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Chapter 7

The mammal fauna of the Nakanai Mountains, East New Britain Province, Papua New Guinea

Ken P. Aplin and Muse Opiang

SUMMARY

We surveyed mammals around three sites in the Nakanai Mountains of East New Britain, including one at higher elevation than any previous work in this area. The survey produced records of ten species of terrestrial mammals (three marsupials and seven rodents), six pteropodid bats, and ten insectivorous bats. At least three (possibly four) of the rodents are undescribed species, two of them representing new genera, and at least one (possibly two) of these species is an entirely new discovery, with no previous record. One of the captured bats is probably an undescribed species related to *Nyctimene albiventer*. Further study of the bats may reveal additional species of special interest, especially in the genus *Miniopterus*.

The results of the Nakanai RAP survey fundamentally alter our perception of the mammal fauna of New Britain. Rather than having a depauperate subset of the New Guinean mammal fauna, New Britain has its own deeply endemic mammal fauna that includes at least two endemic genera of murine rodents as well as endemic species of at least four other murine genera. In addition, it also supports numerous distinctive species or subspecies of bats, many of them shared with New Ireland and/or the northern Solomon Islands. The mammal fauna of New Britain thus contains many mammalian taxa of global significance. Effective protection of the large tracts of pristine forests that exist in the Nakanai Mountains is of fundamental importance to the long-term conservation of these taxa.

INTRODUCTION

New Britain, with a land area of 35,742 km^2, is the largest of the many satellite islands that surround the central landmass of New Guinea. It is also one of the highest, with a maximum elevation of 2,440 m above sea level, and the most mountainous, with several large tracts of montane habitat above 1,000 m, most notably the Whiteman Mountains in the west and the Nakanai Mountains in the east. These upland blocks are not only precipitous but also exceptionally rugged, with spectacular karst terrain including the internationally acclaimed Nakanai megadolines. Today, the majority of people live in the lowlands around the coast, and much of the inland country is rarely visited and hence, difficult to access.

Knowledge of the mammal fauna of New Britain developed slowly in comparison with many other regions of Melanesia. Although various European ships landed on New Britain in the 18th Century (Mayr and Diamond 2001), the earliest biological collections came later, through the targeted efforts of various German collectors (including Carl Hunstein, who fell victim to a tidal wave in 1888 while working in the Kilenge region of West New Britain; Frodin and Gressitt 1982), and through the more eclectic activities of the Reverend George Brown who operated out of Duke of York Island between 1875-1881 but who acquired specimens from various places in the Bismarck Archipelago, leaving uncertainty in some cases over exact collecting localities. Only three mammal species from these early collections were named specifically from New Britain – *Perameles myoides* Günther, 1883 = *Echymipera kalubu*;

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Macroglossus nanus Matschie, 1899 = *Macroglossus minimus*, and *Macroglossus* (*Syconycteris*) *finschi* Matschie, 1899 = *Syconycteris australis finschi*. However, others were described from Duke of York Island (e.g. *Mus musavora* Alston, 1877 = *Melomys rufescens*), from New Ireland (e.g. *Perameles cockerelli* Ramsay, 1877 = *Echymipera kalubu*, *Halmaturus browni* Ramsay, 1877 = *Thylogale browni*, and *Pteropus capistratus* Peters, 1876), or from the general vicinity (e.g. *Uromys rufescens*, Alston 1877 = *Melomys rufescens*).

Biological exploration of New Britain through the 20th Century was largely focussed on its rich and distinctive avifauna (Gilliard and LeCroy 1967, Diamond 1971). However, several of the field workers also collected mammal specimens, particularly bats which were captured in nets set for birds. One notable addition to the fauna of New Britain during this period was *Pteropus gilliardorum* Van Deusen, 1969, described from one specimen collected by Thomas and Margaret Gilliard at their "summit camp" at 1,600 m in the Whiteman Range. This specimen remained the only record of this highly distinctive species until 1994 when it was captured in New Ireland (Bonaccorso 1998: 123, Emmons and Kinbag 2001). Koopman (1979) reported on mammal specimens collected by Jared Diamond on New Britain, and provided the first systematic review of the mammal fauna of the Bismarck Archipelago. His accounts lists four marsupials, six murid rodents, ten insectivorous bats, and 12 pteropodid bats, as occurring on New Britain. Kock (1981) added one extra species - *Philetor brachypterus*.

The first systematic collecting of mammals on New Britain was undertaken in June-August 1979 by a team from the Natural History Museum of Los Angeles County (Smith and Hood 1981). This expedition collected at numerous sites in the lowlands of both New Ireland and New Britain but failed to penetrate the upland habitats on either island. Even so, they added six bat species to the faunal list of New Britain, including one newly recognized - *Hipposideros maggietaylorae* Smith and Hill 1981. Additional mammal surveys on New Britain since that time have included multiple expeditions in the early 1990s by survey teams from the Australian and South Australian Museums (results incorporated into Flannery 1995a), from the Papua New Guinea National Museum and Art Gallery (results incorporated into Bonaccorso 1998), and the privately organized 'New Britain Biological Survey' (Anthony et al. 2008) that worked in the Nakanai Mountains and Willaumez Peninsula between March to April 1999. The latter expedition produced significant new records including one or possibly two new murid rodents – both tentatively referred to the genus *Melomys* (Anthony in Anthony et al. 2008) – that remain undescribed. The presence of additional murid rodent species on New Britain was also noted by each of Flannery (1995a) and Menzies (1996). Flannery (1995a) listed both *Melomys platyops* (= *Paramelomys platyops*) and *Melomys* sp. cf .*M. levipes* as occurring on New Britain, the latter based on a skull (AMNH 194397) collected by Margaret Gilliard in 1959 at 750 m in the Whiteman Range. Menzies (1996) also reported one specimen of a potentially new murid rodent related to *Melomys* from near Kimbe, in East New Britain, based on specimen UP3387.

Knowledge of the prehistory of New Britain's mammals, such as might be obtained from bones recovered from archaeological cave deposits, is non-existent. This is regrettable because evidence of this kind from cave deposits on New Ireland have revealed a complex history of human-assisted introductions of both medium-sized and small mammals, the former probably in a bid to enrich the originally depauperate mammal fauna of the island, and the latter possibly as accidental introductions (Flannery and White 1991, Leavesley 2005). The list of likely prehistoric human-introductions to New Ireland includes a wallaby (*Thylogale browni*), a cuscus (*Phalanger orientalis*), and several rats (*Rattus praetor*, *Rattus exulans*). Whether these species were derived from native populations occurring on New Britain or from further afield, is not yet known. The cave faunas are also informative in revealing which species were present in the vicinity of the cave site. Thus, for New Ireland we can be confident that the prehistoric fauna of the island did not include two of the larger murine rodents endemic to New Britain, namely *Uromys neobrittanicus* and *Hydromys neobrittanicus*.

This report presents findings of a mammal survey at three sites in the Nakanai Mountains of East New Britain in April 2009.

MATERIALS AND METHODS

Data collection and sampling methods

Protocols for capturing and handling of mammals followed guidelines of the American Society of Mammalogists (Gannon et al. 2007). The majority of captured mammals were euthanized for long term preservation as museum voucher specimens, thereby allowing detailed comparative study of both external and internal features (e.g. skull and teeth). Most vouchers were fixed whole in 10% formalin and subsequently transferred to 70% ethanol for long-term storage. A few were skinned in the field and fixed in 70% ethanol for future preparation as puppet skins. Tissue samples were preserved in 95% ethanol for all captured animals to allow efficient extraction of DNA.

Surveys for terrestrial and arboreal mammals were carried out with a combination of live 'box' traps (Elliott traps) and lethal 'break-back' traps. Traps were generally set at irregular intervals alongside an existing or purpose cut walking track passing through representative habitat, with trap placement chosen to maximize likelihood of capture. Traps were set either on the ground (e.g. on animal run ways, under logs, among or under rocks) or suspended above ground (e.g. on logs or hanging branches). No traps were set in the canopy. The trapping effort was supplemented by daytime searches for burrows and other animal signs, and night time spotlight surveys, mostly along walking trails and larger tracks. Other

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participants in the survey also spent time out of camp at night and they sometimes reported sightings of mammals.

Surveys for bats were carried out with a combination of mist nets and harp traps. Mist nets were double-strand 'bird' nets and were shared with the bird surveyor. They were variously placed by the bird or mammal teams, with placement reflecting a variety of factors. The majority of nets set by the bird surveyor were set in parallel series and close to the ground to maximize capture of understorey birds. Nets set by the mammal team were generally set across gullies and other gaps in the understorey. Two double-bank harp traps were employed during the survey. These were set at ground level and positioned in narrow gaps that might be used as flyways, most often across narrow gullies or on tracks through dense understorey.

Specimens from the Nakanai RAP survey are deposited in the Australian National Wildlife Collection, CSIRO Division of Ecosystem Sciences, identified by the prefix ANWCM. Other institutional abbreviations used here are: AMNH (American Museum of Natural History) and UP (University of Papua New Guinea Natural Sciences Resource Centre). Taxonomic and common names generally follow Flannery (1995a). Any departure from this source is discussed under individual species accounts. IUCN Red List ratings are drawn from the 2008 assessment available at (http://www.redlist.org/).

Study sites

The RAP survey was conducted out of three sites, giving an elevational range from below 200 m to just above 1,590 m

Lamas Camp (**5°36.853'S 151°24.483'E**) was situated at 200 m in lowland evergreen forest and surrounded by moderately dissected terrain. Watercourses were mostly gullied and had minimal surface flow at the time of the visit. The camp was accessed by walking trail and the surrounding habitat showed signs of occasional visitation by hunting parties. Six nights were spent at the camp – the nights of the 3rd - 8th April 2009.

Vouvou Camp (**5°26.740'S 151°27.842'E**) was situated at 859 m in lower montane forest. The camp was accessed by vehicle track and was located on the site of a former forestry camp. Areas close to the track showed signs of regular visitation, mainly by groups of people walking between inland villages and the coast, but areas distant from the track showed no recent disturbance. An area of newly established gardens and plantation to the north of the camp was also sampled. Eight nights were spent at the camp – the nights of the 10th - 18th April 2009.

