The mammal fauna of the Kaijende Highlands, Enga Province, Papua New Guinea

Author: Helgen, Kristofer M.

Source: A Rapid Biodiversity Assessment of the Kaijende Highlands, Enga Province, Papua New Guinea: 52

Published By: Conservation International

URL: https://doi.org/10.1896/978-1-934151-08-2.52

Chapter 4

The mammal fauna of the Kaijende Highlands, Enga Province, Papua New Guinea

Kristofer M. Helgen

SUMMARY

I surveyed five sites in the Kaijende Highlands of Enga Province, Papua New Guinea between 25 August and 9 September 2005 to assess the diversity of mammals in this region. This survey confirmed the occurrence of one monotreme, 18 marsupials, nine rodents, two bats, and two non-native placental mammals (wild-living dogs and pigs). Previous surveys of the Kaijende Highlands during the 1980s recorded at least one marsupial species, three rodent species, and one bat species that were not detected in the current survey. This brings the total number of native marsupials, rodents, and bats recorded in the Kaijende Highlands to 35 and in Enga Province to 39. However estimates of inventory completeness suggest that many species remain to be detected and that the local mammal fauna is likely to be twice as diverse as currently recorded.

The Kaijende Highlands mammal fauna includes a poorly known assemblage of rare and threatened species restricted to high-altitude tree fern savanna, tussock grassland, and adjacent upper montane (elfin) forests. These include the wallaby *Thylogale calabyi,* the rodent *Rattus giluwensis,* an unnamed species of bandicoot (*Microperoryctes* sp.), and an unnamed genus and species of rodent. Important range extensions for New Guinea mammals include the third vouchered locality for Calaby's Pademelon (*Thylogale calabyi*) and the first record of the Giluwe Rat (*Rattus giluwensis*) outside of the immediate vicinity of Mt. Giluwe in Southern Highlands Province. Other species of conservation concern that occur in the Kaijende Highlands include the echidna *Zaglossus bartoni* (as documented by informants) and the tree-kangaroo *Dendrolagus dorianus* (as documented by "trophy" mandibles). Inasmuch as the Kaijende Highlands continue to support a largely intact mammal community that has not been reduced in diversity by overhunting, it is a region of great interest and importance for conservation.

INTRODUCTION

Enga Province has received less attention in surveys of mammalian biodiversity than any other province in Papua New Guinea. The paucity of mammal records for Enga Province is notable because the mammal faunas of several neighboring provinces (particularly Southern Highlands, West Sepik, Western, and Madang Provinces) have been the targets of considerable field collecting and systematic study (e.g. Morren 1989, Flannery and Seri 1990, Hyndman and Menzies 1990, Leary and Seri 1997, Flannery 1995, Bonaccorso 1998, Helgen 2007a). The few mammal specimens collected during previous survey work in Enga Province are deposited in the Papua New Guinea National Museum and Art Gallery (PNGNM) and the University of Papua New Guinea (UPNG), both in Port Moresby, and the Western Australian Museum (WAM) in Perth. Brief examinations of Enga specimens in these institutions prior to our 2005 RAP survey revealed just 18 mammal species, reinforcing the need for a more comprehensive assessment of the Province's mammal fauna.

Previous records of mammals from Enga Province derive from three main sources. Two rodent species (*Pogonomys loriae, Pogonomys sylvestris*) and four marsupial species (*Cercartetus caudatus, Phalanger carmelitae, Dactylonax palpator, Petaurus breviceps*) were collected at Wapenamanda (05°38'36"S, 143°53'43"E) by G. George, R. Mackay, and J. Mangi in the late 1960s. Some of these specimens were apparently transported alive to Baiyer River Sanctuary and the specimens were subsequently deposited at the PNGNM. At least 11 species were collected by Pat Woolley and collaborators during a survey of Porgera in 1980 and these specimens were deposited at WAM, PNGNM and UPNG (see below). Finally, Bonaccorso (1998) reported a record of *Miniopterus schreibersii* from Enga Province (collected at Mt. Leiwaro, see below). In addition to these definite Enga records, the American Museum of Natural History in New York and the Australian Museum in Sydney hold small series of specimens that originated from Yaramanda, a village that straddles the border between Enga Province and adjacent Western Highlands Province, but many if not most of these are explicitly marked "Western Highlands" District or Province. PNGNM also holds a specimen of *Mallomys rothschildi* from "Lumus, Enga Province" but this may in fact refer to the locality of Lumis (= Lumusa), situated in Western Highlands Province.

In this chapter I report the results of a mammal survey conducted between 25 August and 9 September 2005 at five sites in the Kaijende Highlands of Enga Province.

MATERIALS AND METHODS

Data collection and sampling methods

Because the majority of Melanesian mammals can only be reliably identified by comparison with museum specimens (Flannery 1995, Bonaccorso 1998, Helgen 2007a), scientific efforts to document mammalian biodiversity in New Guinea require the collection and long-term preservation of voucher specimens. I obtained voucher specimens on the 2005 RAP survey by excavating osteological material from owl pellet deposits and a rock shelter site, scavenging osteological material of naturally-deceased animals, and by collecting animals by live-trapping (cage and Elliott traps), lethal trapping (snap traps), and hunting with residents of the Kaijende Highlands.

Protocols for capture and handling of mammals followed standard guidelines established by the American Society of Mammalogists for animal care and use (American Society of Mammalogists 1998). For each specimen prepared as a museum voucher, standard external measurements were taken with a ruler (total length, tail length, hind foot length with and without the claws, ear length, and in the case of bats, forearm length) and Pesola scales (body mass). The sex and maturity of each specimen were assessed in the field, and microhabitat and other ecological data were noted for each specimen. Vouchers were prepared as study skins and skeletons, or as fluid preparations (fixation in 10% formalin, then transferred to 70% ethanol for long-term storage). For each freshly collected specimen, liver (and in some cases, kidney) tissue was preserved in 95% ethanol for subsequent genetic analyses. Some small mammals were photographed in life in semi-natural settings. Specimens from the Kaijende Highlands RAP survey are deposited in the mammal collections of the Papua New Guinea National Museum and Art Gallery, Port Moresby (PNGNM), the Australian Museum, Sydney (AM), and the South Australian Museum, Adelaide (SAM), along with their associated temporal, geographic, ecological, and mensural data, and genetic samples. These museum abbreviations are used throughout this chapter. Other institutions referenced by abbreviation herein include the American Museum of Natural History, New York (AMNH); the Bernice P. Bishop Museum, Honolulu (BPBM); and the Australian National Wildlife Collection, CSIRO, Canberra, Australia (CSIRO). Common names generally follow Flannery (1995), but in a few cases (among rodents) where taxonomic changes have necessitated a change in vernacular usage, common names follow Musser and Carleton (2005).

Study sites, site-specific trapping protocols and capture rates

The mammal survey focused on two areas, both in the Kaijende Highlands of Enga Province; 1) the vicinity of Lake Tawa, and 2) the area accessible by roads in the immediate vicinity of the town of Porgera and the Porgera Joint Venture (PJV) mining operation.

Lake Tawa Camp (05°35'43"S, 142°50'26"E) was situated at approximately 2,200 m elevation in lower montane forest (*sensu* Grubb and Stevens 1985). This site, described in more detail by Takeuchi (Chapter 1, this volume), was accessed by helicopter and consisted of several small interconnected sinkhole lakes fringed with grassland, and surrounded by forest dominated by *Pandanus.*

I established several trap-lines in the forest around Lake Tawa for 'removal trapping' of small mammals. Up to 50 medium-sized Elliott live traps (two transects) and 20 Victor rat traps (one transect) were set each night, for seven nights, on the forest floor and in vegetation and low trees up to 3 meters above the ground. Several traps were lost and broken over the course of the week, and total trap-nights was 425, with 45 catches (= 11% trap success) representing six species (*Rattus niobe, Paramelomys rubex, Peroryctes raffrayana, Microperoryctes ornata, Pseudohydromys ellermani,* and *Murexia naso*; see species accounts below). The terrestrial murines *Rattus niobe* (69% of captures) and *Paramelomys rubex* (20% of captures) dominated in the forest understorey. Six cage traps were also set each night along animal runways in the grasslands fringing Lake Tawa (Photo 81) and in adjacent forests, without success.

Mist-nets set by day by Beehler for catching birds (Chapter 3, this volume) were monitored at night for opportunistic bat-catching. Six nights of netting yielded only two species, one bat (the blossom-bat *Syconycteris australis,* five captures)

and one marsupial (the glider *Petaurus breviceps*, one capture). A double-stringed harp trap was erected each night for six nights along presumed flyways and entrance points in the forest near Lake Tawa without success.

