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Chapter 18

The non-volant mammal fauna of the Muller Range, Papua New Guinea

Ken P. Aplin and Enock Kale

SUMMARY

We surveyed mammals around three sites in the biologically unexplored Muller Range of Western and Southern Highlands Provinces, Papua New Guinea. The survey resulted in confirmed records of one monotreme, nine marsupials, 12 murid rodents, and the feral New Guinea Singing Dog. With the possible exception of an unusual Long-footed Tree-mouse (*Lorentzimys* sp.), all of the non-volant mammal species recorded are previously known taxa. However, several of the recorded species are currently undescribed and may be restricted to a relatively small area in the headwaters of the Strickland and Kikori Rivers.

Sightings and other evidence of tree kangaroo and a long-beaked echidna in the montane forests of the Muller Range testify to very low hunting pressure, even along walking tracks that traverse the range. Human disturbance appears to be limited to annual visits to the subalpine zone to harvest fruit of a wild *Pandanus*, an activity which has only localised and short-term impacts on wildlife. The Muller Range thus preserves an essentially pristine altitudinal transect that spans hill forests, lower and upper montane forests, and diverse subalpine habitats. Although most of the mammals that inhabit these forests are probably quite widely distributed in the extensive catchments of the Strickland and Kikori Rivers, the intact nature of the forest ecosystems across such a broad elevational gradient is almost without parallel in the wider region. Long-term preservation of this spectacular series of interconnected ecosystems represents a conservation priority of the highest international importance.

INTRODUCTION

The Muller Range of Papua New Guinea was identified during the Papua New Guinea Conservation Needs Assessment as a region of special interest on account of the almost complete lack of prior biological exploration; hence, the high likelihood of new biological discoveries. This range is one of many partially discrete ranges that together form the central cordillera – a more or less continuous belt of mountainous terrain that runs almost the full length of the island. Three sides of the Muller Range are drained by headwater streams of the south-draining Strickland River, and the Strickland Gorge, the single largest cleft in the central cordillera, effectively isolates the Muller Range from the Victor Emmanuel Range and Star Mountains to the west. To the east, relatively continuous land above 1,000 m a.s.l. links the Muller Range to the high country around Tari and Puren in Southern Highlands Province. To the southeast, the Muller Range is delimited by the valley of the Cecilia River, a west-flowing branch of the Strickland system that passes between Mt Huriaga (on the Muller Range) and Mt Sisa (Haliago), the latter being one of several shield volcanos that rise above the Papuan Plateau. The Muller Range itself rises to a maximum elevation at Mt Karoma of 3,629 m above sea level. Much of the range consists of an elevated and karstic limestone plateau lying between 2,000 and 3,000 m and features several clusters of mega-doline structures of international geomorphologic significance (James and Dyson 1980, James 2006).

Prior knowledge of the modern mammals of the Muller Range is restricted to some bats collected during July to August 1978 by participants of the Atea 78 speleological expedition (James and Dyson 1980); these specimens are held in the mammal collection of the Australian Museum, Sydney. In addition, samples of 'fossil' bones were collected in 1982 in several caves including the Mamo Kananda cave system (Worthy and Flannery 1998).

Surrounding areas are much better known. Mt Sisa in Southern Highlands Province in particular is one of the most intensively studied locations in Papua New Guinea due to the extended ethno-zoological studies of Peter Dwyer in 1979–1980 (results summarised in Dwyer 1990), followed by a four month expedition from the South Australian Museum led by Ken Aplin in 1985, and with subsequent work by Tanya Leary and others as part of further survey effort in the Kikori Integrated Conservation and Development Project Area (KICDPA), based in the Kikori River catchment (Leary and Seri 1997). Other well-studied localities in the wider region are the Telefomin Valley and adjacent Victor Emmanuel Range of West Sepik Province (Flannery and Seri 1990), which lie approximately 150 km northwest of the Muller Range (but are separated by the deep gash formed in the central cordillera by the headwaters of the Strickland River) and the vicinity of Tari in the Southern Highlands which lies approximately 50 km to the east in the headwaters of the Kikori River catchment (Leary and Seri 1997).

This report presents findings of a non-volant mammal survey at three sites on the Muller Range of Southern and Western Highlands Provinces of Papua New Guinea in September 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 and preserved as museum voucher specimens to allow detailed comparative study of both external and internal features (e.g. skull and teeth). Vouchers typically were fixed whole in 10% formalin and subsequently transferred to 70% ethanol for long-term storage, but 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.

Survey for terrestrial and arboreal mammals was carried out with a combination of live 'box' traps (Elliott traps) and lethal 'break-back' traps. Traps were set at irregular intervals alongside an existing or purpose cut walking track passing through representative habitat, with trap placement chosen to maximize captures. 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. Daytime searches were carried out for burrows and other animal signs. On most evenings some time was spent walking with a spotlight along trails and larger tracks. Other RAP participants also spent time out of camp at night and they reported sightings of mammals and in a few cases, captured mammals by hand.

Specimens from the Muller Range RAP survey are deposited in the Australian National Wildlife Collection, CSIRO Division of Ecosystem Sciences, identified by the prefix ANWCM. Taxonomic and common names generally follow Flannery (1995). Any departure from this source is discussed under individual species accounts.

