bat is widespread in southern Asia and previously recorded in the Philippines only in Camarines Sur and Laguna provinces on Luzon (Heaney et al., 1998; Ingle, 1993). It was previously documented in primary and disturbed lowland forest between 475 to 750 m (Rickart et al., 1993). We captured an individual at Site 3 in secondary lowland forest at 300 m. Specimen examined: Site 3, 1.
   b. *Kerivoula* cf. *papillosa* (Temminck, 1840). Three species of *Kerivoula* have been documented in the Philippines previously; all three are fairly widespread in Southeast Asia, principally in lowland forest (Esselstyn, 2004; Heaney et al., 1998; Ingle and Heaney, 1992). We captured an individual of a large *Kerivoula* at Site 4 using a V-net set along an existing trail in selectively logged lowland forest. Compared to the known species in the Philippines, our species is much larger, with forearm of 44 mm and a total length of 108 mm. Direct comparison with a series of *K. papillosa* from Vietnam (FMNH 32209, 46564-46568, 46623) show the external morphology and crania to be very similar. *Kerivoula papillosa* occurs from eastern India to Indochina, Borneo, and Sulawesi (Corbet and Hill, 1992; Payne et al., 1985); further study is needed. Specimen examined: Site 4, 1.
   c. *Murina cyclotis* (Dobson, 1872). The round-eared tube-nosed bat occurs from Sri Lanka to Hainan and Borneo, and is widespread in the Philippines. It occurs in primary and lightly disturbed lowland and montane forest between 250 and 1500 m (Corbet and Hill, 1992; Heaney et al., 1998; Lepiten, 1995; Rickart et al., 1993). We captured an individual at Site 3 using mist nets and one individual at Site 4 using a V-net. On Luzon, the species has previously been reported from Camarines Sur (Heaney et al., 1998, 1999), Laguna (Sedlock, 2001) and Kalinga provinces (Heaney et al., 2005). Specimens examined: Site 3, 1; Site 4, 1.
   d. *Myotis horsfieldii* (Temminck, 1840). The common Asiatic myotis occurs from southeastern China to the Malay Peninsula, Bali, and Sulawesi, and is widespread in the Philippines. It inhabits agricultural areas and lowland forest (Heaney et al., 1998; Sedlock, 2001). We captured one individual in selectively logged lowland forest at Site 4 using a V-net. Specimen examined: Site 4, 1.

e. *Myotis muricola* (Gray, 1846). The whiskered myotis is widespread in Asia and throughout the Philippines (Heaney et al., 1998). It inhabits primary and lowland forest from near sea level to 1125 m (Heaney et al., 1999; Rickart et al., 1993). We captured one individual at Site 4 using a V-net in selectively logged lowland forest. Previous Luzon records are from Camarines Sur (Heaney et al., 1999), Laguna (Sedlock, 2001), and Kalinga provinces (Heaney et al., 2005). Specimen examined: Site 4, 1.

f. *Pipistrellus javanicus* (Gray, 1838). The Javan pipistrelle is widespread in eastern Asia (Corbet and Hill, 1992). In the Philippines, it occurs from sea level to 1750 m, where it is common in montane forest and uncommon in lowland forest and mossy forest (Heaney et al., 1998). We captured three individuals at Site 4 in selectively logged lowland forest at 400 m using V-nets, five individuals in primary montane forest at site 9 at 1300 m, and three individuals at Site 10 at 1400 m. Our species seem to consist of two morphs based on some differences on external morphologies noted by Sedlock (2001) and Heaney et al. (2006). Further taxonomic study is needed. Specimens examined: Site 4, 3; Site 9, 3; Site 10, 3.

4. Family Molossidae - Free-tailed bats

a. *Chaerophon plicata* (Buchanan, 1800). The wrinkled-lipped bat occurs from India to Bali, Hainan, and the Philippines (Corbet and Hill, 1992). The species is believed to be declining in the Philippines due to heavy disturbance of caves (Heaney et al., 1998; Rickart et al., 1993). One dead specimen given to us on 14 June 2004 by a local spelunker was taken from a rock near a cave in Barangay Aggugadan, Peñablanca Municipality, Cagayan Province. Local people turned over three more dead specimens from the same cave where the previous one was found. A colony of this species may be present; assessment of the cave is urgently needed. Specimens examined: Near Site 7, 1.