Mammals were also documented at Lake Tawa by day hunting, scavenging, rock shelter excavation, sightings, and examination of spoor. Day hunting involved searching for roosting and sleeping sites of arboreal mammals during the day. Specimens of two species, the marsupials *Dactylonax palpator* and *Phalanger carmelitae*, were obtained in this manner. We did not hunt mammals at night. Scavenging involved searching opportunistically for mammal remains in the vicinity of camp. Cranial (and other) remains of five species (*Dorcopsulus vanheurni, Phalanger carmelitae, Pseudochirops cupreus, Uromys anak,* and *Sus scrofa*) were collected, all in sufficiently excellent condition to serve as good voucher material. I excavated osteological remains of small mammals, mainly mandibles and maxilla, from the surface levels of a rock shelter site situated on a ridge between two sinkhole lakes near camp; remains of at least five species (Table 4.1) were excavated at this site. Two species were documented at the Lake Tawa site by spoor (*Dendrolagus dorianus*), or by both sightings and spoor (*Canis familiaris*).

Porgera: A secondary effort was concentrated at three sites in the vicinity of Porgera: 1) Suyan Village, 2) Paiela Road and 3) Waile Creek including the Porgera Reservoir.

In Suyan Village (05°29'S, 143°09'E) I purchased from local hunters trophy jaws representing six medium-sized and large mammals (Table 4.1), including the macropodids *Dendrolagus dorianus* and *Thylogale calabyi*.

At Paiela Road I set up trap-lines (20 Elliott traps and 5 cage traps) in transects along a creek in upper montane forest (05°30'07"S, 143°04'44"E; 2,900 m asl) for three nights, resulting in the capture of three specimens of *Rattus niobe* in the Elliotts (= 5% trap success) and one specimen of *Uromys anak* in a cage trap (= 7% trap success). I also obtained trophy jaws of three medium-sized mammals from local hunters encountered along Paiela Road (Table 4.1).

At Waile Creek I set 25 Elliott traps per night for four nights, in alpine grassland adjacent to the Porgera Reservoir (ca. 05°33'56"S, 143°03'35"E, 3,010 m) and the Porgera power transformer station (05°33'45"S, 143°03'21"E, 3,076 m), resulting in the capture of eight *Rattus giluwensis* and 10 *Rattus niobe* (= 18% trap success). *Rattus niobe* were trapped in alpine grassland and adjacent upper montane forest but *R. giluwensis* was found only in the grassland. I collected a substantial quantity of bone from an owl pellet deposit in a rock outcropping in alpine grassland near the Porgera Reservoir (Photo 80), including jaws of at least eight small mammal species (Table 4.1). Given the altitude of this collection site (ca. 3,000 m), the only likely candidate for producing these deposits is the Sooty Owl, *Tyto tenebricosa* (see Beehler et al. 1986).

Omyaka Camp

A single skull of a wallaby (*Dorcopsulus* cf. *vanheurni*) was collected by survey personnel at Omyaka Camp (05°31'37"S, 143°03'23"E, 3,203 m) a few days prior to my arrival for the RAP survey (see below).

RESULTS

The mammal fauna of the Kaijende Highlands

During this survey I documented the occurrence of 32 mammal species including one monotreme, 18 marsupials, nine rodents, two bats, and two non-native placental mammals (wild-living dogs and pigs). Combined with the limited data available from previous surveys of the Kaijende Highlands during the 1980s these results increase the total number of native marsupials, rodents, and bats recorded in the Kaijende Highlands to 35 and in Enga Province to 39. Of this latter number, 33 are documented from the area by vouchered museum material, one (*Neophascogale lorentzii*) is documented by a photograph, and four (*Zaglossus bartoni, Crossomys moncktoni, Parahydromys asper,* and *Tadarida kuboriensis*) are documented by what I consider to be unambiguous informant information or reasonably established sightings, as discussed and defended below.

Because our understanding of the taxonomy and geographic distribution of many New Guinean mammals remains in a fairly basic state (Helgen 2007a, 2007b), I have summarized below all available data for each mammal species documented in the Kaijende Highlands. Included are all taxa documented during the 2005 RAP survey, and the four additional species recorded during previous surveys in the region. The taxonomic status of these four species was verified during the author's examination of museum specimens. These species accounts add to our meager knowledge of many poorly-known species, and provide the first major sketch of the mammal community of Enga Province as a whole. It is my hope that the combined taxonomic identifications, ecological contexts, and other information in this list will be useful far beyond the borders of Enga Province and will substantially complement existing regional summaries of New Guinean mammals (e.g. Laurie 1952, Lidicker and Ziegler 1968, Flannery and Seri 1990, Leary and Seri 1997, Cole et al. 1997, Aplin 1998, Aplin et al. 1999).

Order Monotremata, Family Tachyglossidae (Echidnas)

Zaglossus bartoni (Thomas, 1907) (Eastern Long-Beaked Echidna)

This largest of extant monotremes (5–10 kg) occurs in forests and upland grasslands from sea level to an elevation of at least 4,150 m along the length of New Guinea's central cordillera and in the outlying mountain ranges of the Huon Peninsula (Flannery and Groves 1998). It is now rare across much of its geographic range, probably because of widespread and intensive subsistence hunting with the aid of dogs, and it remains common today only in areas of very low human population density (George 1978, Flannery 1995). The subspecies in the Porgera region is presumably *Z. b. diamondi*, the distribution of which stretches from Papua New Guinea's Eastern Highlands to the Paniai (= Wissel) Lakes

of Papua Province, Indonesian New Guinea (Flannery and Groves 1998). I did not observe or collect this rare species during our survey effort in the Kaijende area, but hunters in the region are universally familiar with this animal, known by the name *Foreke* in the Ibile language. One informant recalled a recent sighting in tussock grasslands near the Porgera Reservoir along Waile Creek Road, which many travelers traverse between Porgera and Mt. Kare daily.

Order Dasyuromorphia, Family Dasyuridae (Carnivorous Marsupials)

Dasyrus albopunctatus Schlegel, 1880 (New Guinea Quoll)
This medium-sized dasyurid (500–1000 g) is a scansorial carnivore that inhabits forested areas between sea level and 4,000 m elevation across most of the island of New Guinea. I did not find it during our survey, but all local hunters that I interviewed were familiar with this quoll, known by the name *Forete* in the Ibile language. Its occurrence in the Kaijende Highlands is substantiated by a mandible collected from a cave deposit at Porgera by T. Mala in 1985 (UPNG 1810).

Murexia hageni Laurie, 1952 (Small Eastern Mountain Dasyure)
This small dasyurid (ca. 30 g) is a nocturnal, largely terrestrial insectivore that inhabits high montane forests in Papua New Guinea (1,600 to 3,400 m elevation). In the past, *M. hageni* has usually been considered a synonym of *M. habbema* (Tate and Archbold, 1941) (Flannery 1995, Van Dyck 2002). However, the taxonomy and distribution of *Murexia* (including the nominal genera *Micromurexia, Murexechinus,* and *Paramurexia* of Van Dyck (2002); cf. Krajewski et al. (2000)) are currently under review by Helgen and Darrin Lunde (in litt.), who recognize *M. hageni* as a distinct species endemic to Papua New Guinea's central and Eastern Highlands regions (Helgen 2007a, 2007b).

Most of what is known about the biology of *M. hageni* was reported by Woolley (1989) and Woolley et al. (1991), who studied this species at Porgera in 1985 with spool-and-line tracking methods. It is also represented by a voucher specimen from Porgera collected by Woolley and deposited at PNGNM. During our RAP survey, remains of this species were recovered from owl pellet accumulations in alpine grassland adjacent to the Porgera Reservoir along Waile Creek Road.

Murexia naso (Jentink, 1911) (Long-Nosed Dasyure)
This medium-sized species of *Murexia* is a scansorial carnivore that is widely distributed in upland forests (1,400-2,800 m) along the central cordillera (Flannery 1995, Van Dyck 2002, Helgen 2007b).

In forest near Lake Tawa I trapped a single adult male specimen of *M. naso* (65 g). The specimen was taken in a Victor trap baited with a dead bird and placed on a large log that had fallen across a creek.

Neophascogale lorentzii (Jentink, 1911) (Speckled Dasyure)
This medium-sized dasyurid is known from montane forests (1,200–3,900 m elevation) throughout much of the central cordillera. It was not recorded during our survey, and I know of no museum specimens from the vicinity of Porgera. However, Flannery (1995a) figured a photograph of *N. lorentzii* (by P. Woolley and D. Walsh) taken at Mt. Paiam, a peak overlooking Porgera (Flannery mistakenly attributed this locality to Western Highlands Province). This photograph of *Neophascogale* from the Kaijende Highlands provides the only record of the species between the Star Mountains region (Telefomin, West Sepik Province) and Mt. Giluwe and the Lavani Valley in Southern Highlands Province (all specimens at BPBM).