Material reported by Worthy and Flannery (1998: Table 1) from a surface context in Windy Cave (located at c. 5.55° S, 142.317° E, 2,200 m) included intact owl pellets and is treated here as a 'modern' sample; all other material is here regarded as of uncertain age and cited as 'fossil' occurrences. These collections are housed in the Auckland University Geology Department Museum and were not re-examined as part of this study.

Study sites

The study area for the September 2009 Muller Range RAP survey straddled the border between Western and Southern Highlands Province. Three sites were sampled, giving an altitudinal range from around 500 m to just above 2,900 m.

Camp 1 (Gugusu) was situated on a low ridge at 515 m in lowland/hill rainforest on the southwest margin of the Muller Range at 05°43.751S, 142°15.797E. Although the vegetation at this elevation should be classified as hill forest, the community around Gugusu contained some floristic elements more typical of montane forests, presumably reflecting the extremely high rainfall experienced in this area. Ten nights were spent at the camp – the nights of the 2nd–11th September 2009.

Camp 2 (Sawetau) was situated at 1,587 m on a long narrow ridge (05°39.397S, 142°18.277E) that gave ready access to both lower and higher elevation areas. The area around camp supported montane *Nothofagus* forest with complex understorey that included many *Pandanus* palms. All tree surfaces, rocks and even the ground were blanketed with dripping moss. A walking track along the ridge is used occasionally by people crossing the Muller Range from north to south. Seven nights were spent at the camp – the nights of the 12th–18th September 2009.

Camp 3 (Apalu Reke) was located at 2,875 m on a gently undulating plateau (05°29.174S, 142°18.117E), representing the local summit of the Muller Range in this area. The plateau supports a mosaic of dense stands of mossy upper-montane forest and large openings of sub-alpine *Pandanus* savannah with a dense ground layer of ferns. The camp was positioned to allow sampling of both forest and savannah/fernlend communities. Eight nights were spent at the camp – the nights of the 19th–26th September 2009.

Kale sampled non-volant mammals at all camps. He was joined by Aplin during the work at Sawetau and Apalu Reke. All trapping and other survey methods were deployed at each of the sampling sites. In addition, exploratory forays were made out of Sawetau and Apalu Reke in search of caves that might contain roosting bats or bone deposits accumulated by predators or natural deaths. While based at Gugusu and Sawetau we were assisted by men from the nearby Tobi village in Western Province. While based at Apalu Reke we were assisted by men from the village of Aluni which is located on the northern side of the Muller Range in Southern Highlands Province. These men reported making annual visits to the subalpine habitat to harvest the fruit of wild *Pandanus* and to hunt cassowary, cuscus and other game animals.

RESULTS

General survey results

The survey period and effort deployed at each of the three mammal sampling sites is summarized in Table 18.1. This tabulation also indicates the trapping success at each site. Opportunistic captures by hunters using dogs or by hand are not included in this table but are mentioned in the individual species accounts.

Trapping returns averaged 3.33% across all sites, with slightly better returns (4.66%) at the highest elevation camp (Table 18.1). Low trap success in pristine forest habitats is the norm in Papua New Guinea (Aplin and Opiang Chapter 7, this volume), with most examples of substantially higher returns pertaining to disturbed habitats such as abandoned gardens where ecologically adventitious species of *Rattus* tend to dominate captures (e.g. Dwyer 1984). Eleven species of mammals were documented by trapping.

Observations

The amount of time spent walking around during the days and through the evening could not be quantified as many expedition members contributed to this effort. Sightings of mammals were rare and in many cases the animals were too

high in the canopy for accurate identification. A total of ten mammal species were identified with confidence from sightings. All but two of these species were confirmed by capture of the individuals or subsequent finds of skeletal material.

Summary of mammal records

The survey resulted in confirmed records in the Muller Range of one monotreme, nine marsupials, 12 murid rodents, and one feral canid (Table 18.2). Since many of the species belong to taxonomically complex or otherwise poorly known groups, they are discussed individually in the following section. IUCN Red List ratings are drawn from the 2008 assessment available at <http://www.redlist.org/>.

ANNOTATED SPECIES LIST

Order Monotremata, Family Tachyglossidae

Zaglossus sp. (probably *bartoni*) (Eastern Long-beaked Echidna)

IUCN Red List rating: Critically Endangered

Characteristic digging and probing marks made by echidnas were noted in various places around Sawetau but while they would appear to be moderately common in this area, no actual sighting was made.

Although echidnas were expected to be present in the open subalpine habitats at Apalu Reke, there was no evidence that they occupied either this habitat or the adjacent upper montane forests. The forest habitat at this elevation is extremely dense and it was difficult to move any great distance in search of echidna signs. However, camp assistants familiar with these habitats claimed that Echidnas were not present at high elevations on the Muller Range.

Worthy and Flannery (1998) reported bones of the Short-beaked Echidna *Tachyglossus aculeatus* (Shaw and Nodder, 1972) in an archaeological midden from 'The Backyard' rockshelter. Along with James and Dyson (1980), they also reported the capture and consumption of Long-beaked Echidnas by local assistants.

Order Dasyuromorphia, Family Dasyuridae

Dasyurus albopunctatus Schlegel, 1880 (New Guinea Quoll)

IUCN Red List rating: Near Threatened

An immature male weighing 293 g was captured in a large Elliott trap set (ANWC M35462) on the night of 16th September 2009.