Tompoi Camp (**5°20.623'S 151°18.875'E**) was situated at 1,590 m in the upper montane forest zone. The camp was accessed by helicopter and occupied for the nights of 19th – 25th April 2009. The habitat surrounding Tompoi camp was heavily disturbed, with most of the forest severely damaged by a combination of El Niño fires and then a cyclone. As a result, much of the area supports dense stands of bamboo, interspersed with small patches of 'good' forest. Both kinds of habitat were sampled.

Aplin and Opiang worked together at Lamas and Vouvou Camps, with Opiang working alone to complete the survey at Tompoi Camp. All survey methods were deployed at each of the sampling sites. In addition, exploratory forays were made in search of caves that might contain roosting bats or bone deposits accumulated by predators or natural deaths.

RESULTS AND DISCUSSION

This survey produced important discoveries including examples of at least three undescribed species of rodents, two of them belonging to new genera

Survey methodological analysis

The survey period and effort deployed at each of the three mammal sampling sites is summarized in Table 7.1. This tabulation also indicates the success of each method. Opportunistic captures by hunters using dogs or by hand are not included in this table but are mentioned during the individual species accounts.

Terrestrial mammal trapping

Only 1.04 % of traps resulted in a capture and this falls to 0.45% if the nine captures of *R. exulans* in garden habitat (and the associated trapping effort of 80 trap nights) are excluded from the calculation. This level of 'trap success' in forest habitat can only be described as abysmal – though it is offset entirely by the fact that almost every capture was of a spectacularly interesting mammal!

Anthony (in Anthony et al. 2008) also experienced very low trapping returns in the montane forests of New Britain – a total of 2093 trap nights at 800-980 m yielded only

Table 7.1. Summary of the survey effort and capture returns for mammals at each site. Opportunistic captures by hunters using dogs or by hand are not included in this tabulation.

Camp	Elevation (m)	Sampling 'nights'	Total trap 'nights'	Trap captures	Harp trap 'nights'	Harp trap captures	Mist net 'nights'	Mist net captures
Lamas	200	6	432	0	12	9	55	47
Vouvou	859	8	576	11	16	8	78	33
Tompoi	1,590	6	432	4	12	0	60	5
Total		**20**	**1440**	**15**	**40**	**17**	**193**	**85**

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5 rats, while 1794 trap nights at 1,000-1,200 m yielded 11 rats (seven of them *Rattus* spp.). Although published data on trapping are sparse for New Guinea, in Aplin's experience returns below 1% are typical of primary forest habitats below 1,000 m. Much higher returns occur if trapping is focussed in disturbed habitats such as gardens and along trackways but captures in these habitats are invariably dominated by species of *Rattus*, often including the Pacific Rat (*R. exulans*). Far better trapping returns can be had in primary forests at higher elevations, and especially above 2,000 m, with many species contributing to the elevated returns. At very high elevations, such as in subalpine habitats, trap success can be close to 100% but comprise only a few species, with a native species of *Rattus* usually predominant.

Mist netting

We captured nine bat species in mist nets, including three insectivorous bats. Capture rates in mist nets averaged 0.85 bats per mist net 'night' (i.e. less than one bat per net per night) for Lamas Camp, 0.42 bats per mist net 'night' for Vouvou Camp, and 0.00 bats per mist net 'night' for Tompoi Camp. Similar captures rates and a comparable reduction in mist net returns with increasing elevation were reported by Byrnes (in Anthony et al. 2001) from the 'New Britain Biological Survey' in 1999 – 0.78 bats per mist net 'night' for the lowland site (up to 400m a.s.l), 0.58 bats per mist net 'night' for the mid-elevation site (800-980 m), and 0.44 bats per mist net 'night' for the highest site (1,000-1,200 m).

Harp traps

Whilst harp traps have proven successful for capturing insectivorous bats in closed forests in Australia (Duffy et al. 2000) and Southeast Asia (Kingston et al. 2003), they seem to give generally poor returns when deployed in New Guinean closed forest habitats. We caught a total of 17 individual bats from 40 harp trap 'nights', which is meagre returns by international standards. Very poor success with harp traps has been reported by Richards (no captures from 20-30 harp trap 'nights' in primary forest in Southern Highland Province; Richards 2008), by Helgen (no captures from six harp trap 'nights' in the Kaijende Highlands of Enga Province; Helgen 2007), and by Armstrong and Aplin (no captures from 16 harp trap 'nights' in the Muller Range, Southern Highland Province; Armstrong and Aplin, Chapter 19, this volume).

We caught nine species of bats in harp traps, including the pteropodid *Syconycteris australis finschi*, and six of the ten species of insectivorous bats recorded during the survey were only taken in harp traps. Despite the low overall returns, the method is thus a valuable addition to any survey that seeks to inventory an insectivorous bat fauna.

Observations

The amount of time spent walking around during the days and through the evening was not quantified as many expedition members were active and on the lookout for interesting mammals. On most evenings the two mammal surveyors spent 2-3 hours each moving slowly through forest habitat, with similar time invested by the RAP herpetologist and invertebrate specialists. Sightings of mammals apart from flying bats were rare, and in conformation with some universal rule, most of these were made by non-mammalogists! Most sightings were of non-descript 'rats'. Two exceptions were sightings at Lamas Camp of a tree-mouse by Muse Opiang and of a giant rat by camp assistants (both described in more detail below).

Caves visited during the survey usually proved difficult to penetrate to any depth and no bats were observed. One large cave near Vouvou Camp contained a bat colony in an inaccessible vertical shaft but setting of mist nets and harp traps across entrances resulted in capture of two species.

SUMMARY OF MAMMAL RECORDS

The combined survey methods produced records of ten species of terrestrial mammals (three marsupials and seven rodents), six pteropodid bats, and ten insectivorous bats.

At least three (possibly four) of the rodents are undescribed species, two of them representing new genera, and at least one (possibly two) of these species is an entirely new discovery, with no previous record. Two of the undescribed rodents represent the first novel collections of entirely new genera and species of mammals in Melanesia for many decades. One of these is the *Melomys*-like murine, collected first by Nicola Anthony in 1999 and again during our survey. The other is the *Pogonomys*-like murine captured by Muse Opiang during this survey. Prior to these discoveries, the last collection of an entirely new genus and species was in 1970 when R. Traub and A. B. Mirza captured specimens of *Mirzamys louiseae* in the Star Mountains of West Sepik Province. For many years, this distinctive murine lay undiscovered in the collection of the Bernice P. Bishop Museum until its recent unveiling by Helgen and Helgen (2010). Prior to that, it is necessary to look back to the early 1940s for the novel collection of a suite of new genera during the Archbold Expeditions to New Guinea, including *Paranyctimene raptor* Tate, 1942, *Microhydromys richardsoni* Tate, 1941, and *Paraleptomys wilhelmina* Tate & Archbold, 1941.

One of the bats is probably an undescribed species related to *Nyctimene albiventer*. It has been collected previously on New Ireland (Smith and Hood 1983) and probably also on New Britain (Byrnes in Anthony et al. 2008). Further study of the bats may reveal additional species of special interest, especially in the genus *Miniopterus*.

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Table 7.2. List of mammal species detected at each of the RAP survey camps. Values are the number of times each species was encountered. Also shown are whether or not the species is recorded previously from New Britain, and how it was recorded during the RAP survey. Code for methods: Ha = harp trap; Hu = hunted by hand or with aid of dog; M = mist net; O = visual observation; S = pickup skeleton; T = trap.

Species	Lamas	Vouvou	Tompoi	Recorded previously from New Britain?	How recorded
Peramelidae					
Echymipera kalubu	1	3	-	+	Hu,T
Phalangeridae					
Phalanger orientalis breviceps	-	-	2	+	Hu
Macropodidae					
Thylogale browni	-	+	-	+	S
Muridae					
Melomys undescribed species	-	1	-	+?	Hu
Pogonomys sp. cf. *P. macrourus*	1	-	-	+	O
Rattus exulans	-	9	-	+	T
Rattus sp. cf. *R. praetor*	-	-	3	+	T
Undescribed genus + species 1 (*Melomys*-like)	1	-	-	+	Hu
Undescribed genus + species 2 (*Pogonomys*-like)	-	-	1	-	T
Uromys neobrittanicus	1	-	-	+	O
Pteropodidae					
Dobsonia praedatrix	1	-	-	+	M
Macroglossus minimus nanus	7	1	-	+	M
Nyctimene sp. cf. *N. albiventer*	3	2	3	+	M
Nyctimene vizcaccia	2	1	-	+	M
Rousettus amplexicaudatus	2	-	-	+	M
Syconycteris australis	29	28	2	+	M,Ha
Vespertilionidae					
Miniopteris macrocneme	-	1	-	+	Ha
Miniopteris sp. cf. *M. medius*	-	1	-	?	Ha
Pipistrellus angulatus	-	2	-	+	Ha
Pipistrellus papuanus	1	-	-	+	Ha
Emballonuridae					
Mosia nigrescens	3	-	-	+	Hu
Hipposideridae					
Aselliscus tricuspidatus	3	1	-	+	Ha
Hipposideros diadema	4	2	-	+	M,Ha, S
Hipposideros maggietaylorae	1	3	-	+	M, Ha
Rhinolophidae					
Rhinolophus euryotis	1	-	-	+	Ha
Rhinolophus megaphyllus	2	-	-	+	M,Ha

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ANNOTATED SPECIES LIST

Order Peramelemorphia, Family Peramelidae

Echymipera kalubu (Lesson, 1828) (Common Echymipera)
IUCN Red List rating: Least Concern
Echymipera kalubu as currently understood is the most widely distributed of Melanesian bandicoots, with a range that includes all of the main island of New Guinea and many of its satellites. However, taxonomic studies currently underway by Mike Westerman, Ken Aplin and others suggests that two or more species are probably confused within *E. kalubu*, with two forms probably co-distributed across northern New Guinea. Further genetic and morphological work is needed to clarify the distribution and nomenclature of this complex group.