Order Primates

1. Family Cercopithecidae – Monkeys

a. *Macaca fascicularis* (Raffles, 1821). The long-tailed macaque occurs from Burma to Timor and is widespread in the Philippines (Heaney et al., 1998). We observed this species at most of our sites feeding on fruits in lowland forest canopy.

Based on our interviews, the species is frequently seen in groups of 20 to 30 individuals and feeds on corn and root crops. Our local guide caught one adult male at Site 4. The species is regularly hunted for local consumption.

Order Rodentia

1. Family Muridae – Rats and mice
   a. *Apomys* sp. The genus *Apomys* is the most speciose genus in the Philippines, including a large (and increasing) number of recently discovered and still undescribed species (Heaney et al., 1998; Steppan et al., 2003). Our specimens are the first large series from the Sierra Madre, and preliminary comparisons indicate that they represent one or more previously unknown large-bodied species; investigations are on-going (Heaney et al., in prep.). We captured these large forest mice in secondary lowland forest, montane, and mossy forest. None was captured in forest adjacent to agricultural areas at ca. 300 m elevation, but they were common at sites from 400 to 1500 m (Table 1). Specimens examined: Site 4, 9; Site 6, 15; Site 7, 7; Site 8, 3; Site 9, 67; Site 10, 54; Site 11, 85.
   b. *Apomys* cf. *microdon* (Hollister, 1913). This small Luzon forest mouse is endemic to the Philippines and known only from Catanduanes Island, and from Camarines Sur, Isabela and Kalinga provinces on Luzon (Heaney et al., 1998, 2005). We captured the species at our two highest sites, in montane forest at Site 10 at 1400 m and mossy forest at Site 11 at 1500 m using Victor rat traps and Museum Specials placed on tree branches. We did not catch the species on the ground or at other sites that we surveyed. Specimens examined: Site 10, 2; Site 11, 1.
   c. *Archboldomys musseri* (Rickart et al., 1998). This species is endemic to the Sierra Madre Mountains and is known only from Mt. Cetaceo (Balete et al., 2006). We captured four individuals at Site 11, which is also the locality of holotype that was taken in 1992 (Danielsen et al., 1994; Heaney et al., 1998). We captured the species only in mossy forest at 1500 m despite intensive trapping in montane and lowland forest. They should be sought at the peaks of other high mountains in the Sierra Madre. Specimens examined: Site 11, 4.
   d. *Bullimus* sp. (Thomas, 1895). This genus of large forest rat is endemic to the Philippines. It inhabits primary and disturbed lowland, montane, and mossy forest (Heaney et al., 1998,

2005; Musser, 1982; Sanborn, 1952). We captured this species at all of our sites except at Site 1, where no trapping was done, and at Site 2, in forest adjacent to agricultural areas (Table 1). Morphological differences were observed between our specimens and those from the Central Cordillera; taxonomic investigations are on-going. Specimens examined: Site 2, 1; Site 3, 3; Site 4, 16; Site 5, 4; Site 6, 13; Site 7, 1; Site 8, 2; Site 9, 13; Site 10, 14; Site 11, 6.

e. *Chrotomys* sp. This genus of murid rodents is endemic to the Philippines. Currently, five species are known: *C. gonzalesi* is restricted to Mt. Isarog, *C. whiteheadi* in the Central Cordillera, *C. mindorensis* in the lowlands of central Luzon and Mindoro (Heaney et al., 1998), *C. sibuyanensis* from Sibuyan, and *C. silaceus*, formerly placed in the genus *Celaenomys*, from the Central Cordillera (Rickart et al., 2005). Present ecological data indicates that *C. whiteheadi* occurs at high altitudes, ca. 1000 to 2500 meters (Heaney et al., 1998, 2005), as does *C. gonzalesi* (Rickart et al., 1991). Our first specimen of *Chrotomys* at Site 3 (300 m) was captured by a pet cat. We captured a series at Site 4 between 400 to 700 m; both sites were in secondary lowland forest. Preliminary comparison with the known species indicates that this may represent a sixth species; taxonomic studies are on-going. Specimens examined: Site 3, 1; Site 4, 9.