Order Peramelemorphia, Family Peramelidae (Bandicoots)

Microperoryctes ornata (Thomas, 1904) (Eastern Striped Bandicoot) (Photo 84)
The striped bandicoot *Microperoryctes ornata* is endemic to forested habitats at higher altitudes along the central cordillera (1,000–3,600 m elevation). It is a relatively small terrestrial omnivore that lives in burrows in the ground (Flannery 1995, Helgen 2007). Recognition of *M. ornata* as a species distinct from *M. longicauda* follows Helgen and Flannery (2004). A single adult male (400 g) was trapped in forest at Lake Tawa with an Elliott trap placed amongst fallen ripe *Pandanus* fruits. This is the first record of the species in Enga Province.

Microperoryctes sp. nov. (Subalpine Striped Bandicoot)
Examination of the large collections of *Microperoryctes* in world museums (see Helgen 2007a) indicates that an undescribed species of striped bandicoot occurs on the highest peaks of central and eastern Papua New Guinea, with known localities associated with tussock grasslands above the treeline (> 3,000 m elevation). Museum specimens referred to this taxon (Helgen in prep.) derive from Mt. Giluwe, SHP (BPBM), Mt. Wilhelm, Chimbu Province (AMNH), and Mt. Albert Edward, Central Province (AM, AMNH). Mandibles and maxilla extracted from owl pellet accumulations from a rock outcropping in tussock grassland along Waile Creek Road are tentatively referred to this unnamed species on the basis of mandibular and molar morphology.

Peroryctes raffrayana (Milne-Edwards, 1878) (Raffray's Bandicoot)
This medium-sized bandicoot is a terrestrial, nocturnal omnivore that is widespread in hill and mountain forests throughout New Guinea at elevations between sea level and 4,000 m. It occurs in forests along the northern and southern slopes of the central cordillera, in the outlying mountain ranges of the Huon and Vogelkop Peninsulas, and in the smaller north coastal ranges (Helgen 2007b). During the RAP survey I trapped two specimens in forest near Lake Tawa Camp. A juvenile male (195 g) was taken in an Elliott trap set overnight on the ground amongst fallen ripe *Pandanus* fruits. A large adult female (900 g) was taken in a Victor

Table 4.1. Mammal fauna documented from the Kaijende Highlands, Enga Province.
"Tawa" refers to Lake Tawa. "Suyan", "Paiela", "Reservoir", and "Power" reference sites along access roads in the vicinity of Porgera (see text). "Omyaka" refers to Omyaka Camp. Shaded columns at right indicate records that are not backed by a voucher specimen from the 2005 RAP. The light gray column indicates taxa recorded from the Kaijende Highlands on the basis of informant interviews only during the 2005 RAP (see text). The dark gray column indicates taxa documented at Porgera by Woolley and colleagues in 1985 but not collected during the 2005 RAP.
v = documented by voucher specimen(s) collected by survey personnel
r = documented by osteological remains excavated from a rock shelter or cave
o = documented by osteological remains recovered from owl pellet accumulations
t = documented by osteological remains recovered as trophy material from local hunters
s = documented by a sighting or sign as verified by the author
x = documented during this survey on the strength of unambiguous descriptions from local informants (column marked in light grey)

Site	Tawa	Suyan	Paiela	Reservoir	Power	Omyaka	Informant	Porgera
Approximate Elevation (m)	**2200**	**2300**	**2900**	**3000**	**3100**	**3200**	**> 2000**	**2500–2900**
Year	**2005**	**2005**	**2005**	**2005**	**2005**	**2005**	**2005**	**1985**
Monotremata (Tachyglossidae)								
Zaglossus bartoni							x	
Dasyuromorphia (Dasyuridae)								
Dasyurus albopunctatus							x	r
Murexia hageni				o				
Murexia cf. *longicaudata*	v							
Neophascogale lorentzii								v
Peramelemorphia (Peramelidae)								
Microperoryctes ornata	v, r							
Microperoryctes sp.				o				
Peroryctes raffrayana	v							
Diprotodontia (Macropodidae)								
Dendrolagus cf. *dorianus*	s	t						
Dorcopsulus vanheurni	v					v		
Thylogale calabyi		t						
Diprotodontia (Petauridae)								
Dactylonax palpator	v				s			
Petaurus breviceps	v, r							
Diprotodontia (Phalangeridae)								
Phalanger carmelitae	v	t	t					
Phalanger gymnotis							x	
Phalanger sericeus	r	t				s		
Diprotodontia (Pseudocheiridae)								
Pseudochirops cupreus	v	t	t					
Pseudochirulus forbesi							x	
Pseudochirulus mayeri				o				
Diprotodontia (Burramyidae)								
Cercartetus caudatus	r			o				
Rodentia (Muridae)								
Coccymys ruemmleri				o				
Crossomys moncktoni							x	

continued

Table 4.1. *continued*

Site	Tawa	Suyan	Paiela	Reservoir	Power	Omyaka	Informant	Porgera
Approximate Elevation (m)	**2200**	**2300**	**2900**	**3000**	**3100**	**3200**	**> 2000**	**2500–2900**
Year	**2005**	**2005**	**2005**	**2005**	**2005**	**2005**	**2005**	**1985**
Mallomys istapantap			t					
Mammelomys lanosus								v
Parahydromys asper							x	
Paramelomys rubex	v, r							
Protochromys fellowsi								v
Pseudohydromys ellermani	v							
Rattus giluwensis				v, o	v			
Rattus niobe	v		v	v, o	v			
Uromys anak	v	t	v	o				
Gen. nov., sp. nov.								v
Chiroptera (Pteropodidae)								
Syconycteris australis	v							
Chiroptera (Molossidae)								
(?) *Tadarida kuboriensis*				s				
Carnivora (Canidae)								
Canis familiaris	s							
Artiodactyla (Suidae)								
Sus scrofa	v	s						
Total	**18**	**7**	**5**	**9**	**3**	**2**	**6**	**5**

rat trap baited with rat entrails and fur and set overnight on a fallen log over a creek. Examination of her pouch revealed eight teats, with one small pouch young (date of collection 1 September). This is the first record of the species in Enga Province.

Order Diprotodontia, Family Macropodidae (Kangaroos)

Dendrolagus dorianus Ramsay, 1883 (Doria's Tree-Kangaroo)

Doria's Tree-Kangaroo is a relatively large (ca. 10 kg) arboreal macropodid distributed throughout the mountain ranges of New Guinea's central cordillera, where it occurs most commonly at higher elevations (above 1,500–2,000 m) in the highlands of central Papua New Guinea and West Papua (Flannery and Seri 1990, Flannery et al. 1996). Several geographic forms have been described, and more study is needed to confirm whether these are distinctive subspecies or a complex of parapatric species (Bowyer et al. 2003, Helgen 2007b). The form of Doria's Tree-Kangaroo represented in the Kaijende Highlands is presumably *Dendrolagus dorianus notatus* Matschie, 1916, which according to Flannery (1995) occurs "from Garaina to the Strickland River." Several trophy jaws of this kangaroo were obtained at Suyan Village. These jaws should be of particular interest in future taxonomic and geographic studies of *D. dorianus* in that they are unusually massive, with teeth larger than most *D. dorianus* museum specimens that I have examined (lower cheektooth row in two complete Suyan jaws = 38.5 – 40.6 mm versus 33.6 – 38.8 mm in 30 adult *D. dorianus* jaws at AM, AMNH, and CSIRO that were collected throughout the central cordillera). The exact provenance of the Suyan specimens is not known, but an elder at Suyan informed me that hunting occurred predominantly near the village (maybe within a half-day or day's walk). As far as I am aware, this is the first record of *D. dorianus* in Enga Province. It is known by the name *Andaia* in the Ibile language. Tree-kangaroo claw marks almost certainly representing this species were evident on trees along the forest edge in the immediate vicinity of Lake Tawa.

Hunters from Porgera were also familiar with Goodfellow's Tree Kangaroo (*Dendrolagus goodfellowi* Thomas, 1908), another central cordilleran congener that is easily recognized by its red-brown and gold patterning. It is known by the local Ibile name *Milipu* but it was universally agreed by hunters that *D. goodfellowi* occurs only at lower elevations

and not in the Kaijende Highlands above 2,000 m. Historically, *D. goodfellowi* occurred throughout most of the eastern central cordillera, probably from low foothills up into mid-montane oak forests. In areas of broad co-occurrence with *D. dorianus* it is probably restricted to forest formations at lower elevations (usually below 1,500 m) than *D. dorianus* (e.g. Hide et al. 1984). *D. goodfellowi* occurs as high as 2,865 m in the Star Mountains (Flannery 1995). Both *D. dorianus* and *D. goodfellowi* have been locally extirpated from many areas of New Guinea where they occurred until recent decades (Bulmer and Menzies 1972, George 1978, Flannery 1995, Martin 2005).