This species is widespread on the main island of New Guinea and covers a broad elevational range from sea level up to the treeline.

Neophascogale lorentzii (Jentink, 1911) (Speckled Dasyure)

IUCN Red List rating: Least Concern

This species was not captured. However, sightings by team member Vincent Kalkman of a small, long-snouted, and dark but unstriped mammal active during the day on the

Table 18.1. Summary of the survey effort and capture returns for mammals at each of the three camps in the Muller Range. 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	Captures per trap night
Gugusu	515	10	904	23	2.54%
Sawetau	1,587	7	565	17	3.0%
Apalu Reke	2,875	8	665	31	4.66%
Total		25	2134	71	3.33%

forest floor near Apalu Reke very likely pertain to the Speckled Dasyure.

This taxon is primarily western in its distribution, with the nearest confirmed records coming from the vicinity of Telefomin and the vicinity of Mt Hagen. Somewhat surprisingly, it was not encountered by Dwyer (1990) or subsequent field workers on Mt Sisa. Nothing has been reported of the

ecology of this species which has a recorded elevational range from 1,200 to 3,900 m. (Helgen 2007a).

Worthy and Flannery (1998) reported *Neophascogale lorentzii* in several 'fossil' assemblages and also recorded '*Antechinus* sp.' in the modern Windy Cave assemblage. The latter taxon might represent one or more species of muricine dasyurid but this cannot be further refined without direct examination of the material.

Table 18.2. List of all 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 nearby Mt Sisa, and how it was recorded during the RAP. Code for methods: D = diggings observed; Ha = caught by hand; M = mist net; O = visual observation; S = pickup skeleton; T = trap; T/R = trapped but released.

Species	Gugusu	Sawetau	Apalu Reke	Mt Sisa	How recorded
Tachyglossidae					
<i>Zaglossus</i> sp.	-	+	-	+	D
Dasyuridae					
<i>Neophascogale lorentzii</i>	-	-	+	-	O
<i>Dasyurus albopunctatus</i>	-	1	-	+	T
Phalangeridae					
<i>Phalanger carmelitae</i>	-	-	4	+	S
<i>Phalanger sericeus</i>	-	-	2	+	S
<i>Phalanger</i> sp. (<i>carmelitae</i> or <i>sericeus</i>)	-	-	1		O
Pseudocheiridae					
<i>Pseudocheirus cupreus</i>	-	-	3	+	Ha,S
<i>Pseudochirulus mayeri</i>	-	1	1	+	Ha,O
Acrobatidae					
<i>Distoechurus</i> sp.	-	2	-	+	Ha
Petauridae					
<i>Dactylopsila trivirgata</i>	1				Ha
Macropodidae					
<i>Dendrolagus notatus</i>	-	2	2	+	O,S
Muridae					
<i>Coccymys shawmayeri</i>	-	1	5	-	Ha,T
<i>Lorentzimys</i> sp.	-	1	-	-	T
<i>Mallomys</i> cf. <i>rothschildi</i>	-	-	2	+	Ha,O
<i>Melomys</i> cf. <i>gracilis</i>	2	-	-	+	T
<i>Melomys</i> cf. <i>rufescens</i>	1	-	-	+	T
<i>Paramelomys lorentzii</i>	6	-	-	+	T
<i>Paramelomys mollis</i>	-	7	-	+	T
<i>Paramelomys platyops</i>	2	-	-	+	T
<i>Paramelomys</i> sp. indet	12	-	-	-	T/R
<i>Paramelomys rubex</i>	-	-	8	+	T
<i>Pogonomys</i> cf. <i>loriae</i>	-	1	-	+	Ha
<i>Rattus niobe</i> A	-	7	18	+	T
<i>Rattus niobe</i> B	-	1	-	+	T
Canidae					
<i>Canis familiaris</i> "hallstromi"	-	-	+	?	O

Order Diprotodontia, Family Macropodidae

Dendrolagus notatus Matschie, 1916 (Central Ranges Tree-kangaroo, Ifola)

IUCN Red List rating: Endangered

The various members of the Doria's tree kangaroo group (*dorianus*, *mayri*, *notatus*, *stellarum*) are sometimes treated as subspecies of *D. dorianus*, and sometimes as full species. The latter position is adopted here since it seems to more accurately represent the genetic and morphological diversity of these forms, as well as the fact that some taxa show abutting ranges (e.g. Kawai 1989, Helgen 2007a). *Dendrolagus notatus*, the Central Ranges Tree-kangaroo [Flannery et al. (1996) employ the Kuni (Chimbu Province) name *Ifola*], is the most widely distributed member of this group, with previous records from Garaina in the east to Mt Sisa in the west, and an elevational range from 900 m to 3,100 m (Flannery et al. 1996).

This species was observed on two separate occasions in stunted forest near the top of the ridge above Sawetau, once by Aplin and once by Vincent Kalkman who was able to take some confirmatory photographs. Further confirmation was obtained at Apalu Reke in the form of a fresh skull (ANWC M37301) lying in the *Blechnum* ground cover, probably evidence of dog predation, and faecal pellets found among the tangled roots of a tree in one of the isolated forest patches. Finally, a mandible of this species (ANWC M37310) was found on the floor of a hut used seasonally for drying Pandanus fruit, situated alongside a grassed clearing at 2,764 m at 5° 29.140' S, 142° 18.502' E. These records extend the known range of *D. notatus* by a hundred kilometres or so to the west on the southern side of the cordillera; it is recorded from approximately 100 km further west again on the northern side (e.g. Mt Stolle in West Sepik Province).