Koopman (1979) regarded *E. kalubu* to be present on both New Ireland and New Britain. However, occurrence of the species on New Ireland rests solely on Ramsay's (1877) statement that the syntypes of *Perameles cockerelli* were obtained there, which as Flannery (1995a) has argued, is probably erroneous. No modern specimen of *E. kalubu* has come out of New Ireland, nor have any bandicoot remains yet come from the numerous archaeological excavations on New Ireland.

The occurrence of *Echymipera kalubu* on New Britain was first indicated by the description of *Perameles myoides* Günther, 1883 from an unspecified locality on New Britain. Later confirmation came from specimens collected by the Gilliards in the Whiteman Range, and a juvenile caught by Nicola Anthony in lowland rainforest behind Walindi resort near Kimbe in 1999.

We obtained four specimens of *Echymipera kalubu*. An adult female (ANWC M30822) weighing 780 g was obtained by a hunter working with dogs in disturbed forest, down-slope of Lamas Camp on 5th April 2009. Two of the six teats in the pouch were enlarged and the hunter admitted to feeding two pouch young to his dog. The other three were obtained at Vouvou Camp. One was caught during clearance of the camp site, prior to arrival of the scientific team, and was eaten by the work crew; the skull was recovered (ANWC M30871). Two more were caught during the stay at Vouvou Camp: a juvenile male (ANWC M30890) weighing 103 g taken in a snap trap on 13th April 2009; and an adult female (ANWC M30926) with two pouch young and weighing 690 g that was caught by hand by a local camp helper. Inclusion of these individuals in the ongoing genetic studies of *E. kalubu* will assist with clarification of both the identity and status (whether native or introduced) of the New Britain population.

A form of *Echymipera kalubu* is evidently quite common on the Nakanai Mountains at low to mid-elevations. No evidence of the species was observed around Tompoi Camp.

Order Diprotodontia, Family Macropodidae

Thylogale browni (Ramsay, 1877) (Northern Pademelon)
IUCN Red List rating: Least Concern
The status of *Thylogale browni* in the Bismarck Archipelago is also the subject of ongoing uncertainty. On New Ireland the species is absent from the older layers of archaeological cave deposits and first appears in layers dated to around 7000 years ago, presumably following human-assisted introduction. A recent genetic study of New Guinean pademelons (Macqueen et al. in press) found very low genetic diversity within and between two Bismarck island populations (New Britain and Umboi Island), and found these populations to be closer genetically to a population at Wanuma in Madang Province than to populations on the more proximate Huon Peninsula in Morobe Province. These results are consistent with the notion of a recent introduction to the entire Bismarck Archipelago but do not rule out the possibility of an earlier introduction to New Britain than to New Ireland. No suitable archaeological cave deposits have been excavated on New Britain from which to date the introduction event or establish its likely cause.

We observed footprints of a small wallaby consistent in size with *T. browni* at c. 250 m elevation in hills to the south of Lamas Camp. We also collected skeletal remains at two locations close to Vouvou Camp. One of these was a partial skeleton (ANWC M30915) lying on the forest floor; bone does not survive long under these conditions and the specimen is of guaranteed modern age. The other specimen is an isolated lower jaw (ANWC M30914) collected from the rocky floor of a shallow cave; this specimen could be hundreds or even thousands of years old. Abundant signs of wallaby activity were observed in the open habitats around Tompoi Camp. On the main island of New Guinea similar subalpine communities typically support high population densities of a small montane pademelon, *T. calabyi* (Flannery 1995a).

Flannery (1995a: 83) suggested that *T. browni* "tends to favour disturbed areas" but our observations indicate that it is present in moderate densities in relatively undisturbed forests above 200 m. Elsewhere on New Britain, specimens have been taken at elevations in excess of 1,000 m in the Whiteman Range. Flannery (1995a) noted evidence of population declines in some areas of New Ireland, presumably due to hunting pressure.

Order Diprotodontia, Family Phalangeridae

Phalanger orientalis breviceps Thomas 1888 (Solomon Island Common Cuscus)
IUCN Red List rating: Least Concern
Phalanger orientalis is currently understood to contain two subspecies: *P. o. orientalis* of the main island of New Guinea and west to Timor (probably as a human-assisted introduction) and *P. o. breviceps* of the Bismarck Archipelago and Solomon Islands. Archaeological evidence from New Ireland

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suggests that *Phalanger orientalis* was introduced to that island around 20,000 years ago (Flannery and White 1991, Leavesley 2005). There is no comparable evidence to indicate how long this species has been present in New Britain.

Colgan et al. (1993) compared the genetic composition of *P. o. breviceps* with populations of *P. o. orientalis* and *P. intercastellanus*, using the method of allozyme electrophoresis (that screens variation in the nuclear genome). The results indicate that the *breviceps* populations are genetically most similar to populations of *P. o. orientalis* from the northern lowlands of New Guinea, but there is some sharing of alleles with populations of *P. intercastellanus* of southern New Guinea and the Louisiade Archipelago which might have arisen through hybridization between animals introduced from each of these areas. Solomon Island populations of *P. o. breviceps* also show a peculiarly high level of coat colour variation and a range of cranial and dental abnormalities, such as might be expected in a hybrid population (Norris 1993).

From museum holdings *Phalanger orientalis breviceps* appears to be broadly distributed, altitudinally expansive, and not uncommon on New Britain. The American Museum of Natural History, for example, has 28 specimens from New Britain including examples from 150-610 m in the Whiteman Range. However, Anthony (2008: 38) did not encounter any examples during a six week survey in 1999, "despite repeated nocturnal surveys ... as well as several visits to markets".

We recorded *P. o. breviceps* only at the high elevation Tompoi Camp. Two adults, one of each sex, were obtained by a local hunter on the night of 20th April 2009. Both were located in a dense stand of bamboo near to camp. The adult male (ANWC 30931) weighed 1,700 g and had enlarged testes measuring 26.4 mm in length and 19.5 mm in width. The adult female (ANWC 30930) weighed 2120g and carried a single pouch young. One or two pouch young are commonly observed in this species (Flannery 1995a: 99).

Order Rodentia, Family Muridae

Melomys sp. Undescribed (A mosaic tailed rat)

IUCN Red List rating: Not evaluated

An adult male specimen of an undescribed species of *Melomys* was captured on 11th April 2009 at Vouvou Camp. The animal was caught in a break-back trap set approximately 2 m above the ground on a suspended fallen tree crossing a broad depression. The animal weighed 94 g and has rich orange fur on the back, grey belly fur with a strong gingery wash, a long black tail with pebble-like scales, and broad hind feet. Of the murid rodents previously recorded from New Britain (Flannery 1995a) it most closely resembles *Melomys rufescens* but differs from this species in its larger size, its grey-based rather than white belly fur, and its narrower skull and larger molar teeth. Genetic analysis performed by Litticia Bryant of the Queensland University of Technology suggests that this species is most closely related to (but distinct from) *Melomys rufescens,* a widespread and common species that is recorded across New Guinea through to New Britain and Ireland. Archaeological evidence from New Ireland suggests that *Melomys rufescens* is native to that island, as its remains occur to the basal levels of the cave deposits. Flannery et al. (1993) noted genetic differences between Bismarck Archipelago and mainland New Guinean populations of *M. rufescens* but Menzies (1996) considered there to be too few specimens available from the Bismarck population to support taxonomic distinction.

Throughout its range, *Melomys rufescens* is most often encountered in disturbed forest, plantations and grassland (Flannery 1995b), and it is recorded from these habitats on New Ireland (Flannery 1995a: 145). Aplin recently captured the species in primary hill forest on mainland New Guinea but in this context it appears to be among the rarer elements in the small mammal fauna. Failure to encounter this species during the Nakanai survey may well reflect a similar rarity in the relatively undisturbed habitats that were the primary focus of our survey effort.

It is not yet clear whether the undescribed *Melomys* has been collected previously. There are two possible candidates for prior collection. The first is a skull (AMNH 194397) collected by Margaret Gilliard on 22nd January 1959 at 750 m to the northeast of Kandrian in East New Britain Province. Flannery (1995a: 136) referred this specimen to *Melomys* sp. cf. *M. levipes* (= *Paramelomys levipes*) and the narrowness of the skull of the Nakanai specimen also invited initial comparisons with members of the genus *Paramelomys*. The other candidate is an adult female (UP3387) collected in secondary forest near Kimbe, West New Britain. Menzies (1996: 406) gave a brief description of this specimen which he said "defied identification". The majority of features mentioned by Menzies agree with those of the Nakanai specimen. Addition of genetic data for the newly collected specimen will facilitate taxonomic description of what is clearly a highly distinctive New Britain endemic.

Undescribed Genus and Species 1

IUCN Red List rating: Not evaluated

Anthony (in Anthony et al. 2008) reported capture of two specimens of a large *Melomys*-like rodent at 800-980 m during the 1999 'New Britain Biological Survey'. A juvenile specimen from the same site was tentatively referred to the same taxon. The two adult males weighed 130 g and 160 g, and distinctive features included "a rich dark chocolate color", "a warm ochraceous wash on the underbelly", and "long and narrow" feet (32.3 mm and 34 mm).

We obtained one specimen of the same taxon, an adult male, while based at Lamas Camp. The animal was caught by a local hunter with the aid of a dog, in forest habitat down-slope of the camp. It weighed 168 g and externally resembled an over-sized, heavy-bodied example of *Paramelomys platyops*. The cranium of this specimen unfortunately took a heavy blow from a stick during capture but the molars are proportionally larger than in any *Paramelomys* or

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related genus. Genetic analysis performed by Litticia Bryant of the Queensland University of Technology suggests that this taxon represents an early offshoot of the *Melomys-Paramelomys-Uromys* group within the endemic Australo-Papuan murine Tribe Hydromyini (sensu Lecompte et al. 2008) and this evidence, combined with its unusual external and cranio-dental features, suggest that it warrants description as a new genus and species. This task will be completed in collaboration with Nicola Anthony.