Dorcopsulus vanheurni (Thomas, 1922) (Small Dorcopsis)
This small mountain wallaby (1.5–2.5 kg) is widely distributed in the mountains of New Guinea, where it occurs in forests at elevations between 800 m and 3,200 m (Helgen 2007b). Our survey team scavenged a skin and skull of this species from a fresh kill by a New Guinea singing dog (*Canis familiaris*) in the grassy surrounds of Lake Tawa. Local hunters sighted other individuals in the same area during the day. This species apparently moves through the grass along well-worn runways that extend into adjacent forests. Cage traps set along these runs (baited with fruit) failed to capture any wallabies. This is the first record of *D. vanheurni* in Enga Province. It is known by the name *Wasana* in the Ibile language.

An additional *Dorcopsulus* skull was collected by Steve Richards and other members of the survey team at Omyaka Camp, above the treeline at around 3,200 m elevation. Preliminary comparisons indicate that the craniodental conformation of this skull is distinctive relative to other specimens collected from throughout the mountains of New Guinea and referred to *D. vanheurni*. *Dorcopsulus vanheurni* is not known to occur above the treeline and a detailed study of taxonomic boundaries and geographic variation in *Dorcopsulus* will be needed before the taxonomic status of this unusual skull can be firmly established. One possibility is that it represents a previously undiscovered high-altitude wallaby species. Clearly, a more complete series of specimens from high elevations near Porgera is needed to investigate the status of this potentially new taxon.

Thylogale calabyi Flannery, 1992 (Calaby's Pademelon)
Thylogale calabyi is a little-known, medium-sized wallaby (probably 2–4 kg) previously recorded in the literature only from subalpine grassland habitats (≥ ca. 2,800 m elevation) on two peaks in Papua New Guinea — Mt. Giluwe in Southern Highlands Province and Mt. Albert Edward in Central Province (Flannery 1992). The presence of *T. calabyi* in the Kaijende Highlands is documented by a single trophy jaw collected in the village of Suyan (Figure 4.1). This identification has been confirmed by a direct comparison of the trophy jaw with the holotype of *T. calabyi* at AM and is only the third documented site of occurrence for the species. Ken Aplin (in litt.) informs me that *T. calabyi* is also represented

Figure 4.1. Trophy jaw of *Thylogale calabyi* discovered in the village of Suyan in the Kaijende Highlands. It represents only the third documented site of occurrence for this species. Scale Bar = 25 mm.

in trophy jaw collections at AM taken at Pureni (05°51'S, 142°49'E) in Southern Highlands Province. Wallaby sign observed in subalpine meadows on Mt. Michael, Eastern Highlands Province (Steve Richards, in litt.), indicates that Calaby's Pademelon may also occur on this high peak. These scattered records indicate a disjunct geographic distribution for the species, centered on remnant upland sub-alpine grasslands throughout the eastern portion of New Guinea's central cordillera (Figure 4.2).

Pademelons have disappeared from upland meadows throughout much of New Guinea. Fossil remains document the apparent extinction of two species in the Snow Mountains of West Papua during the Holocene (Hope 1981; Flannery 1995, 1999). Calaby's Pademelon was probably present until recent decades in subalpine meadows on Mt. Wilhelm (Chimbu Province) (Flannery 1992, 1995). These Holocene and modern declines are likely to be associated (at least in part) with the arrival of dogs in the highlands and their widespread use by indigenous hunters. The discovery that *T. calabyi* still occurs in the Kaijende region is thus a result of considerable significance for conservation. Subalpine habitats in the Kaijende Highlands may be one of the largest tracts of habitat remaining for this Endangered species.

Order Diprotodontia, Family Petauridae (Striped Possums and Gliders)

Dactylonax palpator Milne-Edwards, 1888 (Long-Fingered Triok)
This striped possum is widespread in New Guinea's montane forests at elevations of 850–3,000 m, where it lives in tree hollows and in terrestrial burrows. An adult female was

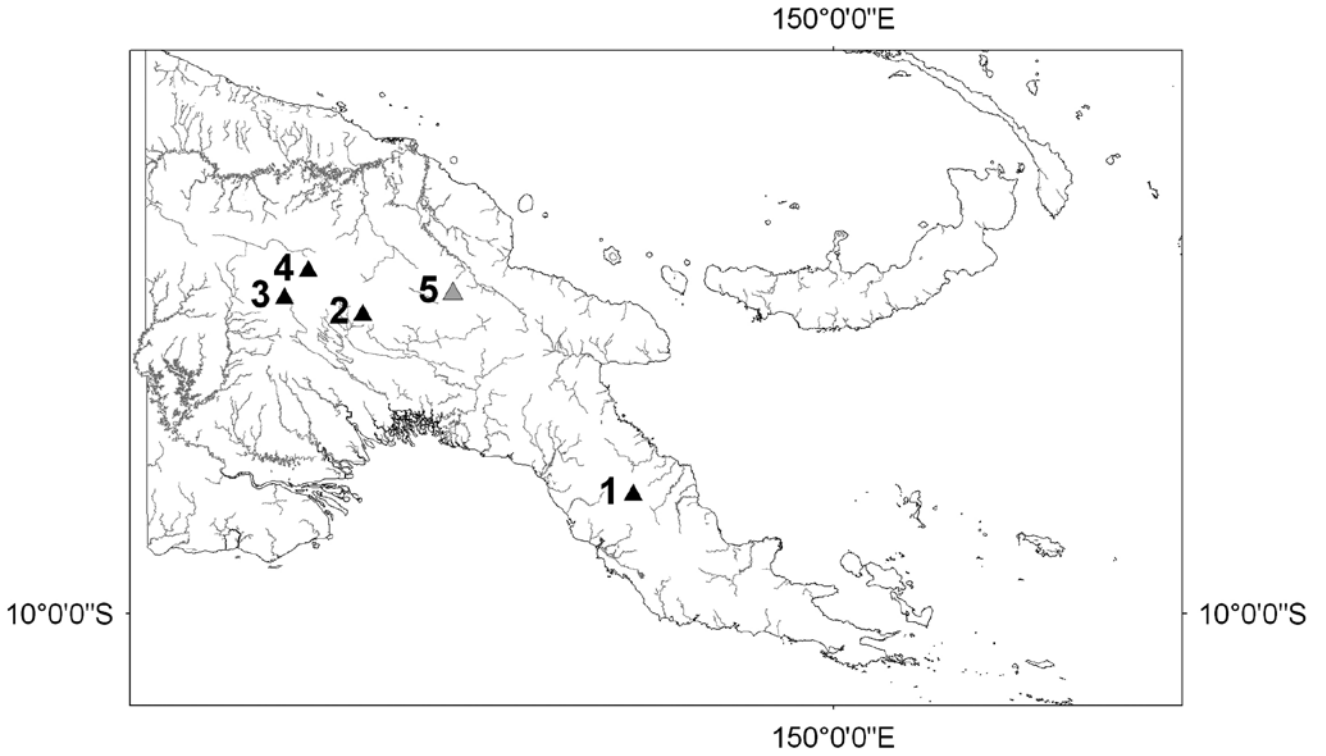

Figure 4.2. Distribution of *Thylogale calabyi*. Vouchered localities: 1. Mt. Albert Edward, Central Province, type locality of *T. calabyi*. 2. Mt. Giluwe, Southern Highlands Province. 3. Pureni, Southern Highlands Provinces. 4. Porgera, Enga Provinces. 5. Mt. Wilhelm, Chimbu Province, (shaded gray rather than black to indicate this is an unvouchered locality where *T. calabyi* may have occurred in the past, even if it does not persist today (see Flannery 1992)).

obtained from hunters at Lake Tawa, who found the animal resting by day in a tree hollow. The pouch of this animal contained a single young weighing 45 g. I also smelled the characteristic scent of this species near the Porgera transformer substation, in stunted upper montane forest at the alpine grassland ecotone (ca. 3,000–3,100 m elevation). This appears to be the upper altitudinal limit for this species throughout New Guinea (Helgen 2007b). This species is called *Piawini* in the Ibile language, but this name may also be a general term for striped possums.

Almost nothing has previously been reported previously about reproduction in *D. palpator* (Flannery 1994, 1995). A review of available data shows that all museum specimens reported to have pouch young contain only a single juvenile in the pouch (n = 6; specimens at AM, BMNH). Although there are two mammae in the pouch, only one seems to be functional at a time. Hide et al. (1984) reported that two females collected on Mt. Karimui were each accompanied by a single subadult male, presumably their nearly-grown offspring. In raising a single young, *D. palpator* contrasts with the sympatric striped possum *Dactylopsila trivirgata*, which more commonly has two pouch young (five of eight litters, based on examination of specimens at AM and BMNH).