Judging by the relative frequency of these encounters and signs, *D. notatus* is moderately abundant across a broad elevational range in the Muller Range. By contrast, excessive hunting has eliminated it from many parts of its former range, often so recently that living men can recall hunting the species in their youth.

Order Diprotodontia, Family Acrobatidae

Distoechurus sp. (A feather-tail possum)

IUCN Red List rating: Not Evaluated

The genus *Distoechurus* is usually treated as monotypic [as *D. pennatus* (Peters, 1874)], with an altitudinal range from sea level to 1,900 m (Flannery 1995). However, ongoing genetic and morphological studies by Aplin and co-workers favour the recognition of multiple well-differentiated species, each probably occupying a discrete geographic area on the main island of New Guinea.

Two feather-tail possums captured at Sawetau are very close in external features and cranio-dental morphology to specimens from nearby Mt Sisa. Collectively, these samples differ from other named regional populations of

Distoechurus, including the nominotypical *D. pennatus* (Peters, 1874) of the Bird's Head Peninsula of Indonesian Papua and *neuhassi* and *amoensis* from the Huon Peninsula, and also from a large series collected around Mount Karimui in south Simbu Province in 1984. Flannery and Seri (1990) did not record a feather-tail possum in the Telefomin area of West Sepik Province although there are records from further west on the central cordillera (Flannery 1995). The Muller Range / Mt Sisa population of *Distoechurus* is very likely an unnamed species but its wider geographic range currently is unknown.

One of the two specimens obtained at Sawetau was found during clearing of the helipad on 9th September 2009. The other was captured by hand in camp on the evening of the 11th September 2009. This followed a sighting the preceding night of a 'small possum' near a light trap set up alongside camp for insects. Both were males, with a fully adult individual weighting 32 g.

Worthy and Flannery (1998) did not record *D. pennatus* in any assemblage but did find the Long-tailed Pygmy Possum [*Cercartetus caudatus* (Milne-Edwards, 1877)] to be well-represented in both modern and fossil assemblages. This species can be locally abundant in both upper montane and subalpine habitats across New Guinea (Flannery 1995) and it very likely occurs across a broad range of habitats on the Muller Range.

Order Diprotodontia, Family Phalangeridae

Phalanger carmelitae Thomas 1898 (Mountain Cuscus)

IUCN Red List rating: Least Concern

Mountain Cuscus is found along virtually the entire length of the central cordillera of New Guinea and also on the isolated ranges of the Huon Peninsula. Most specimens come from between 1,350 m and 2,400 m but on the Huon Peninsula, where it occurs without the morphologically similar Silky Cuscus, it is recorded up to 3,800 m (Helgen 2007b).

Three skulls (e.g. ANWC M37302) found in dense *Blechnum* ground cover near Apalu Reke represents this species.

Phalanger sericeus Thomas 1907 (Silky Cuscus)

IUCN Red List rating: Least Concern

Silky Cuscus is also widespread in the montane forests of the central cordillera but it typically occurs at higher elevations than the morphologically similar Mountain Cuscus. The lowest elevation records for *P. sericeus* (around 1,500 m) are reported in the vicinity of Telefomin (Flannery and Seri 1990).

A skull (ANWC M37311) found in dense *Blechnum* ground cover near Apalu Reke is identified as this species.

Order Diprotodontia, Family Pseudocheiridae

Pseudochirops cupreus (Thomas, 1897) (Coppery Ringtail)

IUCN Red List rating: Least Concern

The Coppery Ringtail is another widespread species of the montane forests of the central cordillera of New Guinea. Elevational range spans from 1,350 m to just below 4,000 m (Flannery 1995), with the highest recorded populations occurring above the treeline in subalpine shrubland (Hope 1976, Flannery 1995).

An adult Coppery Ringtail was captured and eaten at Apalu Reke on the evening of the 17th September 2009, prior to the arrival of the scientific team. The skull (ANWC M37308) was retrieved from the refuse pit. Several other partial skeletons including jaws and crania were found in the *Blechnum* fern understorey during the following week, and it was clear that the Coppery Ringtail was not only locally common, but also a regular prey item of the wild dogs that inhabit these high elevation clearings.

Pseudochirulus mayeri (Rothschild & Dollman, 1932) (Pygmy Ringtail)

IUCN Red List rating: Least Concern

The Pygmy Ringtail is recorded from scattered localities along the central cordillera of New Guinea, with a known elevational range from 1,200 m to 4,200 m (Helgen 2007a). Although many individuals were captured at the Wissel Lakes in the early 1960s (Husson 1964), other localities have produced relatively few records. At Mt Sisa, for example, only one *P. mayeri* was captured during a full 12 months of hunting out of Bobole village (Dwyer 1990).

An adult male Pygmy Ringtail weighing 117 g was captured by hand by Piotr Naskrecki at night in forest understorey near Sawetau.