Undescribed Genus and Species 2
IUCN Red List rating: Not evaluated
One adult male of a beautiful long-tailed mouse was captured in a mist net by the late Paul Igag on the night of 21st April near Tompoi Camp. The net was draped across a fallen log and the mouse was presumably running along the log when it became entangled. This specimen resembles species of *Pogonomys*, the 'prehensile-tailed tree mice' of New Guinea, in general body proportions, facial features and the nature of tail scalation (see Flannery 1995b for illustrations). However, it differs from all *Pogonomys* species in having more elongate hind feet and the presence of a long, pure white tail tip. In some cranial features, it more closely resembles species of *Chiruromys* (another genus of New Guinean 'tree mice') but it differs from all members of this genus in tail scale morphology and in numerous details of its skull and teeth. DNA sequencing performed by Dr Kyle Armstrong of the University of Adelaide has shown the taxon to be remote from each of *Pogonomys* and *Chiruromys* and further work is underway to determine its wider relationships to other Australo-Papuan Murinae.

This newly discovered mouse is clearly distinct from the species reported previously from New Britain as *Pogonomys macrourus* (Flannery 1995a). A possible sighting of that species was made by Opiang at Lamas Camp (see below) but no individuals were captured. That species was captured during the 1999 'New Britain Biological Survey' (Anthony in Anthony et al. 2008) and its tissues have been included in an ongoing genetic survey of the genus *Pogonomys* (Steve Hamilton, pers. comm.). Although that taxon very likely represents an undescribed species, its affinities are solidly with the genus *Pogonomys* and it is certainly not the same taxon reported here as a new genus and species. Hence, there is little doubt that the highly distinctive species collected at Tompoi has not been recorded on any previous expedition.

Rattus exulans (Peale, 1848) (Pacific Rat)
IUCN Red List rating: Least Concern
The Pacific Rat was encountered only in the context of a newly established garden on the road way that passed through Vouvou Camp. Eight specimens of *R. exulans* were trapped at this locality with minimal effort, and many burrows probably belonging to this species were observed around the field.

The apparent absence of the species in the Vouvou camp area, despite the history of disturbance in this area, suggests that *R. exulans* in this area is conforming to its 'classic' profile of an early succession species (Dwyer 1978, Aplin et al. 2003). Whether it is present as a rare species in the more established forests is unknown, as is its capacity to maintain populations along the linear disturbance habitat of the roadside.

Rattus sp. cf. *R. praetor* (Thomas, 1888) (Large Spiny Rat)
IUCN Red List rating: Least Concern
Three specimens of a large species of *Rattus* were taken in break-back traps set around Tompoi Camp. All are adult females with mammary formulae of 1+1+2, body weights in the range 140-170 g, and moderately spiny dorsal fur.

Comparison of the Nakanai specimens with examples of *Rattus sanila* ruled out the possibility that our specimens represented this purportedly extinct species (Flannery and White 1991). *Rattus sanila* has a distinctive dental morphology that clearly distinguishes it from this species and both *R. mordax*, the species with which it was originally associated, and *R. praetor*. However we consider it likely that *Rattus sanila* will be found as a living animal on both New Ireland and New Britain.

In general features these specimens resemble *Rattus praetor*, which is recorded from New Britain and New Ireland, the latter as a likely late prehistoric introduction (Flannery and White 1991). However, comparison with specimens of *R. praetor* from the Sepik Basin of northern New Guinea revealed potentially significant differences in external and cranio-dental morphology, and we hesitate to refer the specimens to this taxon without further study. They may yet prove to represent an undescribed, endemic species of *Rattus*.

Although a detailed morphometric assessment of New Guinean *Rattus* was long ago completed (Taylor et al. 1982), genetic studies of this complex assemblage have only recently begun (Rowe et al. 2010). Nevertheless, the early indication is of a recent and complex evolutionary radiation, driven in part at least by chromosomal rearrangements (Dennis and Menzies 1978), thereby giving good cause for caution in regard to any morphologically divergent population.

Failure to capture any native species of *Rattus* at the two lower elevation camps is likely to reflect the relatively undisturbed nature of the forest habitats at these sites. Elsewhere in New Guinea, species of *Rattus* tend to be most abundant in disturbed habitats at lower elevations, but abundant in undisturbed habitats in high elevation sites. In our view, this is a logical extension of the documented role of *Rattus* as an early forest succession specialist in New Guinea (Dwyer 1984), with the genus perhaps playing a similar role at an evolutionary timescale in regard to the most recently created habitats situated toward the summit of rapidly uplifting mountains.

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Pogonomys sp. cf. *P. macrourus* (Milne-Edwards, 1877) (Chestnut Tree-mouse)

IUCN Red List rating: Least Concern

A possible sighting of this species was made by Muse Opiang on the evening of 6th April 2009 alongside Lamas Camp. Traps were set around the locality and regular observations made on the following night but there was no further sighting. On 8th April a burrow entrance was located in this area and partial excavations made of a large multi-branched burrow system that ran just below the ground surface. This burrow was similar to those made by other *Pogonomys* species in New Guinea (Flannery 1995b) but unfortunately the animal was not captured so its identification was not confirmed.

A species of *Pogonomys* has been collected twice before on New Britain. One specimen held in Berlin was collected by P. R. Schumm in October 1927 near Talasea in West New Britain Province. This locality was doubted by Dennis and Menzies (1979) but it was vindicated by the collection in 1999 by Nicola Anthony of two specimens at 100-1,200 m during the 'New Britain Biological Survey' to the Nakanai Range (Anthony in Anthony et al. 2001: 40). As noted above, the New Britain *Pogonomys* is probably specifically distinct and it requires formal description.

Uromys neobrittanicus Tate & Archbold, 1935 (Bismarck Giant Rat)

IUCN Red List rating: Near Threatened

A very large, dark-furred rat was observed at Lamas Camp on the night of 7th April 2009 by camp assistants. It was said to have descended a large tree to enter camp but returned up the tree when chased. The estimated size and dark colouration of this rat are consistent with *Uromys neobrittanicus*, a poorly known arboreal murine known from scattered localities across a wide elevational range in New Britain (Flannery 1995a: 174).

Order Chiroptera, Family Pteropodidae

Dobsonia praedatrix Andersen, 1909 (Bismarck Bare-backed Fruit-bat)

IUCN Red List rating: Least Concern

This small species of Bare-backed Fruit-bat is endemic to the Bismarck Archipelago and nearby Umboi Island (Flannery 1995a, Bonaccorso 1998). Byrnes (in Anthony et al. 2008) reported capture in April 1999 of 20 individuals at the lowest elevation site during the 'New Britain Biological Survey'. Bonaccorso (1998: 103) has the species "restricted to lowland habitats of primary and secondary forests, plantations, and small gardens". Roosting sites are usually within dry foliage such as in coconut palms, rather than in caves (Smith and Hood 1981, Bonaccorso 1998), but a small maternity colony in a sea cave was reported by Flannery (1995a: 205).

We captured one subadult female (ANWC M30862) of this species on 7th April 2009 in a mist net set at Lamas Camp. The animal weighed 160 g and had a forearm length of 113.7 mm. Large bats with the characteristic 'pock pock' wing beat of *Dobsonia* spp. were commonly heard moving around the forest canopy at Vouvou Camp but it is not known whether these were *D. praedatrix* or the slightly larger *D. andersoni*, also endemic to the Bismarck Archipelago, but which is reported to have a wider elevational range than *D. praedatrix* (Flannery 1995a, Bonaccorso 1998, Byrnes in Anthony et al. 2008).

Macroglossus minimus nanus (Matschie, 1899) (Northern Blossom-bat)

IUCN Red List rating: Least Concern

This species occurs over a huge geographic range from Indochina to Australia and while there are many named regional variants, there generally is little firm ground on which to recognize taxonomic subdivisions. However, in the Melanesian region the large-bodied and large-eared *M. m. nanus* of New Guinea and the Bismarck Archipelago is readily distinguished from the diminutive and small-eared *M. m. microtis* of the Solomon Islands (Flannery 1995a, Bonaccorso 1998). The elevational range of *M. m. nanus* extends from sea level throughout its range to as high as 1,200 m on the main island of New Guinea (Bonaccorso 1998) and 1,155 m on the island of Bougainville (McKean 1972). Byrnes (in Anthony et al. 2001) caught 14 specimens up to an elevation of 980 m in the Nakanai Mountains in April 1999.

We caught eight individuals of *M. minimus*, all taken in mist nets. Seven of these were caught at Lamas Camp, the other at Vouvou Camp. Body weight and forearm measurements of this series are consistent with the ranges given by Bonaccorso (1998: 196) and Byrnes (in Anthony et al. 2001).

Nyctimene sp. cf. *N. albiventer* (Gray, 1863) (Common Tube-nosed Bat)

IUCN Red List rating: Least Concern

The taxonomy of the smaller tube-nosed bats of wider Melanesia remains poorly understood and this is nowhere better exemplified than in the islands to the east of New Guinea. Koopman (1979) recognized four species from the island of New Guinea (*N. albiventer*, *N. draconilla*, *N. cyclotis*, and *N. aello*), two from New Britain (*N. albiventer* and *N. major*), and only one (*N. major*) from New Ireland. Koopman (1979) recorded one additional species (*N. cephalotes vizcaccia*) from Umboi Island to the west of New Britain. *Nyctimene aello* and *N. major* are both relatively large bats and are readily distinguished from the remaining species.

More recent treatments have produced wildly different arrangements. Smith and Hood (1981) distinguished three smaller tube-nosed bats in samples from New Ireland and associated two of these with the holotypes of *N. vizcaccia* and *N. albiventer*. The third was described as a new species possibly endemic to New Ireland – *N. masalai* (Smith and Hood 1983). Smith and Hood (1981) also assigned specimens from an elevation of 1,350 m at Warangoi,

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East New Britain Province to *N. cyclotis*, a species found in montane habitats across New Guinea. Petersen (1992) likewise reported *N. cyclotis* from Mt Sinewet, East New Britain Province. Flannery and White (1991) re-examined New Ireland populations and concluded that local populations of *N. masalai* and *N. albiventer* were indistinguishable. Flannery (1995a: 227) also placed *N. vizcaccia* in synonymy of *N. albiventer*, although he recognized *N. bougainville* as an endemic of Bougainville Island and the Solomon Islands. His distribution maps indicate the *Nyctimene* fauna of New Britain to comprise three species: *N. albiventer*, *N. major* and *N. cyclotis*. Smith and Hood (1981) had earlier treated *N. bougainville* as a subspecies of *N. vizcaccia*. Bonaccorso (1998) followed Smith and Hood (1981) in distinguishing *N. vizcaccia* from *N. albiventer* and in treating *bougainville* as a subspecies of *N. vizcaccia*, but he failed to recognize *N. masalai* as distinct. Bonaccorso (1998) allocated the montane specimens previously identified as *N. cyclotis* to *N. vizcaccia*. His distribution maps thus show the *Nyctimene* fauna of New Britain to comprise only *N. vizcaccia vizcaccia* and *N. major major*. Macaranas et al. (2003) found no genetic evidence for more than two *Nyctimene* species in a sample that included animals from throughout the Bismarck Archipelago and the Solomon Islands. However, they did not conduct any detailed morphological assessment of the related specimens and it is unclear whether their sampling spanned all of the various putative species.