The average body mass of four *D. palpator* mothers with pouch young (based on specimens at AM, including the Lake Tawa specimen) is 340 g (range 300–390 g).

Petaurus breviceps Waterhouse, 1838 (Sugar Glider) (Photo 83)
This common and widespread, small (mass ca. 50–120 g) forest-living glider is common in nearly all forest formations in New Guinea between sea level and at least 3,000 m elevation. It was recorded at Lake Tawa, where an adult female (49 g) was captured at night in a mist net. Osteological material of this species was collected at a rock shelter site in the same area, and its characteristic vocalizations were heard near our camp.

Order Diprotodontia, Family Phalangeridae (Cuscuses)
Phalanger carmelitae Thomas, 1898 (Mountain Cuscus)
This medium-sized cuscus (mass ca. 1.5–2.5 kg) is widespread, and often common, in montane forests between 1,350 and 3,800 m elevation (Helgen 2007b) throughout the central cordillera and on the Huon Peninsula (Flannery 1994, 1995). One adult female (mass 1.8 kg) with a very small pouch young (crown-rump length 15 mm, mass < 1 gram) was found sleeping in a tree hole during the day

by local assistants in forest around Lake Tawa (Photo 79). Another young adult female (1.15 kg) was found in the same area, sleeping by day in pandanus fronds. Trophy jaws representing this species were purchased from hunters at Suyan Village and on the Paiela Road.

Phalanger gymnotis (Peters and Doria, 1875) (Ground Cuscus)
The Ground Cuscus is a medium-sized to large (mass ca. 2–5 kg) terrestrial phalanger that is widespread in lowland and montane forest (0–2,700 m elevation) throughout New Guinea. Although I did not document this Cuscus at any site our assistants at Lake Tawa were familiar with the species — they described its appearance and habits unambiguously and used the Ibile name *Wapia* for it. Its occurrence in the Kaijende Highlands is substantiated by a voucher specimen from Porgera at PNGNM, collected by G. George in 1980.

Phalanger sericeus Thomas, 1907 (Silky Cuscus)
The Silky Cuscus is a medium-sized (mass ca. 2–2.5 kg) scansorial phalanger endemic to montane forest at elevations between 1,500 and 3,900 m along New Guinea's central cordillera. Externally it superficially resembles *Phalanger carmelitae* and it is sometimes confused with that species (Menzies and Pernetta 1986, Flannery 1995). This species is represented by trophy jaws purchased at Suyan Village near Porgera. As far as I am aware, this is the first record of the species in Enga Province. *Phalanger sericeus* is also probably the cuscus observed by Steve Richards (pers. comm.) and other members of the survey team in the vicinity of Omyaka Camp at 3,200 m elevation.

Order Diprotodontia, Family Pseudocheiridae (Ringtail Possums)
Pseudochirops cupreus (Thomas, 1897) (Coppery Ringtail)
This large ringtail (1.5–2.5 kg) is a common inhabitant of montane forests throughout New Guinea's central cordillera; it has a wide altitudinal range, extending from 1,350 to 4,000 m. Three complete skulls of this species were recovered in forest near Lake Tawa, and trophy jaws were purchased at Suyan Village and on the Paiela Road. *P. cupreus* is apparently called *Tanakai* in the Ibile language and this name was also applied to photographs of *Pseudochirops corrinae* (Thomas, 1897), another species which is likely to occur in the Kaijende Highlands. PNGNM holds additional osteological material representing *P. cupreus* collected from caves at Porgera in 1985 by T. Mala and P. Lambley.

Pseudochirulus forbesi (Thomas, 1887) (Painted Ringtail)
This medium-sized ringtail (400–1000 g) is a common inhabitant of montane forests in New Guinea, occurring throughout the eastern half of the central cordillera and in various isolated ranges (Flannery 1995, Helgen 2007b). It has been recorded from 450–3,800 m elevation but most records are from between 1,200 and 2,800 m (Helgen 2007b). The subspecies in central Papua New Guinea, including Enga Province, is *P. f. larvatus* (Forster and Rothschild, 1911). I did not document *P. forbesi* during the RAP survey, but Kaijende hunters were familiar with this species, called *Inalapei* in the Ibile language, which they identified from a photograph. Its occurrence in the Kaijende Highlands is substantiated by an adult male voucher specimen weighing 600 g that was collected from moss forest at 2,400 m on Mt. Waruwari by P. Woolley in 1985 (PNGM 24739).

Pseudochirulus mayeri (Rothschild and Dollman, 1932) (Pygmy Ringtail)
This small ringtail (100–200 g) is a common inhabitant of montane forests from 1,200 to at least 4,200 m elevation throughout New Guinea's central cordillera. Jaws of this species were recovered from owl pellet deposits in rock outcroppings in tree fern savanna adjacent to the Porgera Reservoir. P. Woolley collected a single specimen of *P. mayeri* at Porgera on June 6th 1985 — an adult female (PNGM 24746), weighing 151 g, with one pouch young. This species is called *Onopipi* in the Ibile language.

Order Diprotodontia, Family Burramyidae (Pygmy Possums)
Cercartetus caudatus (Milne-Edwards, 1877) (Long-Tailed Pygmy Possum)
This tiny possum (mass ca. 20 g) occurs across the entire length of the central cordillera and in the outlying mountains of the Vogelkop and Huon Peninsulas. It is a scansorial insectivore that occurs in montane forests and adjacent alpine grasslands at elevations between 1000 and 3700 m (Helgen 2007b). Osteological remains of this species were obtained from a rock shelter site at Lake Tawa and from owl pellet accumulations in a rock outcropping in alpine grasslands near the Porgera Reservoir. Several local informants applied the Ibile name *Penjo* to a photograph of this species.

Order Rodentia, Family Muridae (Rats and Mice)
Coccymys ruemmleri (Tate and Archbold, 1941) (Rümmler's Mouse)
This small scansorial murine (mass ca. 30 g) is a common inhabitant of montane forests and alpine grasslands throughout the central cordillera between 1,900 and 4,100 m elevation (Flannery 1995, Helgen 2007b). Jaws of this species were found in owl pellets in alpine grassland along Waile Creek Road near the Porgera Reservoir.

Crossomys moncktoni Thomas, 1907 (Earless Water-Rat)
Crossomys moncktoni is the most aquatic of all murine rodents and is classified in a monotypic genus (Thomas 1907). A medium-sized species (ca. 200 g), it is endemic to New Guinea's central cordillera where it occurs in fast-flowing streams in montane forests between 1,200 and 3,600 m elevation (Flannery 1995, Musser and Carleton 2005, Helgen 2007b). Previous compilations of museum records documented *Crossomys* only from the eastern portion of the central cordillera, with the Kikori River Basin (Southern Highlands Province) providing the westernmost record (Flannery 1995). However Helgen (2007b) reported a specimen from the Baliem Valley, demonstrating that its

distribution extends far into western New Guinea. There are no records from Enga Province and we did not document any specimens during our survey, despite intensive stream-side trapping along the Paiela Road. However a hunter on the Paiela Road was familiar with this species, calling it by the Ibile name *Ambulimawa* and reporting that it occurs in streams along the Paiela Road. He provided an accurate description of the species' semi-aquatic habits, size, webbed feet, and lack of external ears, amounting to what I consider an unambiguous description of *Crossomys*. The only other rodent with which *Crossomys* might be easily confused is another gray, semi-aquatic hydromyin, *Baiyankamys shawmayeri* (see Helgen 2005b) which probably occurs in the Kaijende Highlands, but has external ears. Although I am confident that *Crossomys* occurs in the Kaijende Highlands on the basis of my discussion with this Paiela hunter, verification of this species' occurrence in the region is still needed.

Mallomys istapantap Flannery, Aplin, and Groves, 1989 (Subalpine Giant-Rat)
Three species of *Mallomys* — large, scansorial and arboreal "woolly-rats" — co-occur in the central cordillera in Papua New Guinea — *M. aroaensis, M. rothschildi,* and *M. istapantap* (Flannery et al. 1989, Helgen 2007a). On the Paiela Road I purchased from a local hunter a single trophy jaw representing a species of *Mallomys*; comparison with voucher material at the Australian Museum confirms the Kaijende specimen as *M. istapantap,* the largest of the *Mallomys* species in New Guinea (adult mass ca. 1.9 kg). This record of *M. istapantap*, and another record from Dokfuma in the Star Mountains (Helgen 2007a), are significant in that they bridge a large gap in this species' previously recorded distribution. There were previously no records of this species between Mt. Giluwe and Lake Habbema. The distribution of *M. istapantap* is now known to extend across most of the central cordillera (Figure 4.3).