Worthy and Flannery (1998) found this species to be abundant in both modern and 'fossil' assemblages from caves on the Muller Plateau. They also reported one specimen of the Painted Ringtail [*Pseudochirulus forbesi* (Thomas, 1887)] from the 'modern' assemblage from Windy Cave. Across its range, the latter species is more often recorded at lower montane elevations and can be particularly abundant in areas of secondary forest (Flannery 1995).

Order Diprotodontia, Family Petauridae

Dactylopsila trivirgata Gray, 1858 (Striped Possum)

IUCN Red List rating: Least Concern

An adult female (ANWC M35460) carrying a fully-furred pouch young weighing 109 g (ANWC M35461) was captured by hand at Gugusu on the 11th September 2009.

Striped possums occur across the entire main island of New Guinea, from sea-level to as high as 2,400 m (Helgen 2007a). However, most records come from below 1,600 m and there are also relatively few in true lowland rainforest (Flannery 1995). Many captures come from secondary forest

and even gardens, and the species is clearly quite tolerant of disturbance to its natural habitat.

Several populations of Striped Possums have been distinguished taxonomically but the validity of these taxa has not been tested by modern systematic work.

Order Rodentia, Family Muridae

Coccymys shawmayeri (Hinton, 1943) (Shawmayer's Mouse)

IUCN Red List rating: Not Evaluated

The distinctness of this species was only recently appreciated, following a full revision of all available specimens of *Coccymys* (Musser and Lunde 2009). Three species are now recognised, all resident in the upper montane forests of the central cordillera, and with a sequential replacement from east to west. *Coccymys shawmayeri* occupies the central portion of this mountain chain, from the Owen Stanley Range in the east to the vicinity of Telefomin in the west, and across a broad elevational range from 1,600 m to 3,500 m, where it inhabits a variety of montane forest and subalpine habitats.

We captured one specimen of *C. shawmayeri* (ANWC M35506, an adult female weighing 24.5 g) by hand at Sawetau, and five more in kill-traps and Elliott traps at Apalu Reke. The Sawetau record at 1,587 m in transitional lower to upper montane forest represents the lowest elevation record for the species. At Apalu Reke we trapped the species around the margins of clusters of low trees and shrubs, and around the upper montane forest margin. Judging by our capture rate at Apalu Reke, this species is extremely abundant in the *Pandanus-Blechnum* community at high elevations in the Muller Range and perhaps less common in upper montane forest habitat.

Lorentzimys sp. (A long-footed tree-mouse)

IUCN Red List rating: Not Evaluated

A single long-footed tree-mouse, an adult male weighing 17.8 g, was captured in a break-back trap set at an elevation of 1,540 m on the ridge below Sawetau Camp. The trap was positioned on the ground beside a small entrance leading into a vertical cavity inside a tree with a diameter at chest height of 40 cm. The entrance showed indications of recent use and it is likely that the tree-mouse was resident.

Only one species of *Lorentzimys* (*L. nouhuysi* Jentink, 1911) is recognized in recent synthetic works (Flannery 1995, Musser and Carleton 2005). However, the genus has not been subject to systematic review and it includes considerable morphological diversity. Preliminary comparisons suggest that the Muller Range specimen is quite different from individuals collected at each of Mt Sisa and Telefomin, and is more similar to a population sampled on Mt Missim in Morobe Province. One unusual feature that is uniquely shared by the Muller and Mt Missim populations is the elongation of terminal tail hairs to form a delicately pointed 'paint-brush'-like structure. In the Muller Range specimen this remarkable structure extends over 25 mm beyond the end of the tail. Other populations lack this specialization of

the terminal tail hairs, hence the structure has not been mentioned in previous descriptions of these beautiful little mice.

The Muller Range *Lorentzimys* almost certainly represents an undescribed species but until more exhaustive studies are carried out of previous collections, it is not possible to state whether or not it has been collected at any other locality.

Long-footed tree-mice show variable nesting behaviour. Flannery (1995) described a nest containing multiple long-footed tree mice in a crown of a tree fern in the Telefomin area but Aplin has experience from Mt Sisa of both single and multiple captures from nests inside tree hollows.

Mallomys sp. cf. *M. rothschildi* Thomas 1898 (Rothschild's Woolly-rat)

IUCN Red List rating: Least Concern

Felling of a tree at Apalu Reke produced a juvenile Woolly-rat (ANWC M35463) and a glimpse of a fleeing adult, presumably a female. The juvenile weighed 223 g but the fact that its molar crowns have not breached the gums suggests that it was still entirely dependent on suckling. The combination of blackish-brown dorsal fur and heavily pigmented ears is consistent with *M. rothschildi*, a widely distributed species of the central cordillera (Flannery 1995). However, genetic analysis is probably required to confirm this identification based on such an immature individual.

A second possible sighting of a woolly-rat at Apalu Reke involved observation of a large dark rat in the crown of a *Pandanus* tree. This animal fled into dense forest canopy upon being disturbed.

Melomys sp. cf. *M. rufescens* (Alston, 1887) (Black-tailed Melomys)

IUCN Red List rating: Least Concern

The taxonomy of the Black-tailed Melomys group remains confused, despite the efforts of Flannery et al. (1994) and Musser and Carleton (2005) to resolve the marked variability into a few widespread species.