f. *Phloeomys pallidus* (Nehring, 1890). The slender-tailed cloud rat is endemic to the Philippines and occurs only in the central and northern part of Luzon Island (Heaney et al., 1998; Oliver et al., 1993). Most of our information on this species was based on interviews, though we encountered them at two of our sites. An adult male foraging in a cornfield was caught by a farmer at Site 1. At Site 8, our local guide shot an individual a kilometer away from the camp in secondary lowland forest at about 500 m. Based on our interviews, a dark brown color-morph was also reported in the area, which resembles *Phloeomys cumingi* that occurs in the central and southern part of Luzon. These large (ca. 2.5 kg) rodents are hunted regularly in the Sierra Madre. Local residents often reported capturing this species on their farms or in coconut plantations, and some were caught by dogs; we confirmed the species to be *P. pallidus* by showing them pictures.

g. *Rattus everetti* (Gunther, 1879). The common Philippine forest rat is endemic to the Philippines (Heaney et.al. 1998), in secondary and primary lowland and montane forest and less often at high elevations (Rickart et.al., 1991, 1993). We captured the species at all of our study sites except at Site 1 where no trapping was done. They were relatively common in secondary lowland forest and declined in relative abundance as elevation increased (Table 1). Specimens examined: Site 2, 3; Site 3, 4; Site 4, 23; Site 5, 5; Site 6, 7; Site 7, 2; Site 8, 1; Site 9, 5; Site 10, 8; Site 11, 1.

h. *Rattus exulans* (Peale, 1848). The spiny rice-field rat occurs from Bangladesh to Easter Island and throughout the Philippines (Heaney et al., 1998), usually in open agricultural or fire-associated grassland habitats, and rarely in forest (Heaney et al., 1989; Heideman et al., 1987; Rickart et al., 1993). We captured only one individual at Site 4 in forest edge adjacent to an agricultural area. Specimen examined: Site 4, 1.

Order Carnivora

1. Family Viverridae – Civets
   a. *Paradoxurus hermaphroditus* (Pallas, 1777). The common palm civet occurs from Sri Lanka to Hainan and Lesser Sunda Islands and widespread in the Philippines (Heaney et al., 1998). We captured one adult male in secondary lowland forest at Site 5 using a local snare set by our guides, and one young individual in a cage trap in montane forest at Site 8. Both individuals were later released. Based on our interviews, the species is hunted for local consumption.

Order Artiodactyla

1. Family Suidae – Pigs
   a. *Sus philippensis* (Nehring, 1886). The Philippine warty pig is endemic to the Philippines (Heaney et al., 1998). We documented this species at all of our study sites. We often observed tracks in lowland and montane forest between 300 and 1300 m. An adult male was captured in a local snare at Site 9, and a captive young individual was seen in the house of a local resident near Site 4. Based on our interviews with the local people, the species is regularly hunted in the Sierra Madre both for local and commercial consumption.

2. Family Cervidae – Deer
   a. *Cervus mariannus* (Desmarest, 1822). The Philippine brown

deer occurred originally only in the Philippines but was later introduced to the Marianna Islands (Heaney et al., 1998). We observed one captive individual at a house near Site 1. Another individual was seen in the back yard of a local resident at Site 3. The owners told us that they intended to raise them in captivity as they fetch a high price in the market. At Site 4 a local resident offered to sell a skin and head of a deer. We also encountered hunters at Site 9 carrying a newly butchered deer and we also observed a deer foraging near our camp at Site 10. According to local hunters, they were having difficulty catching the species, unlike in previous years; hunters now must spend more time in the forest and further away from settlements. The species is hunted both for local and commercial consumption.