Byrnes (in Anthony et al. 2001: 52-53) reported captures of at least two and possibly three species of *Nyctimene* during the 1999 survey of the Nakanai Mountains. These were reported as *N. major* and 'two distinct populations' within *N. vizcaccia*, one being "a warm copper-brown, the other with grey and black coloration'. Byrnes (in Anthony et al. 2001: 58) also reported preliminary genetic evidence that appeared to distinguish these forms.

Our *Nyctimene* sample consists entirely of smaller-bodied animals, i.e. we did not capture any specimens of *N. major*. Since our series also shows colour variation along the lines described by Byrnes (in Anthony et al. 2001), we explored this variation by examining the cranio-dental morphology in all specimens. By doing so, we were able to separate our series into two quite distinct taxa that correspond to Smith and Hood's (1983) *N. albiventer* type (with a broad u-shaped upper dental arcade) and *N. vizcaccia* type (with an anteriorly convergent upper dental arcade). Assuming that *N. major* is a distinct taxon (a reasonable assumption, considering its much larger size), our observations thus support those of Byrnes (in Anthony et al. 2001) in recognizing a minimum of three species on New Britain.

Eight specimens from this survey display the *'N. albiventer'* morphology as defined by Smith and Hood (1983). This taxon was captured at all three camps and at Tompoi it was one of only two bat species caught (the other being *Syconycteris australis finschi*, see below). Externally, these specimens are characterized by a relative weak blotching of the wing membranes and a dorsal stripe that begins below the nape. Contrary to Bonaccorso's (1998: 165) account of New Guinean populations of *N. albiventer*, the dorsal fur in the Nakanai sample is tri-coloured rather than bicoloured, with slate-grey bases, a paler mid-shaft, and dark tipping. Compared with specimens from Lamas and Vouvou, specimens from the high elevation site of Tompoi have reduced pale blotching on the ears and shorter nostril tubes but they are otherwise very similar.

Wider comparison of the Nakanai sample of *N.* sp. cf. *N. albiventer* revealed a close match with some populations referred to *N. albiventer* on the main island New Guinea. In particular, two small series held in the ANWC collection, one from Mt. Hunstein in East Sepik Province (ANWC M2268 and M4410) and one from Lake Kutubu in Southern Highlands Province (ANWC M2316 and M2317) are very close to the Nakanai specimens in both fur colouration and cranio-dental morphology. McKean (1972) had referred the Lake Kutubu specimens to *N. cyclotis*, presumably on account of their somewhat mottled dorsal fur, while a note in Frank Bonaccorso's hand refers them instead to *N. albiventer*. Other mainland populations of *N. albiventer* do have bicoloured fur, as reported by Bonaccorso (1998). Taxonomic studies currently underway by Nancy Irwin will lay the foundation for a full revision of the small-bodied members of the genus *Nyctimene*.

Nyctimene vizcaccia Thomas, 1914 (Bismarck Tube-nosed Bat)

IUCN Red List rating: Least Concern

As noted above, this species has had a chequered taxonomic history. We agree with Smith and Hood (1981) and Bonaccorso (1998) that it is quite distinct from any form of *N. albiventer*, and probably closer to each of *N. cephalotes* and *N. bougainville*, from which it differs mainly in its smaller size.

We captured three specimens of *N. vizcaccia*, two in the vicinity of Lamas Camp and one at Vouvou Camp. These records, compared with captures of the previous species, suggest that *N. vizcaccia* is more typical of lowland to mid-elevation habitats. Byrnes (in Anthony et al. 2001) did not report the elevational distribution of her two 'forms' of *N. vizcaccia* which was unfortunate given the high capture rate of these taxa (total of 48 specimens) on the 1999 'New Britain Biological Survey'.

Rousettus amplexicaudatus brachyotis (Dobson, 1877) (Rousette Bat)

IUCN Red List rating: Least Concern

This extremely wide-ranging bat species occurs from Burma to the northern Solomon Islands. Throughout most of its range *R. amplexicaudatus* is restricted to lowland habitats but on New Guinea it is recorded as high as 1,700 m and on Bougainville Island, up to 1,900 m. Two subspecies are recognized in the New Guinea region, with *R. a. brachyotis* restricted to the islands of the Admiralty and Bismarck groups, and to Bougainville and Buka Islands in the Solomon Island group (Rookmaker and Bergmans 1981,

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Flannery 1995a, Bonaccorso 1998). Macanaras et al. (2003) found low levels of genetic differentiation among various islands populations of *R. a. brachyotis* but did not compare this subspecies with *R. amplexicaudatus* of mainland New Guinea.

Rousettus amplexicaudatus is an obligate cave rooster that typically occupies the twilight zone of deeper cave systems; hence, it depends on local availability of substantial cave systems to inhabit an area of otherwise suitable habitat. On New Ireland, colonies of many thousands are recorded in natural caves but the species seems not to use tunnels dug during the Second World War (Smith and Hood, 1981). We did not locate any colonies during our exploration of cave systems around each of Lamas and Vouvou Camps.

This species is readily captured in mist nets. Byrnes (in Anthony et al. 2008) reported captures of nine individuals during the 1999 'New Britain Biological Survey', all taken below 1,000 m. We caught two sub-adult individuals at Lamas Camp: a female (ANWC M30833) weighing 46.9 g and a male (ANWC M30842) weighing 49.2 g. Bonaccorso (1998: 155) reported adult body weights up to 76 g for females and 68 g for males.

Syconycteris australis finschi (Matschie, 1899) (Bismarck Blossom Bat)

IUCN Red List rating: Least Concern

Blossom-bats of the genus *Syconycteris* are the most frequently captured bats during mist-net surveys in most habitats across Melanesia. Currently two species are recognized, a restricted montane species (*S. hobbit*) and a widespread lower elevation species (*S. australis*), with an as yet uncertain pattern of geographic variation in the latter. Flannery (1995a) recognized two subspecies in the New Guinea region (*papuana* and *naias*, the latter confined to Woodlark Island in the Louisiade Archipelago), while Bonaccorso (1998) recognized four, including *S. a. finschi* in the Admiralty and Bismarck Island groups. Measurements given by Bonaccorso (1998: 209-210) illustrate the smaller size of *S. a. finschi* relative to *S. a. papuana*.

Ongoing taxonomic studies suggest that the current arrangement of *Syconycteris* is very imperfect. Populations of *S.* '*australis*' on the main island of New Guinea probably belong to at least three species, with many examples of local coexistence between subtly different forms (e.g. Armstrong and Aplin, Chapter 19, this volume). This includes apparent examples of sympatry between larger and smaller forms at sites in the Sepik lowlands of New Guinea, the smaller form bearing a close resemblance to examplars of *S. a. finschi*. Our prediction is that *finschi* will prove to be specifically distinct, with a range that includes the northern lowlands of New Guinea as well as the Admiralty Islands and Bismarck Archipelago.

Bonaccorso (1998: 204) remarked that *S. a. finschi* is "rare" on New Britain and New Ireland, "possibly due to competition with *Melonycteris melanops* and *Macroglossus minimus*." This certainly appears to be the case on New Ireland, where Smith and Hood (1981) obtained only a single capture of the species, the first record of the species for the island, over several months of field work. In contrast, the results of recent field surveys on New Britain suggest that it is at least locally abundant there. Byrnes (in Anthony et al. 2001) reported 43 mist net captures of *S. australis*, making it the second most frequent captured bat after *Nyctimene* '*viz-caccia*'. The majority of these captures were made at higher elevation sites above 800 m but seven individuals were netted below 400 m on Mt Garbuna, Willaumez Peninsula.

We found *S. a. finschi* to be abundant around Lamas and Vouvou Camps, and to be present also at the highest elevation surveyed. Ranges of body weights (11.7-17.2 g for males, n = 35; 12-17.6 g for females, n = 27), and forearm measurements (36.6-44.7 mm for males; 38.6-41.5 mm for females) of adults in our series are consistent with values given by Bonaccorso (1998: 210) and Byrnes (in Anthony et al. 2001: Table 1) for this taxon. Although the sex ratio of captures is even for the entire sample, this is not the case if captures are examined for each camp. Thus the sample from Lamas Camp is strongly biased toward males (23 males *vs* 8 females), while the sample from Vouvou is slightly biased the other way (11 males *vs* 18 females). Byrnes (in Anthony et al. 2001) reported a similar pattern with a bias towards male captures at the lowland site (5 males *vs* 2 females) and between 800 m and 980 m (13 males *vs* 4 females), with a more even sex ratio in nets set above 1,000 m (12 males *vs* 7 females). Bonaccorso (1998: 205) also reported male-biased captures of adult *S. a. papuanus* (19 males *vs* 9 females) by Deb Wright at Crater Mountain, Chimbu Province. A sex bias in mist net captures most likely reflects differences in home range size between the sexes. Furthermore, it is possible that this relationship varies with elevation according to elevational gradients in resource availability. However, very little is yet known of movement and habitat use by any species of *Syconycteris*, hence further speculation is not warranted.

Order Chiroptera, Family Emballonuridae

Mosia nigrescens Gray, 1843 (Lesser Sheathtail-bat)

IUCN Red List rating: Least Concern

This tiny bat has a geographic range that extends from Sulawesi to the Solomon Islands and a recorded altitudinal range on New Guinea from sea level to 1,600 m (Bonaccorso 1998: 234). Two subspecies are recognized in Melanesia – *M. n. papuana* on the main island and some western satellite islands, and *M. n. solomonis* on islands of the Admiralty group and the Bismarck and Louisiade Archipelagos.