Three individuals of this group were captured at Gugusu. Two are relatively long-tailed (ANWC M 35574 and M35575) and have robust hind feet, while the third (ANWC M35576) is shorter-tailed and has more slender feet. Flannery (1995) recorded *M. gracilis* (Thomas, 1906) at Mt Sisa and it is possible that the longer-tailed form represents this poorly known species. If so, the shorter-tailed form is presumably true *M. rufescens* or a close relative if this species is endemic to the Bismarck Archipelago.

Paramelomys lorentzi (Jentink, 1908) (Lorentz's Paramelomys)

IUCN Red List rating: Least Concern

Trapping around the Gugusu camp produced a total of 20 individual *Paramelomys*, all identified in the field as *P. platyops* (Thomas, 1906). Only eight of these were kept as vouchers, and the remaining 12 released after taking measurements. Careful study of the vouchers revealed a second species, *P. lorentzi*, with this turning out to be dominant in the voucher series (6 *lorentzi* vs 2 *platyops*). The two species

are distinguishable on hind foot and tail proportions, and on the morphology of the tail which has three hairs per scale in *P. lorentzi* but only one in *P. platyops*.

Paramelomys lorentzi is primarily a western species of hill and lower montane forests, with records from near sea level to 1,500 m (Musser and Carleton 1993). The closest previous record is a large series from the Upper Fly River, reported by Tate (1951), and examples from Mt Bosavi, reported by Menzies (1996). The Muller Range series fills a significant gap between these localities.

Paramelomys mollis (Thomas, 1913) (Thomas's Paramelomys)

IUCN Red List rating: Least Concern

Thomas's Paramelomys occurs along the entire central cordillera of New Guinea and this is one of the most widely distributed of all Paramelomys. It also has one of the narrowest elevational ranges, from 1,200 m to 2,500 m according to Helgen (2007a).

We captured 12 individuals of this species at Sawetau but none were taken at camps above or below this site. Our findings thus are consistent with Flannery's (1995) account and further suggest that the species can be locally abundant within suitable habitats.

Paramelomys platyops (Thomas, 1906) (Lowland Paramelomys)

IUCN Red List rating: Least Concern

Two specimens of this extremely widespread species were collected at Gugusu. The altitudinal range across New Guinea extends to 1,500 m (Menzies 1996) but most records come from below 900 m (Flannery 1995).

Paramelomys rubex (Thomas, 1922) (Mountain Paramelomys)

IUCN Red List rating: Least Concern

Eight individuals were captured at Apalu Reke in traps set around the margin of the forest and around isolated clusters of low trees and shrubs. Despite capture records from elsewhere in New Guinea that extend down to below 1,000 m (Flannery 1995, Menzies 1996), the species was not taken at Sawetau.

Menzies (1996: 413) stated the habitat range of *P. rubex* as "lower to midmontane forests throughout the mountain ranges of New Guinea ... from about 1,200 to 2,500 m or higher". Helgen (2007a) reported an even broader range, from 900 m to 3,000 m. While our records from subalpine scrub appear somewhat exceptional, it is possible that the species penetrates only a short distance into this habitat from adjoining upper montane forest. Despite the taxonomic work of Menzies (1996), *Melomys rubex* almost certainly still harbours multiple species; hence, it is premature to comment on the wider affinities of the Muller Range population.

Pogonomys sp. cf. *P. loriae* Thomas, 1897 (Large Tree-mouse)

IUCN Red List rating: Least Concern

One tree-mouse was captured by hand at Sawetau after it climbed onto a camp bench in the evening. It was an adult male with a body weight of 66 g and the general features

of *Pogonomys loriae* Thomas, 1897. However, because this group is taxonomically complex, it is not yet clear which of two or three taxa currently grouped under '*P. loriae*' is represented. Genetic studies currently underway should resolve this issue in the near future.

Worthy and Flannery (1998) reported a tentative record of *Pogonomys sylvestris* Thomas, 1920 in several fossil assemblages but this allocation needs to be reassessed.

Rattus niobe Complex (Moss-forest Rats)

IUCN Red List rating: Least Concern

Small, short-tailed *Rattus* are abundant in montane habitats across the whole of New Guinea. Most recent accounts (e.g. Taylor et al. 1982, Flannery 1995) treat these as a single variable species, *R. niobe* (Thomas, 1906) which is sometimes placed in the genus *Stenomys*, (e.g. Flannery 1995). Musser and Carleton (2005) provisionally recognized four species: *R. niobe*, *R. arrogans* (Thomas, 1922), *R. arfakiensis* (Rümmeler, 1935) and *R. pococki* Ellerman, 1941. Under this arrangement, all populations in Papua New Guinea would be identified as *R. niobe*. The inadequacy of this position is apparent from numerous regional collections including the present series.

Moss-forest rats were captured at Sawetau (8 individuals) and Apalu Reke (18 captures). All individuals captured at Apalu Reke and most of those taken at Sawetau are small-bodied, with body weights under 55 g, and have very dark brown dorsal fur. However, one individual (ANWC M35547), captured down-slope of Sawetau, clearly represents a different species - it is substantially heavier (67 g) and has dull brown dorsal fur and larger ears. A broad survey of *R. niobe* populations is needed to identify the true pattern of species diversity in this group.