Mammalian diversity

It has been about two decades since the first moderately comprehensive biological surveys of mammals were conducted in the Sierra Madre, each at a single site or in limited areas (Danielsen et al., 1994; Mudar and Allen, 1986). Although several surveys have followed, very few have been published and few specimens are available. Our 2002 to 2005 surveys have generated information on the importance of the mountain range in terms of mammalian diversity. We documented a total of 37 species of mammals during our surveys (Table 1). Among these, one shrew, five fruit bats, four insectivorous bats, seven murid rodents, and two ungulates are endemic to the Philippines. Seven species of insectivorous bats were documented for the first time in the Sierra Madre and two species of rodents are potentially new species. We captured *Kerivoula* cf. *papillosa*, documented within the Philippines for the first time. *Coelops hirsutus*, captured in Quirino Province, was previously recorded only from Mindoro and Mindanao Islands (Heaney et al., 1998), but this elusive bat was also captured in 2004 on Mt. Makiling (J. Sedlock, personal communication), suggesting that this species is widely distributed on Luzon and throughout the country. In addition, *Rhinolophus inops*, *R. philippinensis* and *Hipposideros obscurus* have not been previously recorded in the mountain range (Heaney et al., 1998). Similarly, the only previous record of *Harpiocephalus harpia* from Luzon is from Camarines Sur despite the fact that it is widespread in southern Asia (Heaney et al., 1998; Nowak, 1991). *Murina cyclotis* has been documented at scattered localities in the Philippines, but not previously in the Sierra Madre.

Additionally, species of insectivorous bats that we have tentatively identified as *R. arcuatus*, *Rhinolophus virgo*, and *Pipistrellus javanicus* need further investigation. Like any other potential new species, nothing is certain unless a thorough taxonomic study has been made and specimens compared with other known species. Among the murid rodents, *Chrotomys mindorensis* was reported from Isabela (NORDECO-DENR, 1998), but this needs to be reexamined in the light of our large series of what appears to be a distinct, new species. Two additional rodents that we have documented may represent new species, *Bullimus* sp. and *Apomys* sp.; the existence of the series we collected makes taxonomic studies possible. We observed that majority of the native species of rodents, such as *Apomys* sp., *Bullimus* sp., *Chrotomys* sp., and *Rattus everetti*, were captured in primary and disturbed forest, while commensal species such as *Rattus exulans* were caught only in agricultural areas adjacent to forest.

As observed in the past, surveys of insectivorous bats by means of standard mist-netting methods is inadequate, as these bats can echolocate and thus evade mist-nets easily (Alviola, 2000; Sedlock, 2001). We employed a novel mist-netting technique (V-nets) at Sites 4, 5 and 6. This resulted in 11 species of insectivorous bats captured, a relatively high number for microchiropterans (Table 1). Tunnel-trapping on Polillo Island (Alviola, 2000) and Mt. Makiling (P. Alviola, personal communication; Sedlock, 2001) have resulted in 10 and 11 new records for the two localities, respectively.

Conservation priorities

Many of the insectivorous bats documented in the survey are cave dwellers. Unfortunately, no study has been done on caves in the Sierra Madre. Many of these caves harbor large colonies of insectivorous bats, such as the "Bat Cave" in the municipality of Peñablanca, Bolos Point Cave in Gattaran, Kapanikian caves in Sta. Ana, Cagayan Province, Aglipay Caves in Quirino Province, and several other large caves reported in our study sites. We documented specimens of *Chaerophon plicata* near Site 7; although they are not endemic or officially listed as threatened, several caves that were known to support the typically very large colonies of this species have been destroyed (Heaney et al., 1998; Rickart et al., 1993). Survey of these caves should be done and protection measures should be put in place, particularly those that support large colonies of insectivorous bats that are located adjacent to human settlements.

The Philippine warty pig and Philippine brown deer are the most frequently hunted mammals in the Sierra Madre as they fetch a high

price in the market. Although these species were reported to be relatively common in our study sites, many of the local people we interviewed noted that they were becoming scarce. The Philippine macaque and cloud rats were frequently encountered in farm lots adjacent to forest areas. They were hunted by the local people and were sometimes considered as pests of agricultural crops. Colonies of flying foxes were also reported in our study sites but we did not have the chance to visit these areas. Existing roosts comprising *A. jubatus* and *P. vampyrus* in Divilacan and Dinapigue, Isabela numbering to about 60,000 - 120,000 individuals have been reported (Danielsen et al., 1994). Most of these roost sites are located in the lowland forest and accessible to local people, making them vulnerable to hunting and destruction of roosting areas. A survey should be conducted to locate these roosting sites, conduct population and ecological studies and put management and protection measures in place.