Mammelomys lanosus (Thomas, 1922) (Highland Mammelomys)
This medium-sized rat (ca. 100 g) occurs in upland forests (1,000–3,200 m) of the central cordillera and North Coastal Ranges (Flannery 1995, Musser and Carleton 2005, Helgen 2007). I did not collect it during the 2005 RAP, but WAM holds a series of specimens from Porgera collected by Pat Woolley (K. Aplin, in litt.).

Paramelomys rubex (Thomas, 1922) (Mountain Paramelomys)
Paramelomys rubex is a small, largely terrestrial, omnivorous rat that occurs in montane areas from 900 to 3000 m elevation throughout New Guinea (Flannery 1995). It is often the most common terrestrial mosaic-tailed rat in New Guin-

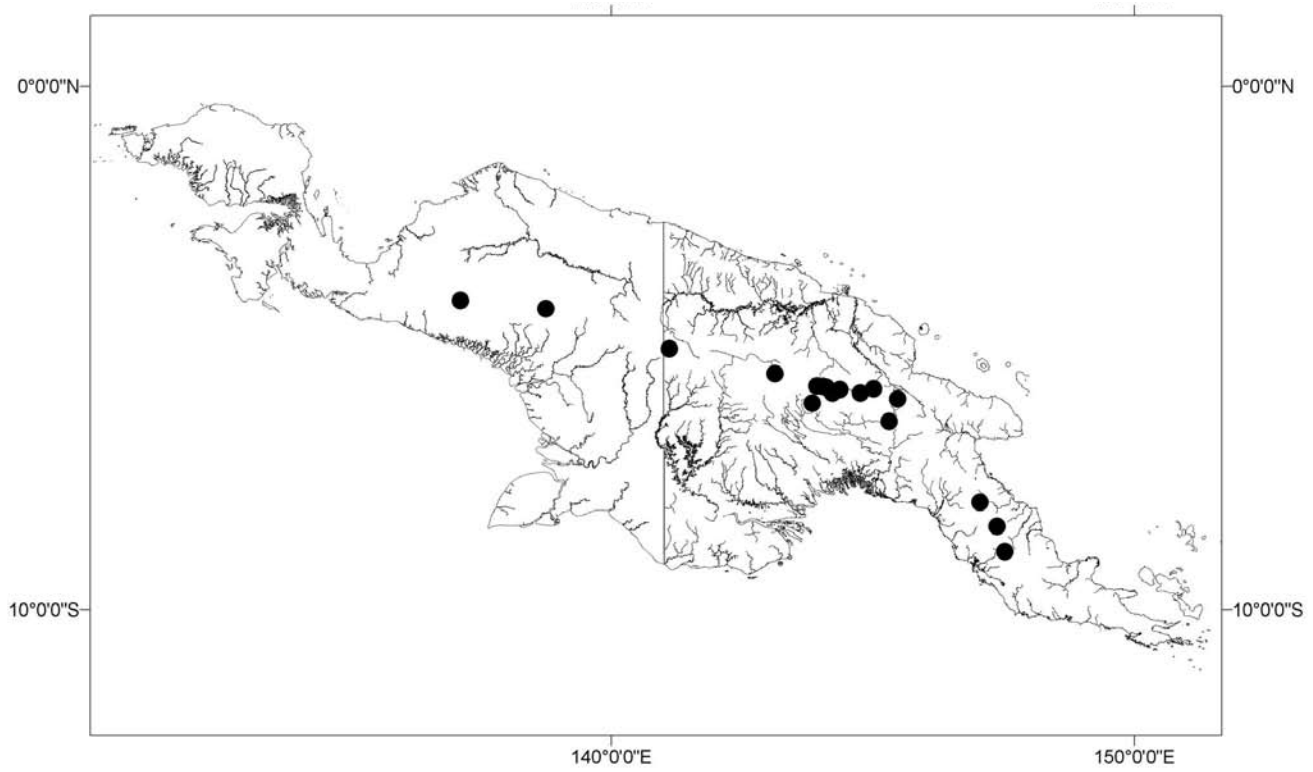

Figure 4.3. Distribution of *Mallomys istapantap* (adapted from Helgen 2007a).

ean montane forests. However, current taxonomic interpretations of *P. rubex* are likely to incorporate multiple distinct, currently undiagnosed species (Helgen 2007a).

I trapped many individuals at Lake Tawa, both in Elliott and snap traps, mostly on the ground but also on logs and low trees 1–2 m off the ground. Successful baits included peanut butter and oats, live worms, and pieces of a dead bird scavenged in the forest. After *Rattus niobe,* this was the most commonly trapped small mammal at Lake Tawa. However, no *Paramelomys* were trapped in upper montane forests along the Paiela Road, or in elfin forest or tree fern savannas along Waile Creek Road near the Porgera Reservoir and transformer station.

Parahydromys asper (Thomas, 1906) (Waterside Rat)
This semi-aquatic murine (ca. 500 g) occurs in all montane areas of New Guinea, including the entire length of the central cordillera, the isolated mountain ranges along the north coast, and on the Huon and Vogelkop peninsulas. In the central cordillera *P. asper* occurs at altitudes between 700 and 2,800 m (Helgen 2005b). Local informants in the Kaijende Highlands were familiar with this rodent, describing accurately its large lips and vibrissae, color, body size, general semi-aquatic habits, and waterside burrows. Although these descriptions could conceivably refer to a species of *Hydromys,* no *Hydromys* are known to occur above 2000 meters elevation (Helgen 2005b). Informants used the Ibile name *Poske* for this animal. Based on this information, and because it occurs along the length of the central cordillera to the east and west of Enga Province, there is little doubt that *Parahydromys* occurs in the Kaijende Highlands. Nevertheless, voucher material to confirm this species' occurrence in the region is still needed.

Protochromys fellowsi (Hinton, 1943) (Papuan Protochromys)
This little-known, small murine (mass ca. 80 g) was considered a species of *Melomys* until it was placed in a newly-erected monotypic genus, *Protochromys,* by Menzies (1996). It occurs in mossy forests at elevations between 1,800 and 2,800 m in the central highlands of New Guinea, with records from Porgera and the Hagen and Bismarck Ranges (Flannery 1995, Menzies 1996). Local population abundance appears to be variable. The species was reported as being common at some sites (Brass 1964, Menzies and Dennis 1979) but our survey did not encounter this species; the Porgera record (based on vouchers at PNGNM) was cited by Menzies (1996).

Pseudohydromys ellermani (Laurie and Hill, 1954)
This small, insectivorous, terrestrial moss-mouse inhabits mossy forests between 1,400–2,800 m elevation in the central portion of the central cordillera, with records from Lake Habbema in the west to Mt. Kaindi in the east (Helgen 2005a, 2007a). Along with *Pseudohydromys germani,* this species was previously classified in the genus *Mayermys* (see Helgen 2005a), which was subsumed into *Pseudohydromys* by Musser and Carleton (2005) and Helgen (2007a). I collected an adult female of this species (mass 15 g) in closed forest near Lake Tawa at 19:00 hrs. The snap trap was baited with a large live grub and placed at the base of a fallen log that formed a bridge over a small stream.

Rattus giluwensis Hill, 1960 (Giluwe Rat)
This distinctive montane murine was previously known only from the immediate vicinity of a single mountain peak, Mt. Giluwe, in Southern Highlands Province, Papua New Guinea (Taylor et al. 1982, Flannery 1995). Its capture in the Kaijende Highlands represents a range extension of major importance. I trapped seven individuals of this species (adult mass 50–100 g) in Elliott traps (baited with breadstuffs) along the Waile Creek Road in alpine grasslands near the Porgera transformer substation and the Porgera Reservoir. This short-tailed, large-headed, golden-brown rat has a highly distinctive appearance, superficially resembling a hamster (Photo 82).

Taylor et al. (1982) wrote that "The climate on Mt. Giluwe is cold and wet, and the surface humus, in which the tussock grasses grow, is subject to constant fracturing and reshaping by needle ice…The rats must utilize natural crevices and form burrow systems and extensive runways throughout the friable humus. Alpine bogs are common on at least the western slopes of Mt. Giluwe and thus much of the soil is continuously waterlogged." *Rattus giluwensis* occurs in a similar ecological context in upland grasslands in the Kaijende Highlands.

Rattus niobe Thomas, 1906 (Moss-Forest Rat)
Current taxonomic interpretations of *Rattus niobe* (Musser and Carleton 2005, Helgen 2007b) restrict its occurrence to the eastern half of the New Guinean central cordillera. Even with the taxonomic exclusion of a number of former synonyms (Musser and Carleton 2005, Helgen 2007b), the taxonomy of *Rattus niobe* is highly problematic and it probably incorporates multiple species that may be widely sympatric in the mountains of Papua New Guinea. With this caveat, I have tentatively identified the most common murine collected at Lake Tawa and in the Porgera area as *Rattus niobe*. This small (adult specimens from Lake Tawa weighed 40–50 g), largely terrestrial rat was trapped at all trapping stations during the survey (see "Study site", above). Detailed study of the comparative anatomy and genetics of trapped specimens will be needed to evaluate the tentative hypothesis that all specimens from the 2005 RAP survey represent a single biological species.