Three individuals – an adult male (ANWC M30846) and two adult females (ANWC M30847 and M 30848) were found hanging together in a row under a palm leaf on the evening of 6th April 2009, close to Lamas Camp. This roosting behaviour was first reported by Smith and Hood (1981: 97), who described an adult male and adult female hanging together beneath a *Haliconia* leaf at Gunanar Plantation

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on New Britain. Hill and Rozendaal (1989) reported six individuals (three adult males, two adult females and one sub-adult male) roosting in this way below a banana leaf on Halmahera Island in eastern Indonesia. Bonaccorso (1998: 235) found four individuals of unspecified sex under a fish-tail palm frond in Madang Province. Although this roosting behaviour is clearly very common and widespread in *M. nigrescens*, there are also reports of the species roosting in limestone caves (Smith and Hood 1981: 97), shady rock overhangs, and in house roofs (Flannery 1995a: 323).

Forearm measurements and body weights of the Nakanai specimens are 35.8 mm and 4.1 g for the male and 37.3-37.4 mm and 5.2 g for the two females. These are consistent with ranges provided by Bonaccorso (1998: 237) for *M. n. solomonis* which averages larger in size than *M. n. papuana*.

Order Chiroptera, Family Hipposideridae

Aselliscus tricuspidatus koopmani (Schlitter, Williams and Hill, 1983) (Trident Horseshoe-bat)

IUCN Red List rating: Least Concern

The subspecies *koopmani* of the Trident Horseshoe-bat is endemic to the islands off the eastern end of New Guinea, and its range includes both New Britain and New Ireland (Flannery 1995a, Bonaccorso 1998). All populations of the species appear to be cave roosting and colonies of several hundreds of individuals are recorded on New Ireland (Smith and Hood 1981).

We captured one adult male (ANWC M30817), two adult females (ANWC M30845 and M30854), and one subadult female (ANWC M30898) in the vicinity of Lamas Camp. Although the species can be captured using mist nets (Flannery 1995a: 336; pers. obs.), all of our captures were made in harp traps set in deep gullies with cobbled floors and few isolated pools of water. Forearm measurements of 38.8 mm for the male and 38.3-39.8 mm for the three females fall in the range given by Bonaccorso (1998: 263) for *A. t. koopmani* but are smaller than those given for *A. t. novaeguineae* of New Guinea.

Hipposideros diadema oceanitis Andersen, 1905 (Diadem Horsesoe-bat)

IUCN Red List rating: Least Concern

The Bismarck and northern Solomon Island populations of the Diadem Horseshoe-bat are morphologically quite distinct (Kitchener et al. 1992) and are accorded subspecific distinction from populations on New Guinea (*H. d. griseus*), Manus Island (*H. d. mirandus*), and the southern Solomon Islands (*H. d. demissus*). Smith and Hood (1981: 106) found this species to be abundant in caves and tunnels on both New Ireland and New Britain, and also netted the species in gardens and stands of bananas. Its preferred roosting sites are in the deeper, more humid chambers of caves where it tends to roost apart from other, smaller bat species.

We captured six individuals and collected one nearly complete skeleton of *H. d. oceanitis*. All were taken from around a large cave located very close to Vouvou Camp. The tall and wide cave entrance narrowed at the rear into a deep sink-hole that was frequently filled with mist and presumably led to a subterranean river passage. Individuals of *H. d. oceanitis*, unmistakable in their large size, were seen on several occasions hanging on the rear wall of the sink-hole. Mist nets were set high across the cave entrance and a harp trap was placed in a smaller cave entrance nearby. Both proved effective at capturing this species. Four of the six live captures were adult males (ANWC M30865, M30873, M30886 and M30891) and two were adult females (ANWC M30858 and M30867). All of the males have dull brown dorsal fur, whereas the two females are both a bright orange colour. Smith and Hill (1981) remarked on this colour variation in Bismarck populations but did not note any association with gender. It remains to seen whether it represents true sexual dichromatism or is a product of differential bleaching between males and females, perhaps due to contrasting roosting behaviour.

The body measurements of the Vouvou camp series fall within the range of documented variation, as cited by Bonaccorso (1998: 284).

Hipposideros maggietaylorae maggietaylorae Smith and Hill, 1981 (Maggie Taylor's Horseshoe-bat)

IUCN Red List rating: Least Concern

This species was distinguished from the smaller *Hipposideros calcaratus* by Smith and Hill (1981). They reported it to be abundant in large caves and tunnel complexes on both main islands of the Bismarck Archipelago. Bismarck populations are distinguished as the nominotypical form from a smaller subspecies found on New Guinea and its western satellite island of Batanta (Flannery, 1995a).

Hipposideros maggietaylorae appears to be an obligate cave rooster throughout its range. Like many other species of horseshoe-bat, it favours warmer and more humid chambers, typically situated in the deeper reaches of caves. We captured this species in a mist net set in dense understorey at Lamas Camp (ANWC M30805, an adult female) and in a harp trap placed in a narrow gully over shallow pools of water at Vouvou Camp (two adult males: ANWC M30917 and M30918; and one subadult male: M30919). Forearm measurements and body weights of these specimens are 61.8 mm and 19.0 g for the female, and 58.0-63.2 mm and 17-24 g for the males. These fall within the range of measurements compiled by Bonaccorso 1998: 292).

Order Chiroptera, Family Rhinolophidae

Rhinolophus euryotis Temminck, 1835 (New Guinea Horseshoe-bat)

IUCN Red List rating: Least Concern

Rhinolophus euryotis is one of the less commonly encountered Horseshoe-bats. Koopman (1979: 9) gave the first report of the species from New Britain, based on specimens in the American Museum of Natural History. Smith and Hood

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(1981: 102) recorded one specimen from New Britain in a complex tunnel system dug by Japanese soldiers. Flannery (1995a: 358) reported two specimens from the Fulleborn area of New Britain, and recorded the species for the first time on Duke of York Island and in southern New Ireland. Bonaccorso (1998: 306) reported a series of 11 specimens collected in August 1995 at Gilim in West New Britain by Paulus Kei of the University of Papua New Guinea. Byrnes (in Anthony et al. 2001: 55) captured one adult male in a double-tiered mist net set at an elevation in excess of 980 m during the "New Britain Biological Survey' in 1999.

The taxonomy of Melanesian populations of this species has not been investigated in any detail. Bonaccorso (1998: 306) referred the Bismarck populations to the subspecies *R. e. timidus*, which is recorded also from the main island of New Guinea and as far west as Halmahera Island in eastern Indonesia, but we prefer to leave the poorly sampled Bismarck Archipelago population unallocated at subspecies level.

All populations of *R. euryotis* probably roost deep inside caves and large maternity colonies of more than 1,000 individuals are known (Bonaccorso 1998: 307). They are collected only occasionally outside of this context, typically in mist nets.

We captured an adult female (ANWC M30806) in a harp trap set across a dry, boulder-strewn gully running alongside Lamas Camp, on the night of 3rd April 2009. The animal weighed 15.0 g and had a forearm length of 55.0 mm. The body weight was below the range (17.8-21.5 g) given for four adult females by McKean (1972; repeated by Bonaccorso 1998: 308) but the forearm measurement was well within the stated range (53.0-58.0 mm). The adult male reported by Byrnes (in Anthony et al. 2001: Table 1) had a forearm length of 58 mm and a body weight of 16.7 g.

Rhinolophus megaphyllus vandeuseni Koopman, 1982 (Eastern Horseshoe-bat)

IUCN Red List rating: Least Concern

Koopman (1979: 9) reported *Rhinolophus megaphyllus* from both New Britain and New Ireland, and later gave the Bismarck populations the subspecies name *vandeuseni* to distinguish them from populations on New Guinea and the D'Entrecasteaux Islands (*R. m. fallax*), and in the Louisiade Archipelago (*R. m. monarchus*). Smith and Hood (1981: 99) reported the species to be "in great abundance in caves on New Ireland and Japanese tunnels on New Britain", and they also reported captures in mist nets "set in native gardens and in stands of bananas".

All forms of *R. megaphyllus* are cave roosting bats and they typically occupy the deeper, more humid and warmer chambers of extensive cave systems. On New Guinea it is recorded from sea level up to 1,600 m (Bonaccorso 1998: 309).

We caught two males on the night of 5th April 2009, one in a harp trap set across a dry gully (ANWC M30814) at Lamas Camp and the other (ANWC M30815) in a mist net set close to the ground in dense understorey. Although both individuals appear to be fully adult, they differ in numerous ways including size (body weight 7.0 g *vs* 6.0 g; forearm length 44.5 mm *vs* 41.2 mm), dorsal fur colour (reddish-brown *vs* a mouse-grey), shape of the nose leaf, and length of the penis (longer in M30814). These differences may reflect individual age, as reddening of the fur through bleaching is known to occur with time in some cave roosting bats (Smith and Hood 1981: 99). However, the differences are suggestive of cryptic diversity which needs to be tested using molecular comparisons of these individuals and other populations of *R. megaphyllus*.

Order Chiroptera, Family Vespertilionidae

Miniopterus macrocneme Revilliod, 1913-1914 (Small Melanesian Bentwing-bat)

IUCN Red List rating: Data Deficient

Exactly how many species of *Miniopterus* occur on New Britain is not yet settled. Koopman (1979: Table 1) listed only *M. tristis* but owned to the possibility of three species in the wider Bismarck Archipelago. Smith and Hood (1981), using Hill (1971) as a guide, settled on four species and identified them as *M. tristis*, *M. schreibersii*, *M. medius*, and *M. australis*. Flannery (1995a) recognized three species on New Britain (*M. australis*, *M. macrocneme*, and *M. propistristis*) and these plus *M. schreibersii* on New Ireland. Bonaccorso (1995) revised this to *M. australis*, *M. macrocneme*, *M. medius*, and *M. propistristis* on New Britain, and *M. macrocneme*, *M. medius*, *M. propistristis*, and *M. schreibersii*on New Ireland. All are cave roosting bats and mixed aggregations are commonly encountered in large caves (Bonaccorso 1995).