In addition, many of the endemic mammals we documented at our study use both secondary and primary lowland forest. This includes four species whose ranges are confined to Luzon: *Otopteropus cartilagonodus*, *Apomys* sp., *Bullimus* sp., and *Phloeomys pallidus*. As mentioned above, *O. cartilagonodus* was recorded at almost all of our survey sites from 300 m to 1300 m. (Heaney et al., 1998; Ruedas et al., 1994). *Haplonycteris fischeri*, which is abundant in the southern Philippines, is less common on Luzon and is generally dependent on primary or good quality secondary forest at low elevation (Heaney et al., 1989, 1998; Ingle, 1992). We trapped *Bullimus* sp. and *Apomys* sp. at nearly all of our sampling sites. This suggests that both species have wide habitat preference and can tolerate disturbed lowland forest (Table 1). We recorded *P. pallidus* at all sites except Site 5, thus tentatively concurring with its reported distribution, which is confined to northern and central Luzon (Oliver et al., 1993). We received reports from local communities in the Sierra Madre that they have encountered a darker version of the species in areas where *P. pallidus* is known to occur. This observation needs further investigation.

Despite the cancellation of Timber License Agreements in the 1990s, destruction of forest in the Sierra Madre remains unabated. Almost all of the lowland forest in the western side of Sierra Madre from 300 - 800 m is accessible because of old logging roads. This has led to the transformation of many of these areas into farmlands and has provided easy access to the remaining forest for timber poachers. Management and protection of the lowland forest should be a high priority if we are to protect our endemic species, and the watershed

forests where they live. Very few have been declared as protected areas. Although some have been placed under the Community based Forest Management Agreement (CBFMA) and Certificate of Ancestral Domain Claim (CADC), the lowland forest still does not receive enough protection. New protected areas should be large enough to include all known habitat types, even the degraded lowland forests. Existing protected areas should be expanded to include adjacent forest areas to maintain their watershed functions.

Our data show that there is a need for more research, especially in areas not previously studied, particularly the caves, high elevations and the canopy of lowland forest, and on the still unsurveyed high peaks where more endemic mammal species might be found. Filling in these gaps will help us better understand the mammalian diversity of the Sierra Madre and to formulate better conservation measures to protect the wildlife of the mountain range.

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References

Alviola, P.A. 2000. The distribution and ecology of bats in the Polillo Islands, Philippines. In: Bennett, D. [ed]. Wildlife of Polillo Island, Philippines. University of Oxford-University of the Philippines at Los Banos Polillo'99 Project: Final Report. Viper Press, Glossop.

Balete, D.S. and L.R. Heaney. 1997. Density, biomass, and movement estimates for murid rodents in mossy forest on Mount Isarog, southern Luzon, Philippines. Ecotropica 3: 91-100.

Balete, D.S., E.A. Rickart, and L.R. Heaney. 2006. A new species of the shrew-mouse, *Archboldomys* (Rodentia: Muridae: Murinae), from the Philippines. Systematics and Biodiversity 4: 489-501.

Balete, D.S., E.A. Rickart, R.G.B. Rosell-Ambal, S. Jansa, and L.R. Heaney. 2007. Descriptions of two new species of *Rhynchomys* Thomas (Rodentia: Muridae: Murinae), from Luzon Island, Philippines. J. Mammalogy 88:287-301.

Brooks, T., M. Abuel, L. Co, O. Coroza, M.V. Duya, M.R. Duya, P. Langhammer, A. Mallari, C. Morales, N. Palomar, R. Rodriguez, B.R. Tabaranza Jr., and R. Trono. 2004. Targets and priorities for biodiversity conservation globally, and in the Philippines. Agham Mindanaw 2:1-10.

Corbet, G. and J.E. Hill. 1992. The mammals of the Indomalayan Region. Oxford University Press, Oxford.

Danielsen, F., D.S. Balete, T.D. Christensen, M. Heegaard, O.F. Jakobsen, A. Jensen, T. Lund, and M.K. Poulsen. 1994. Conservation of biological diversity in the Sierra Madre mountains of Isabela and southern Cagayan province, the Philippines. BirdLife International, Manila and Copenhagen.