Uromys anak Thomas, 1907 (Black-Tailed Giant-Rat)
This large scansorial rodent is often common in forested areas above 2,000 m elevation throughout the central cordillera and on the Huon Peninsula (Groves and Flannery 1994), and extends as low as 850 m in some areas. No other *Uromys* occurs above 1,900 m in New Guinea. At Lake Tawa one of our local assistants found a skull of this species,

complete with mandible, on the ground. The skull exhibited braincase damage consistent with a raptor kill. Along the Paiela Road I also trapped an immature male (300 g) *Uromys anak* in a cage trap that was set overnight beside a stream and baited with fruit, lunchmeat, and bread. The Ibile names *Maiyanke* and *Poko* are applied to this species. The Beehler name *Kojo* is sometimes applied to this species.

A new genus and species of murine rodent

Two specimens of an unnamed genus and species of rodent were collected at 2,650 m elevation at Porgera by P. Woolley in May 1985. It is a small (30 g), chestnut-brown terrestrial "moss-mouse." The Kaijende specimens were identified as "*Pseudohydromys occidentalis*" by Jackson and Woolley (1993) and were deposited at WAM and PNGNM. Their taxonomic status was discussed in detail by Helgen (2007a). An unnamed congener occurs further to the west in the Star Mountains of West Sepik and Western Provinces. The Porgera taxon was not encountered during our 2005 survey of the Kaijende Highlands but, like its congener from the Star Mountains, it probably occurs in upper montane forest and along the alpine grassland-forest ecotone (Helgen 2007b). This new taxon is the only mammal species currently known only from the Kaijende Highlands. I will formally describe it in a forthcoming paper.

Order Chiroptera, Family Pteropodidae (Fruit-Bats)

Syconycteris australis (Peters, 1867) (Common Blossom-Bat)

This small pteropodid bat is the most commonly mist-netted bat in New Guinea and is found across the island from sea level to 3,000 m elevation. Five adults were collected during mist-netting in forest at Lake Tawa (forearms 41–43 mm, mass 13–17.5 g). Two of three adult females, collected on 30 and 31 August 2005, were pregnant. Fetal crown-rump lengths were 17 and 10 mm, respectively. The wing membranes of one individual were marked with de-pigmented spots in a left-right symmetrical arrangement, a trait not previously reported for *S. australis* (Lawrence 1991, Bonnacorso 1998).

As far as I am aware, these are the first records of *Syconycteris* in Enga Province (cf. Lawrence 1991, Bonnacorso 1998). No other bats were collected in six nights of mist-netting at Lake Tawa. Small bats, including both small pteropodids (such as *Syconycteris*) and insectivorous bats ("Microchiroptera"), are apparently referred to as *Apaiyake* in the Ibile language.

Order Chiroptera, Family Vespertilionidae (Evening Bats)

Miniopterus schreibersii (Kuhl, 1819) (Common Bentwing-Bat)

We did not document the occurrence of any vespertilionid bats in the Kaijende Highlands during our survey. The only record from the province appears to be Bonaccorso's (1998) report of *Miniopterus schreibersii* from Mt. Leiwaro (5°33'S, 143°14'E), a locality that lies in, or in close proximity to, the Kaijende Highlands. I am unfamiliar with the voucher material on which this record is based but I presume that it is deposited at PNGNM. *Miniopterus schreibersii* has a broad altitudinal distribution in New Guinea (sea level to at least 2,900 m) and a wide global geographic distribution, occurring (as currently understood) in Africa, Eurasia, the Malay Archipelago, and Oceania (Simmons 2005).

Order Chiroptera, Family Molossidae (Free-Tailed Bats)

? Tadarida kuboriensis McKean and Calaby, 1968 (New Guinea Mastiff-Bat)

This molossid bat is found only in forested habitats along the central cordillera of New Guinea, where it has been recorded from six scattered localities at elevations between 1,900 and 2,950 m (Flannery 1995, Bonaccorso 1998). During our survey, unidentified bats which I took to be molossids were observed hawking insects around several security lights in alpine grassland at the Porgera Reservoir (~3,100 m elevation). Harp trapping at this site (two nights) was unsuccessful so the bats' identity remains to be verified. This population can probably be sampled from this exact location in the future. Because it is the only New Guinean molossid known to occur above 2,000 m, I tentatively attribute the record to *Tadarida kuboriensis*.

Order Carnivora, Family Canidae (Dogs)

Canis (lupus) familiaris Linnaeus, 1758 (New Guinea Singing Dog)

Dogs are represented in New Guinea both by domesticated village dogs, commonly used for hunting throughout the island, and by distinctive highland populations of feral dogs referred to as "New Guinea Singing Dogs". Wild-living dogs have probably been present in New Guinea for only about 3,000 years (Hope 1981). As I note in a forthcoming review (Helgen 2007b), "singing dog" populations are biologically interesting and deserve continued ecological study, but neither molecular (e.g., Leonard et al. 2002) nor morphological evidence (particularly in light of the morphological plasticity of the domesticated dog) support the explicit taxonomic claim that these dogs represent a distinct canid species ("*Canis hallstromi*"), as some have recently argued (see Koler-Matznick et al. 2003).

New Guinea Singing Dogs were present, though fleeting from sight, at Lake Tawa. At least one animal was seen by one of our local guides, who scavenged a freshly-killed *Dorcopsulus* wallaby from it for our scientific collection. We also collected singing dog scat samples for potential future dietary and genetic analyses. Our local assistants assured us that the dogs at Lake Tawa were truly wild-living dogs, and there were no villages near our relatively remote camp.

Order Artiodactyla, Family Suidae (Pigs)

Sus scrofa Linnaeus, 1758 (Feral Pig)

Pigs occur as both domesticated and wild-living (feral) populations throughout the island of New Guinea (Hide 2004). They were apparently introduced to New Guinea by humans several thousand years ago (Flannery 1995). Bones and teeth of pigs were found in the forest near Lake Tawa,

and free-ranging domesticated pigs were common in and around Porgera.

DISCUSSION

Notes on Inventory Completeness

On the basis of their recorded global geographic distributions and ecological requirements (Menzies 1991, Flannery 1995, Bonaccorso 1998, Helgen 2007a, 2007b), it is estimated that an additional 4–6 marsupial species, 12–16 rodent species, and 10–13 bat species are likely to occur in the Kaijende Highlands, an indication that efforts aimed at inventorying mammals in the area are far from complete.

Inventory completeness: Marsupials

I have demonstrated that at least 19 species of marsupials occur in the Kaijende Highlands at and above 2,200 m. At least four additional marsupials are expected to occur in the Kaijende Highlands, including three small dasyurids (*Murexia wilhelmina, Murexia naso, Phascolosorex brevicaudata*; see Helgen 2007b for taxonomy) and one ringtail possum (pseudocheirid) — the 'Plush-Coated Ringtail`, *Pseudochirops corinnae*. All four of these species are widespread in montane forests at and above 2,200 m in the central cordillera, extending at least from the vicinity of Wau (PNG) in the east to the Snow and Weyland Mountains in the west (Flannery 1995, Helgen 2007a, 2007b). These taxa are most commonly encountered in undisturbed montane forests. There is no reason to anticipate their absence from the Kaijende fauna. Instead, failure to detect the three dasyurid species in the area can probably be attributed to insufficient trapping efforts at Lake Tawa — I suggest that more extensive trapping and use of pitfall traps would probably record their presence. It is also highly likely that a greater emphasis on hunting, particularly at night, would record the presence of *Pseudochirops corinnae* at Lake Tawa. Collection of larger series of trophy mandibles from communities around Porgera might show that it also persists in that area.

Populations of two other marsupial species in particular might be expected in the Kaijende Highlands — Stein's Cuscus (*Phalanger vestitus*) and the Common Striped Possum (*Dactylopsila trivirgata*). Both of these taxa are widespread in the central cordillera of New Guinea and their altitudinal distribution extends above 2,000 m (Flannery 1995). However *P. vestitus* appears to be patchily distributed throughout the cordillera, being common in some areas and absent or extremely uncommon in others (Flannery 1994, 1995; Menzies and Pernetta 1986, Menzies 1991, Helgen 2007b). This phenomenon is not well-understood, but Flannery (1995) indicated that the species may be largely restricted to primary montane oak forests at middle altitudes (1,200 to 2,200 m). *Dactylopsila trivirgata* has been recorded in central cordilleran montane forests at elevations as high as 2,400 m; however, it may not occur in the immediate vicinity of our survey sites because it is more typically encountered in forests below 2,000 m (Helgen 2007b).