We captured two bentwing-bats in harp traps set around Vouvou Camp. An adult female (ANWC M30928) captured on 18th April 2009 is identified with some confidence as *M. macrocneme* on account of its uniformly dark brown dorsal fur, moderate-size (body weight 11.0 g, forearm length 47.6 mm), and relatively long lower leg (tibia length 19.6 mm). Bonaccorso (1995: Fig. 4.47) mentioned only one previous record of this poorly known species from New Britain. IUCN Red List ranking of this species as Data Deficient reflects both taxonomic uncertainties and the paucity of confirmed records.

Miniopterus sp. cf. *M. medius* Thomas and Wroughton, 1909 (Medium Bentwing-bat)

IUCN Red List rating: Least Concern

One individual (ANWC M30902) of a smaller species of bentwing-bat was captured in a harp trap at Vouvou Camp on the 13th April 2009. It is an adult female with a body weight of 7.5 g, a forearm length of 43.1 mm, and a tibia length of 18.4 mm. The dorsal fur is distinctly redder than in the exemplar of *M. macrocneme*.

The identity of this specimen is uncertain. It is similar in overall body size to *M. australis* but has a significantly longer forearm (37.2-40.0 mm in female *M. australis tibialis*; Bonaccorso 1995: 389). It is smaller than *M. magnater*

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and *M. propistristis insularis* (both with forearm lengths > 47 mm; Bonaccorso 1995: 3395, 403). *Miniopterus medius* is similar in body weight (females 7.0-11.5 g) and in both forearm (females 40.5-45.0 mm) and tibia lengths (females 17.2-20.0 mm; all measurements from Bonaccorso 1998: 398). However, both the dorsal and ventral fur of ANWC M30902 is reddish brown to the roots, whereas *M. medius* is described by Bonaccorso (1995: 396) as having contrasting dorsal and ventral coloration: "bicolored dorsum is gray brown or medium red brown externally, with a hidden pale gray brown base underneath" while "the ventrum is more clearly bicolored, the hairs being medium gray brown at base and having a mixture of red and pale brown frosted tips". *Miniopterus schriebersi* tends to be heavier (females 9.0-17.5 g) and with a slightly longer forearm (45.0-51.0 mm; measurement ranges from Bonaccorso 1998: 406) and the dorsal fur is also bicolored.

For the present, we tentatively refer this interesting bentwing-bat to *M. medius* but further work, especially using molecular techniques, seems likely to revise this determination.

Pipistrellus angulatus angulatus (Peters, 1880) (New Guinea Pipistrelle)

IUCN Red List rating: Least Concern

Koopman (1973) included this species within *P. tenuis* and reported a series from New Britain in the American Museum of Natural History. Smith and Hood (1981) located two colonies – one in a cave and the other in the wall of a school building – on New Ireland but did not encounter it on New Britain. The taxonomic distinctiveness of the species was confirmed by Kitchener et al. (1986) who distinguished two subspecies, the nominotypical form found on the main islands of New Guinea and its closer satellite islands, and *P. a. ponceleti* found on Bougainville Island and elsewhere in the Solomon Island group.

We captured two adult females of *P. a. angulatus* at Vouvou Camp. Both were taken in a harp trap set within a narrow gully over shallow, fast flowing water. Body measurements of the specimens (ANWC30889: weight - 4.7 g; forearm length - 33.8 mm; ANWC30927: weight - 5.0 g; forearm length - 34.0 mm) are slightly larger than those measured by Bonaccorso (1998) for a geographically broader sample of *P. a. angulatus*.

Pipistrellus papuanus (Peters & Doria, 1881) (Papuan Pipistrelle)

IUCN Red List rating: Least Concern

Pipistrellus papuanus was first recorded on New Britain by Bonaccorso (1998) who reported capture of an adult female in 1993 at Kerevat near Rabaul, East New Britain. Byrnes (2008) reported a series of 10 females and one male captured on Mt Garbuna on the Willaumez Peninsula "in primary forest at approximately 180 m over a fast flowing stream in a narrow valley about 6m wide". Measurements provided by Byrnes (in Anthony et al. 2008: Table 1) are consistent with the geographically broader sample of *P. papuanus* measured by Bonaccorso (1998).

We captured an adult female *P. papuanus* (ANWCM3063) in a harp trap set across a narrow gully adjacent to Lamas Camp at 200 m. The body weight (5.1 g) and forearm length (30.9 mm) fall within the ranges given by Byrnes (in Anthony et al. 2008) and Bonaccorso (1998). On the main island of New Guinea *P. papuanus* is recorded from sea level to 1,300 m (Bonaccorso 1998). The wider range of the species includes the islands of Eastern Indonesia (Flannery 1995a, Bonaccorso 1998). Smith and Hood (1981: 100-111) and Flannery (1995a: 396) reported observations of the species roosting in small cavities in coconut palms, with individual groups of 40-50 bats, while Bonaccorso (1998: 340) noted several instances of roosting inside walls of buildings. In the absence of these human-associated habitats, the species presumably roosts in tree hollows.

DISCUSSION

Remarks on inventory completeness

More than two hundred years of opportunistic collecting and less than 50 years of more systematic biological surveys on New Britain have produced confirmed records of three marsupials, nine rodents, 14 pteropodid bats, and 25 insectivorous bats. Two other marsupials, a tree kangaroo (*Dendrolagus* sp.) and a spotted cuscus (*Spilocuscus* sp.) are the subject of localised reports from the main island of New Britain. For the tree kangaroo, Flannery et al. (1996: 110) noted a record from Mt Agulupella in West New Britain Province but regarded this population and another on Umboi Island (to the west of New Britain) as "almost certainly introduced". For the spotted cuscus, Anthony (in Anthony et al. (2008: 38) figured a skin of *Spilocuscus kraemeri* (as *S. maculatus*) seen at a local market in Kimbe and said to have come from "the island of Bali, off the North coast of New Britain", and Helgen and Flannery (2004) reported a specimen of *S. kraemeri* in the Australian Museum marked "New Britain". We obtained records of all three previously confirmed marsupials, six of the rodents, six of the pteropodid bats, and 10 of the insectivorous bats. We also recorded one entirely new murine rodent, bringing the tally of murine rodents (excluding European introductions such as the Black Rat, *Rattus rattus*) for New Britain to ten. Our survey results for the Nakanai Mountains thus include records for just under half (26 of 56 species, including the new discovery) of the total known mammal fauna of New Britain.

It is instructive to consider what the gaps in our survey results mean for the fauna of the Nakanai Mountains. For marsupials, failure to locate populations of *Spilocuscus* sp. or *Dendrolagus* sp. does not signify their absence. Without use of skilled hunters assisted by dogs, these species are not readily observed. Were *Spilocuscus kraemeri* present on New Britain it might be expected to be conspicuous in areas of

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secondary forest and to have been collected long ago, as the best known species in the genus (*S. maculatus*) is moderately resilient to pressures of forest disturbance and hunting (Flannery 1995b: 182). However, other species of *Spliocuscus* (e.g. *S. rufoniger*) are far less resilient and the presence of a different taxon on New Britain cannot be excluded. Indeed, on biogeographic criteria, the most likely native inhabitant of New Britain is *S. kraemeri* which occurs on Manus Island in the Admiralty group, though most likely as a human introduction (Flannery 1995a: 105). This species is common in gardens and regrowth forest on Manus Island but its ecology might be different within its as yet undetermined natural range. Discovery of one good archaeological cave fauna on New Britain would almost certainly resolve this vexed issue of whether or not species of *Spilocuscus* and *Dendrolagus* are native to New Britain.

We did not obtain records of three or four species of the murine rodents previously reported from New Britain: *Melomys rufescens*, *Hydromys neobrittanicus*, *Paramelomys platyops*, and possibly *Rattus praetor*. Of these, *Melomys rufescens* and *Rattus praetor* are most often captured in disturbed habitats, with low population densities expected in relatively undisturbed forest habitat. Failure to detect these species in this survey probably reflects our strong focus on 'pristine' habitats. The New Britain Water-rat (*Hydromys neobrittanicus*) is known from only three specimens, both collected more than 80 years ago (Flannery 1995a: 128). This species is listed as Data Deficient by the IUCN Red List, partly on account of uncertainty about the level of distinction from a widespread congener – *Hydromys chrysogaster*. The larger-bodied water-rats of the genus *Hydromys* are semi-amphibious and most often associated with larger waterways. It is unlikely that this species would occupy the small and largely ephemeral waterways found around each of our survey camps. The basis of Flannery's (1995a: 143) inclusion of New Britain in the range of *Paramelomys platyops* is uncertain and it is possible that it relates to one of the other undescribed murines that we have mentioned.

It is a remarkable fact that at least four (possibly five) of the seven murine rodent species that we recorded are undescribed species of mammals. While it is true that the majority of these have been collected previously, either during the 'New Britain Biological Survey' to the Nakanai Mountains in 1999 or during previous brief visits by other biologists, all are yet known from only a handful of specimens. In large part, this paucity of specimens can be attributed to the very low trap success experienced by all fieldworkers who have tried to collect native terrestrial mammals in the forests of New Britain. Densities of all terrestrial mammal species seem to be very low in these forests, and with so few specimens in collections, and so many undescribed rodents already represented, we can only wonder how many more terrestrial mammal species might yet be found in the hill and montane forests of New Britain. More native rodents seem most likely, possibly including other species of *Rattus* (maybe even *Rattus sanila*) and *Pogonomys* (two species are commonly found together in New Guinea). Anthony (in Anthony et al. 2008: 42) mentioned local accounts of "a large white-tailed rodent" in the Nakanai Mountains and speculated that this might be *Anisomys imitator* or *Uromys caudimaculatus*, both of which occur on New Guinea. Other possibilities exist, and the recognition that two of the undescribed rodent species belong to endemic, monotypic genera should make it clear that almost anything is possible. Smaller rodents might also be part of the undiscovered rodent fauna of New Britain, possibly including species of *Lorentzimys* and one or more genera of 'moss-mice' (*sensu* Helgen and Helgen 2010); these species can be difficult to catch and the 'moss-mice' might be restricted to the higher elevation forests where survey effort has very been least. Likewise, the potential for discovery of a small dasyurid marsupial on New Britain should not be dismissed out of hand. All that is certain is that the process of inventory of terrestrial mammals of New Britain has a long way to go.