Esselstyn, J.A., P. Widmann, and L.R. Heaney. 2004. The mammals of Palawan Island, Philippines. Proc. Biological Soc. Washington 117:271–302.

Heaney L.R., P.C. Gonzales, R.C.B. Utzurrum, and E.A. Rickart. 1991. The mammals of Catanduanes Island: Implications for the biogeography of small land bridge islands in the Philippines. Proc. Biological Soc. Washington 104:399–415.

Heaney, L.R., D.S. Balete, L. Dolar, A.C. Alcala, A. Dans, P.C. Gonzales, N.R. Ingle, M. V. Lepiten-Tabao, W. Oliver, P.S. Ong, E.A. Rickart, B.R. Tabaranza Jr., and R.C.B. Utzurrum. 1998. A synopsis of the mammalian fauna of the Philippine Islands. Fieldiana: Zoology, new series 88:1–61.

Heaney, L.R., P.D. Heideman, E.A. Rickart, R.C.B. Utzurrum, and J.S.H. Klompen. 1989. Elevational zonation of mammals in the central Philippines. J. Trop. Ecol. 5:259-280.

Heaney, L.R. and N.A.D. Mallari. 2002. A preliminary analysis of current gaps in the protection of threatened Philippine terrestrial mammals. Sylvatrop 10:28–39.

Heaney, L.R., D.S. Balete, E.A. Rickart, R. C.B. Utzurrum, and P.C. Gonzales. 1999. Mammalian diversity on Mount Isarog, a threatened center of endemism on Southern Luzon Island, Philippines. Fieldiana: Zoology, new series 95:1–62.

Heaney, L.R., D.S. Balete , G.A. Gee, M.V. Lepiten-Tabao, E.A. Rickart, and B.R. Tabaranza Jr. 2005. Preliminary report on the mammals of Balbalasang, Kalinga Province, Luzon. Sylvatrop 13:51-62.

Heaney, L.R., B.R. Tabaranza Jr., D.S. Balete, E.A. Rickart, and N.R. Ingle. 2006. The mammals of Mt. Kitanglad Nature Park, Mindanao, Philippines. Fieldiana: Zoology, new series 112:1-63.

Heaney, L.R., E.K. Walker, B.R. Tabaranza Jr., and N.R. Ingle. 2002. Mammalian diversity in the Philippines: an assessment of the adequacy of current data. Sylvatrop 10:6-27.

Heideman, P.D. and L.R. Heaney. 1989. Population biology of fruit bats (Pteropodidae) in Philippine submontane rainforest. J. Zoology (London) 218:565–586.

Heideman, P.D., L.R. Heaney, R.L. Thomas, and K.R. Erickson. 1987. Patterns of faunal diversity and species abundance of non-volant small mammals on Negros Island, Philippines. J. Mammalogy 68:884-888

Hoogstraal, H.H. 1951. Philippine zoological expedition, 1946-1947. Narrative and itinerary. Fieldiana: Zoology 33:1-86.

Ingle, N.R. 1992. The natural history of bats on Mt. Makiling, Luzon Island, Philippines. Silliman J. 36:1-26.

Ingle, N.R. 1993. Vertical stratification of bats in a Philippine rainforest. Asia Life Science 2:215-222.

Ingle, N.R. and L.R. Heaney. 1992. A key to the bats of the Philippine Islands. Fieldiana: Zoology, new series 69:1–44.

Lepiten, M.V. 1995. The mammals of Siquijor Island, central Philippines. Sylvatrop J. 5:1-17.

Mearns, E.A. 1905. Descriptions of new genera and species of mammals from the Philippine Islands. Proc. U.S. National Museum 28:425-460.

Mildenstein, T.L., S.C. Stier, C.E. Nuevo-Diego, and L.S. Mills. 2005. Habitat selection of endangered and endemic large flying-foxes in Subic Bay, Philippines. Biological Conservation 126:93–102.

Mudar, K.M. and M.S. Allen. 1986. A list of bats from Northeastern Luzon, Philippines. Mammalia 50:219-225.