Order Carnivora, Family Canidae

Canis familiaris "*hallstromi*" Troughton, 1957 (New Guinea Singing Dog)

Koler-Matznick et al. (2003) recently reviewed information on the distribution, behaviour and ecology of the New Guinea Singing Dog. They give the elevational range as c. 2,500 m to 4,700 m with populations found along the length of the central cordillera, and make a case for recognition of the taxon at specific level, based on unique aspects of its morphology and behaviour. With Bulmer (2001), they further postulate that *C. hallstromi* was introduced to New Guinea as a wild canid that formerly occupied all of New Guinea, but later became restricted to the upper mountains following expansion of human agriculturalists from 9,000 years ago. A contrary view is strongly suggested by genetic analyses that favour feral derivation of the New Guinea Singing Dog from a domestic stock of East Asian origin (Savolainen et al. 2004).

A large population of New Guinea Singing Dogs is clearly present in the open habitats on the top of the Muller Range. During the first two nights after establishment of Apalu Reke

camp their characteristic 'singing' vocalization was heard but they were not heard subsequently. However, signs of dog activity in the form of partially consumed mammal carcasses and piles of fragmented bone derived from degraded dog faeces were ubiquitous through the *Blechnum* understorey. Mammalian carcasses left behind by dogs show characteristic features including the consumption of the braincase, leaving behind the tooth-bearing parts of the head.

DISCUSSION

Remarks on inventory completeness

Our survey in the Muller Range resulted in confirmed records of one monotreme, eight marsupials, 12 murid rodents, and one feral canid. With the possible exception of the unusual Long-footed Tree-mouse (*Lorentzimys* sp.), all of the non-volant mammal species recorded are previously known taxa.

Despite the significant results from this RAP survey, many gaps in knowledge remain. This is readily appreciated by comparison with the mammal species listing of Leary and Seri (1997) for the Kikori Integrated Conservation and Development Project Area (KICDPA), an area that includes the comparatively well-sampled localities of Mt Sisa, Mt Bosavi, and Tari and the Doma Peaks. For this wider area, with sites ranging in elevation from 20 m to over 2,000 m, the full non-volant mammal fauna comprises one monotreme, 29 marsupials and 35 murid rodents. Major gaps in our coverage can be inferred among dasyurids (2 species vs 4 in the KICDPA), bandicoots (no records vs 4 species in the KICDPA), wallabies and kangaroos (1 species vs 5 in the KICDPA), cuscuses (2 species vs 6 in the KICDPA), and ringtail possums (2 species vs 5 in the KICDPA). Among murid rodents, we recorded only one 'giant rat' whereas Leary and Seri (1997) recorded eight species for the KICDPA in the genera *Anisomys*, *Hyomys*, *Macruromys*, *Malomys*, *Uromys* and *Xenuromys*. The same assemblage of 'giant rats' is very likely present on the Muller Range, judging from their wider pattern of occurrence. Failure to encounter many of these larger bodied mammals reflects the lack of systematic hunting out of our camps, and particularly, the lack of dogs as part of the camp entourage. Hunting with dogs in New Guinea is significantly more productive than hunting alone, because the dogs are adept at locating daytime den sites for many of the nocturnal marsupials and rats (Dwyer 1990). However, the use of dogs during a RAP survey is problematic because of the havoc they are likely to cause around camps.

For the smaller murids, our inventory appears relatively complete for terrestrial species but poor for arboreal taxa. Other species of *Pogonomys* almost certainly occur on the Muller Range, and we might also expect species of *Pogonomelomys* and possibly of *Chiruromys*. These species are all rarely trapped, even if traps are placed in low trees and along fallen timber, but they can be obtained by arboreal trapping with

traditional snares, by hunting at night, and by systematic examination of known or likely den sites (Dwyer 1990).

Additional taxa recorded by Worthy and Flannery (1998) in the 'modern' Windy Cave assemblage include the dasyurid '*Antechinus* sp.', a striped bandicoot *Microperoryctes longicauda*, the Long-tailed Pygmy Possum *Cercartetus caudatus*, the Painted Ringtail *Pseudochirulus forbesi*, and several rodents including the Waterside Rat *Parahydromys asper* and a water rat listed as *?Leptomys* sp. but more likely the Short-haired Water Rat *Paraleptomys wilhelmina*.

New mammal species and other significant results

As noted above, the unusual Long-footed Tree-mouse (*Lorentzimys* sp.) from Sawetau is the species most likely to represent a completely new discovery. However, other captured species are almost certainly unnamed species, including the Feather-tail Possum (*Distoechurus* sp.) captured at Sawetau which was previously known only from Mt Sisa. Taxonomic uncertainties within the tree-mouse genus *Pogonomys* and within each of the Mountain Paramelomys (*Paramelomys rubex* Complex) and the Montane Rat (*Rattus niobe* Complex) also leaves open the possibility of local endemism within the non-volant mammal fauna of the Muller Range.

Ecological observations with significance for conservation

The obvious abundance of large mammals such as tree kangaroos and echidnas around the Sawetau camp is a strong indicator of low levels of hunting pressure, despite the presence of an established walking trail that passed through the site. Other disturbance also appears to be limited to a narrow strip along the track and the area therefore may be regarded as effectively pristine.