We recorded only 37.2% of the bat species known to occur on New Britain. There are many different reasons behind our failure to detect particular species. Among the pteropodid bats, we did not attempt to collect larger fruit-bats that generally need to be shot from the canopy for reliable identification. Three species that might have occurred in the forests that we surveyed were *Dobsonia andersoni*, *Pteropus capistratus capistratus* and *Pteropus gilliardorum*, each of which is recorded to over 1,200 m on New Britain (Bonaccorso 1998: 87, 114). Byrnes (in Anthony et al. 2001) did capture some *D. andersoni* in mist nets but she also caught many more of the smaller-bodied D. *praedatrix* that we did, and this might have been due to different fruiting activity at the time or place of the surveys. Three other large fruit bats recorded on New Britain (*Pteropus admiralitatum admiralitatum*, *P. hypomelanus*, and *P. neohibernicus*) are all restricted or most abundant at low elevations, typically below 200 m (Flannery 1995a, Bonaccorso 1998) and these may not have been present in the survey area.

Failure to capture two smaller pteropodid bats is less readily explained. *Nyctimene major major* occurs to 900 m on New Britain and is recorded from a variety of vegetation types including primary forest and gardens (Bonaccorso 1995: 177). However, Byrnes (in Anthony et al. 2001) captured this species only in lowland forests below 400 m and it is possible that it extends to higher elevations only in the context of disturbed habitats. This phenomenon has been observed by Aplin for several New Guinean pteropodid bats including *Nyctimene aello* and *Macroglossus minimus*, and it urges caution about the use of elevational ranges to predict species occurrences without specifying habitat types. A case in point might be the Bismarck Blossom-bat (*Melonycteris melanops*) which is recorded to 1600 m on New Britain but said to be common in gardens and plantations but rare in primary forest (Bonaccorso 1998: 198). Byrnes (in Anthony et al. 2001) made occasional captures of this species in montane forest habitat, thereby confirming its occurrence in the Nakanai Mountains.

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Many species of insectivorous bats recorded from New Britain evaded detection during the survey. Echolocating bats are typically good at avoiding capture in mist nets and they can generally chew themselves free if not removed quickly. Many are also able to avoid capture in harp traps unless these are set inside caves where many bats seem to fly without much use of ultrasound. Indeed, many insectivorous bats are known primarily from series collected at roosting caves, hence detection of these species relies on finding suitable caves that can be entered safely. Despite some effort on our part, we were unable to locate any caves with large and/or diverse roosting bat colonies. Additional species of insectivorous bats that might be expected to occur in the surveyed area are: the vespertilionids *Kerivoula myrella* (perhaps only at lower elevations; Bonaccorso 1998: 377), *Murina florium*, *Myotis moluccarum*, *Philetor brachypterus*, *Phoniscus papuensis*, *Miniopterus australis*, *M. propitristis insularis*, *M. schreibersii*, *Nyctophilus microtis* (only recorded from New Ireland and New Guinea; Bonaccorso 1998: 362); the molossids *Chaerephon jobensis* and *Mormopterus beccarii* (perhaps only at lower elevations; Bonaccorso 1998: 414); the hipposiderids *Hipposideros ater*, *Hipposideros calcaratus cupidus*, and *Hipposideros cervinus*; and the emballonurids *Saccolaimus saccolaimus* (probably only at lower elevations; Bonaccorso 1998: 243) and *Emballonura dianae rickwoodi*.

Use of acoustic recording and analysis techniques greatly improves the detection rates for echolocating bats in the context of a mammal survey (e.g. Armstrong and Aplin Chapter 19, this volume), despite problems with identification of many call types due to a lack of a comprehensive reference library for Melanesian bats. Failure to deploy this method during the Nakanai RAP is regretted.

New mammal species and other significant outcomes

The discovery of a completely new genus and species of murine rodent at Tompoi Camp is an event of international significance and is surely the standout result of the mammal survey. However, other highly significant outcomes are the collection of new material of at least two other undescribed murine rodents, all of which can now be named on the basis of the expanded collections. In total, specimens are now in hand of at least four and possibly five (if *Rattus* sp. cf. *R. praetor* is included) undescribed murine rodents, two of which warrant description in new genera, and all of which are probably endemic to New Britain. Two or three of these are currently known only from the Nakanai Mountains and it is a high priority to determine whether they occur more widely on New Britain, particularly in the Whiteman Mountains of West New Britain.

Bats have received much greater survey effort on New Britain and this is reflected in the fact that we did not discover any entirely new species on the 2009 RAP. However, we did encounter at least one species of bat (*Nyctimene* sp. cf. *N. albiventer*) that does not yet have a scientific name and another (*Syconycteris australis finschi*) that almost certainly deserves recognition as a full species rather than a subspecies. Further study of the *Miniopterus* and *Rhinolophus* bats collected during the RAP may yet reveal an additional undescribed species.

Ecological observations with significance for conservation

The very low trapping success and low contact rates during night patrols give a consistent picture of a terrestrial and arboreal mammal community characterized by extremely low population densities. Since our mammal survey was conducted in relatively undisturbed habitats and used standard methods that have yielded much higher returns in other places in Papua New Guinea, this observation must reflect the intrinsically low biological productivity of limestone karst rainforests where standing biomass is high but nutrient levels and rates of energy turnover are both low. Under such conditions, plants are likely to invest a minimum of energy on flowering and seed/fruit production, and this may be sporadic and highly dispersed across the landscape. In turn, this is likely to result in naturally low population densities for any consumer species that are relatively sedentary. For terrestrial mammals, this may be further compounded by competition for resources from lizards and terrestrial birds, whereas for arboreal mammals, the major competitors for food resources are more canopy birds and bats.

As volant mammals, bats probably fare better than arboreal species due to their ability to forage over much large ranges, thereby allowing them to better exploit spatially and temporally discontinuous flowering/fruiting events. Mist-netting returns at all sites were dominated by blossom and fruit-eating bats which are readily captured using this method. As expected, given their echolocation abilities, fewer insectivorous bats were taken in mist nets. However, harp traps also captured only small numbers of microchiropterans and relatively few were observed flying at night. Acoustic data from sites in New Guinea (Armstrong and Aplin unpublished) suggest that insectivorous bat activity is likely to be concentrated in the upper forest strata which are difficult to sample using netting or trapping methods.

These observations lead us to postulate that bats will predominate over terrestrial and arboreal mammals in low to mid-elevation Melanesian rainforests due to their greater ability to exploit sporadic and highly dispersed food resources, with the result that population densities of many terrestrial and arboreal mammal species are extremely low. One important implication of this model is that very large areas of pristine habitat may be required for effective conservation of these species. This proposition will be developed more fully in another context, using information from a range of survey sites across Melanesia.

CONSERVATION RECOMMENDATIONS

The 2009 Nakanai survey has greatly enhanced scientific knowledge of the mammal fauna of the Nakanai Mountains of East New Britain Province. Most significantly, it has

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resulted in the discovery of a completely new genus and species of murine rodent, and given strong emphasis to the presence in the area of at least four additional mammal species that are currently undescribed – at least one tube-nosed bat and three or four other murine rodents, one of which also warrants description in a new, monotypic genus.

These discoveries fundamentally alter our perception of the mammal fauna of New Britain. Rather than having a depauperate subset of the New Guinean mammal fauna, New Britain has its own deeply endemic mammal fauna that includes two endemic genera of murine rodents (both yet to be named), endemic species of other murine genera (e.g. *Uromys*, *Hydromys, Pogonomys*, *Melomys*; the latter two genera with endemic species yet to be named), and numerous distinctive species (e.g. *Syconycteris finschi*; the unnamed *albiventer*-like *Nyctimene*) or subspecies of bats, many of them shared with New Ireland and/or the northern Solomon Islands. The mammal fauna of New Britain is unique at a high level of importance and its effective conservation is a matter of international concern.

Effective conservation of the currently remote and largely unutilized landscape of the Nakanai Mountains of East New Britain is contingent on maintaining the remoteness and isolation of these habitats. Any inroads into this area, even for targeted extraction of forestry or mineral resources, will almost certainly result in greater utilization of areas along roads and paths for gardening and extraction of forest products. This in turn will result in changes in mammal community structure, with likely increasing dominance of the disturbance-loving *Rattus* species, especially the invasive species *R. exulans* and *R. rattus*. Given inroads into areas of primary forest, these species have a proven capacity throughout the Indo-Pacific region to establish 'naturalized' populations in forest habitat, and their adaptability and capacity for rapid response to ephemeral resources (Aplin et al. 2003) will very likely prove to the detriment of other groups of murine rodents. Gardens also bring hunters and populations of cuscus, wallabies, and possibly the larger rats are all likely to suffer, at least on a local scale. It is important to always remember that many local changes will soon add up to regional scale changes, which on an island of endemics like New Britain, translates to global scale changes.

Priorities for conservation almost always clash with the imperatives of increased food production and wealth generation. In a place as important for global conservation as the Nakanai Mountains, it is essential that these conflicting demands are carefully balanced, with every effort made to carry out food production and wealth generation activities in ways that minimize the impact on surrounding natural habitats. For the Nakanai Mountains, an effective management plan will require great skill in the design of food production systems to limit impacts to immediate areas, to ensure sustainability in these areas, and to minimize the risk of transfer of invasive plants and animals into natural habitats. Other strategies will be needed to guard against large scale incursions into natural habitats, or if these must occur, to ensure that development footprints are minimized and that effective habitat restoration has a high priority.

These futures are possible but they require genuine commitment to conservation from all partners. They also require a deep knowledge of the biological systems – of the biodiversity and how it is distributed within the landscape, and of how the ecosystems work. The scientific results of the Nakanai RAP survey represent a step toward acquisition of the necessary knowledge. However, in revealing how much we did not know about the plants and animals of the Nakanai Mountains, the survey has also taught us how much more there is yet to learn. Further biological survey work is essential, especially in the higher montane forest habitats. However, future research activity should also focus on the fundamental ecological knowledge that will underpin effective management of this rugged but extremely vulnerable environment.

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