Musser, G.G. 1982. Results of the Archbold Expedition No. 108. The definition of the genus *Apomys*, a native rat of the Philippine Islands. American Museum Novitates 2746:1-43.

Musser, G.G. and P.W. Freeman 1981. A new species of *Rhynchomys* (Muridae) from the Philippines. J. Mammalogy 62:154-159.

Musser, G.G. and L.R. Heaney. 1992. Philippine rodents: Definitions of *Tarsomys* and *Limnomys* plus a preliminary assessment of phylogenetic patterns among native Philippine murines (Murinae, Muridae). Bulletin of the American Museum of Natural History 211:135-138.

NORDECO-DENR. 1998. Technical Report. Integrating conservation and development in protected area management in the Northern Sierra Madre Natural Park, the Philippines. NORDECO, Copenhagen and DENR, Manila.

Oliver, W.L.R., C.R. Cox, P.C. Gonzales, and L.R. Heaney. 1993. Cloud rats in the Philippines: Preliminary report on the distribution and status. Oryx 27:41-48.

Ong, P., L.E. Afuang, and R.G. Rosell-Ambal (eds.). 2002. Philippine biodiversity conservation priorities: A second iteration of the national biodiversity strategy and action plan. Philippine Department of Environment and Natural Resources, Quezon City.

Payne, J., C.M. Francis, and K. Phillips. 1985. A field guide to the mammals of Borneo. Sabah Society, Kota Kanabalu.

Rabor, D.S. 1955. Notes on mammals and birds of the Central Northern Luzon Highlands, Philippines. Part 1. Notes on mammals. Silliman J. 2:193-218.

Rabor, D.S. 1986. Guide to the Philippine flora and fauna, Vol. XI: Birds, Mammals. Natural Resources Management Centre, Ministry of Natural Resources and University of the Philippines, Quezon City.

Rickart, E.A. and L.R. Heaney. 1991. A new species of *Chrotomys* (Muridae) from Luzon Island, Philippines. Proc. Biological Soc. Washington 104:387-398.

Rickart, E.A., L.R. Heaney, and R.B. Utzurrum. 1991. Distribution and ecology of small mammals along an elevational transect in Southeastern Luzon, Philippines. J. Mammalogy 72:458-469.

Rickart, E.A., L.R. Heaney, D.S. Balete, and B.R. Tabaranza Jr. 1998. A review of the genera *Crunomys* and *Archboldomys* (Rodentia, Muridae, Murinae) with descriptions of two new species for the Philippines. Fieldiana, Zoology, new series 89:1-24.

Rickart, E.A., L.R. Heaney, P.D. Heideman, and R.C.B. Utzurrum. 1993. The distribution and ecology of mammals on Leyte, Biliran, and Maripipi islands, Philippines. Fieldiana: Zoology, new series 72:1-62.

Rickart, E.A., L.R. Heaney, S.M. Goodman, and S. Jansa. 2005. Review of the Philippine genera *Chrotomys* and *Celaenomys* (Murinae) and description of a new species. J. Mammalogy 86:415-428.

Ruedas, L.A., J.R. Demboski, and R.V. Sison. 1994. Morphological and ecological variation in *Otopteropus cartilagonodus* Kock 1969 (Mammalia: Chiroptera: Pteropodidae) from Luzon, Philippines. Proc. Biological Soc. Washington 107:1-16.

Sanborn, C.C. 1952. Philippine Zoological Expedition 1946–1947: Mammals. Fieldiana: Zoology 33:89–158.

Sedlock, J.L. 2001. Inventory of insectivorous bats on Mount Makiling, Philippines using echolocation call signatures and a new tunnel trap. Acta Chiropterologica 3(2): 163-178.

Steppan, S.J., C. Zawadzki, and L.R. Heaney. 2003. Molecular phylogeny of endemic Philippine rodents *Apomys* (Muridae) and the dynamics of diversification in an oceanic archipelago. Biological J. Linnean Soc. 80:699-715.

Thomas, O. 1898. On the mammals obtained by Mr. John Whitehead during his recent expedition to the Philippines. Trans. Zool. Soc. London 14:377-414.

Utzurrum, R.C.B. 1992. Conservation status of Philippine fruit bats (Pteropodidae). Silliman J.36:27-45.