An occupied hunting camp was observed by one of the RAP team at an altitude of approximately 1,900 m a.s.l. above the Sawetau camp. Other evidence of hunting was observed at a seasonal camp in a grassland basin at 2,764 m, below Apalu Reke camp. This camp was positioned against a low limestone overhang and contained benches set up for smoking and drying of wild *Pandanus* fruits. According to our local field assistants, this harvest takes place annually over a period of a few weeks, and represents an occasion for hunting of game animals including cassowary and possums. Some of the meat procured during these forays is also smoked and taken back to villages on the northeast side of the Muller Range.

Long-beaked Echidnas and pademelons are both conspicuous in their absence from the high altitude grasslands and shrublands of the Muller Range. The absence of these taxa was confirmed by local field assistants, and substantiated in the case of pademelons by the absence of faecal pellets or sleeping retreats around the forest margin. Pademelons are abundant in similar subalpine habitats to the east, including the Kaijende grasslands in Enga Province (Helgen 2007b), and on the summits of Mt Giluwe in Western Highlands Province and Mt Albert Edward in the Owen Stanley Range

(Flannery 1995), and their presence at these sites is advertised by abundant faeces which persist in the environment for a considerable period of time.

Pademelons are currently absent from similar habitats in the Star Mountains and areas further west. However, in these areas, prehistoric remains from archaeological sites attest to the former occurrence of two species, *T. christenseni* and *Thylogale* sp. (Hope 1976, Flannery 1995). Overhunting may have caused local extinction of these western pademelon populations sometime during the mid- to late Holocene. Whether or not a similar history of local extinction applies in the case of the Muller Range is currently unknown. However, at least for the Long-beaked Echidna, this seems unlikely in view of the presence of a healthy population of this species at lower altitude.

The low trapping success for small terrestrial mammals and low contact rates during night patrols for small to medium-sized arboreal mammals contribute to an emerging picture of New Guinean hill to lower montane forest mammal communities characterized by low population densities across all species. As argued by Aplin and Opiang (Chapter 7, this volume), this situation most likely reflects intrinsically low biological productivity of ecosystems where standing biomass is high but nutrient levels and rates of energy turnover are both low. Under these 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. For any consumer species that is relatively sedentary, this scenario is likely to result in naturally low population densities, especially where there is competition for resources from other groups of primary consumers such as lizards and terrestrial birds. For arboreal mammals, the major competitors for food resources are more canopy birds and bats, both of which have the advantage of greater mobility that will allow them to utilise resources that are spatially and temporally discontinuous.

As discussed at greater length by Aplin and Opiang (Chapter 7, this volume), this model of New Guinean mammal community structure has other implications for community ecology and for conservation. In particular, it leads to the prediction 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. Population densities of many terrestrial and arboreal mammal species may, therefore, be extremely low even in the most pristine environments. A corollary of this prediction is that very large areas of pristine habitat may be required for effective conservation of these species.

CONSERVATION RECOMMENDATIONS

The 2009 Muller Range RAP survey provided a brief and very partial glimpse of a diverse mammal community living in an almost pristine swathe of forest that spans a remarkably broad elevational range on the western side of the range, beginning with hill forests at around 500 m and passing up through lower and upper montane forests to culminate in a diversity of spectacular and unique subalpine habitats above 2,500 m. Although most of the mammals that inhabit these forests are probably quite widely distributed in the extensive catchments of the Strickland and Kikori Rivers, the intact nature of the forest ecosystems across such a broad elevational gradient is almost without parallel in the wider region.

Long-term preservation of this spectacular series of interconnected ecosystems represents a conservation priority of the highest international importance. The potential benefits are most obvious for various threatened species such as echidnas and tree-kangaroos which are declining under intense hunting pressure in many parts of their range. However, a case for equal if not greater importance can be made for preservation of a pristine elevational gradient that provides a rare opportunity for conservation on a landscape scale such that a regional biota can respond and adapt to future climatic changes and regimes in a fully natural way, without the added complexity that is introduced through human activities and the presence of exotic organisms. There are few places in the world, and even fewer places in the Old World tropics, where such a dream could become reality through relatively simple measures.

The extremely high conservation values of the Muller Range are a product of its current remoteness from major human populations and from resource development projects. Any inroads into this area, whether for targeted extraction of forestry or mineral resources or to accommodate population growth in surrounding areas, will bring with it a large risk of habitat degradation on a local to regional scale. Gardeners in Papua New Guinea are also enthusiastic hunters, and populations of echidnas, tree-kangaroos, possums and giant rats are all likely to suffer, at least on a local scale, from local population growth and encroachment. Resource development projects invariably require transport infrastructure and a work force, and will usually result in quite severe local impacts that, if not properly managed, can blow out into regional impacts.

The Muller Range is one of the very few places on Earth where the pressures of the modern age have yet to arrive. From the standpoint of conservation, it would be best if they never did. However, a more likely future will involve some degree of incursion of the modern world into this pristine paradise, and it can only be hoped that this occurs with a genuine commitment to conservation from all partners. Knowledge of the ecosystems will be fundamental to achieving the best possible outcome – knowledge of the biodiversity and how it is distributed within the landscape; knowledge of how the organisms work together to form

balanced ecosystems; and knowledge of how human-induced changes might impact on the environment at all levels, from individual species through to entire ecosystems. The scientific results of the Muller Range RAP are a small first step toward acquisition of the necessary knowledge.

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