Inventory completeness: Rodents

I have confirmed that at least 12 species of rodents occur in the Kaijende Highlands at and above 2,200 m asl. At least 12 additional terrestrial and scansorial rodent species (*Abeomelomys sevia, Anisomys imitator, Hyomys goliath, Mallomys aroaensis, Mallomys rothschildi, Lorentzimys nouhuysi, Paramelomys mollis, Melomys rufescens, Pogonomys loriae, Pogonomys sylvestris, Rattus steini,* and *Rattus verecundus*) almost certainly occur in the Kaijende Highlands. All of these taxa occur at elevations above 2,000 m throughout much of the length of the New Guinean central cordillera, both to the east and west of Enga Province. At least three of these species (*Mallomys rothschildi, Pogonomys loriae,* and *Pogonomys sylvestris*) have been recorded from elsewhere in the province (see Introduction). It is highly likely that one additional amphibious rat (*Baiyankamys shawmayeri*), one or two additional species of moss-mice (*Pseudohydromys* spp.), and a terrestrial hydromyin species of *Paraleptomys* or *Leptomys* occur in the area. The latter taxa are two ecomorphologically similar genera that replace one another along the central cordillera from west to east, respectively, somewhere between Telefomin and Mt. Karimui (Helgen 2005b, 2007a; Musser et al. 2007).

During the 2005 RAP I trapped rodents for only a few days at each site. Failure to record most if not all of these 12–16 species in the Kaijende Highlands probably reflects insufficient trapping efforts and the difficulty of obtaining unambiguous identifications of these morphologically similar taxa from local informants in the absence of voucher material. This was compounded by the fact that I was unable to hunt animals at night in montane forests and as a result failed to secure vouchers of large nocturnal rats like *Mallomys* and *Hyomys*). Future efforts aimed at surveying the rodent fauna of Enga Province's montane forests should ideally include both longer-term removal trapping (with snap traps and/or Sherman/Elliott traps) and pitfall trapping. In addition, focused collection of trophy jaws from other communities around Porgera would probably yield osteological material of larger rats (*Anisomys imitator, Hyomys goliath, Mallomys aroaensis,* and *Mallomys rothschildi*) because these species are large enough to be targeted as food items and their incisors are used for carving in many areas of New Guinea.

Inventory completeness: Bats

In New Guinea bats are most diverse and most abundant in tropical lowland rainforest and species richness decreases precipitously above 1,000 m elevation (Helgen 2007b). Chiropteran faunas in high montane forests (above 2,000 m) are especially depauperate. Two of New Guinea's six families of bats (Emballonuridae and Rhinolophidae) are not known to occur above 2,000 m on the island, and the remaining families (Pteropodidae, Hipposideridae, Vespertilionidae,

and Molossidae) are represented above this elevation only by a relatively small number of species (five, one, eight, and one respectively). Thus it was not entirely surprising to record only two species of bats in the Kaijende Highlands where all of our survey effort took place above 2,100 m. However, despite the depauperate fauna expected at these altitudes the actual chiropteran component of the Kaijende mammal fauna is undoubtedly larger than we documented, and our failure to mist-net or harp-trap certain expected species is puzzling. An additional 10–13 additional species of bats may occur in the area and these can be divided into four categories.

First, seven bat species that are widespread in New Guinea's lowland forests (*Dobsonia moluccensis, Miniopterus macrocneme, Miniopterus schreibersii, Murina florium, Nyctophilus microtis, Philetor brachypterus,* and *Pipistrellus angulatus*) extend regularly or occasionally to altitudes above 2,000 m, and should be expected in the Kaijende area between 2,000 and 2,800 m, especially in areas with caves. At Lake Tawa I searched intensively in *Pandanus* holes and hollows and in hanging vegetation for forest-tree roosters such as *Murina florium* (or molossid bats), without success.

Second, several bat species which are montane specialists (*Nyctimene cyclotis* [including *N. certans*], *Syconycteris hobbit,* and *Pipistrellus collinus*) are widespread along the central cordillera and should occur in montane forests in the Kaijende Highlands up to elevations of 2,800–3,000 m. All three of these species are apparently rather easily caught in mist-nets in areas where they are common, so their absence from our sampling at Lake Tawa is interesting.

Third, two additional montane endemics (*Hipposideros corynophyllus,* recorded only from the Snow and Star Mountains, and *Nyctophilus microdon* known from the nearby Eastern Highlands, Chimbu, Western Highlands, and Southern Highlands Provinces of PNG) could occur in the mountains of Enga Province as well.

Fourth and finally, the rare Bulmer's Fruit-bat, *Aproteles bulmerae*, apparently an obligate cave rooster, might occur in caves in the Kaijende Highlands. This little-known species (classified in a monotypic genus) was initially described by Menzies (1977) based on Late Pleistocene fossil material from Mt. Elimbari in Chimbu Province. The only known modern specimens have originated from montane sites in Western, Eastern Highlands, and Chimbu Provinces (reviewed by Flannery (1995) and Bonaccorso (1998)). This Critically Endangered species apparently occupies caves only in areas with low human disturbance, and may well occur in remote caves in Enga Province. If present in the Kaijende Highlands, it would deserve a great deal of conservation attention including strict protection of animals and roosting sites.

Future efforts to more intensively survey the Kaijende Highlands chiropteran fauna should ideally focus on locating caves and sampling bats at cave roosts to document the presence of *Miniopterus* spp., *Dobsonia moluccensis*, or even *Aproteles*. Focused collection of trophy jaws from more local communities in the vicinity of Porgera could yield osteological material of *Dobsonia moluccensis,* a large bat often commonly hunted where it occurs, or even *Aproteles* if it survives in the Kaijende Highlands.

CONSERVATION RECOMMENDATIONS

The 2005 Kaijende Highlands RAP has dramatically increased our knowledge of the mammal fauna of Enga Province, raising the number of species documented in the province from 18 to 39 and recording a number of rare and threatened mammals.

While much has been learned, our knowledge of the Kaijende mammal fauna nevertheless remains relatively slim. If mammalogical research in the Kaijende Highlands continues in collaboration between PJV and Conservation International, I would recommend that it be focused along two particular paths. First, basic biodiversity surveys, such as the survey work discussed herein, should continue, incorporating more sites and additional habitats. It has been suggested above that all previous mammalogical research in Enga Province, including the 2005 RAP, has probably documented less than 50% of the actual Kaijende Highlands mammal fauna. Further surveys will undoubtedly record additional species in the area, potentially including species of conservation concern and focus such as the Critically Endangered Bulmer's Fruit-Bat (*Aproteles bulmerae*). Additional basic survey work will certainly add to our knowledge of what species occur in the region and, if focused on new sites and habitats, will also begin to illuminate a more detailed picture of the distribution and abundance of individual species (and habitat-associated species assemblages), including those taxa of special interest to conservation efforts (see below). Secondly, more tightly targeted ecological studies are needed to assess in greater detail the distribution, abundance, and threats faced by certain "focal species" in the region. In particular, two groupings of mammals in the Kaijende Highlands can be singled out for their conservation importance.

The first group consists of the larger terrestrial mammals of the region, particularly macropodids and echidnas, which are often targets of concerted hunting pressure. Wallabies, tree-kangaroos, and echidnas have disappeared from most areas with high human population density and high hunting pressure throughout New Guinea (Bulmer and Menzies 1972; George 1978; Flannery 1992, 1995; Flannery and Groves 1998; Martin 2005). The fact that *Zaglossus* and at least three different kangaroo species (*Dendrolagus dorianus, Dorcopsulus vanheurni,* and *Thylogale calabyi*), all good proxy taxa for understanding hunting pressure, still persist in the vicinity of Porgera is a good sign that hunting has not yet resulted in mammal extirpations in the area. On the other hand, the only reason we know that two of these four species occur at Porgera is because they are represented in trophy jaw collections held by local hunters, demonstrating that there is at least some hunting pressure on these animals.

Indeed, the major result of our RAP survey has been to improve our understanding of what species definitely occur in the Kaijende Highlands. Apart from predictable elevational associations, no detailed information is yet available regarding the true extent of their abundance, threats, or microdistribution in the region, as potentially influenced by habitat availability and hunting. These are important topics for further study, particularly in the case of echidnas and kangaroos. Attempts to map the occurrence and estimate the abundance of these focal taxa in the vicinity of Porgera would require the assistance and knowledge of local communities, and might prove to be a straightforward and manageable project, perhaps one that can be undertaken by a sponsored student or a PJV Environmental Officer.

A second group of focal taxa is an assemblage of rare, threatened, and/or range-restricted species found within the Kaijende Highlands area only in high-altitude habitats such as tree fern savanna, tussock grassland, and adjacent upper montane (elfin) forests. This group of species partially overlaps with the last; it includes the Eastern Long-Beaked Echidna (*Zaglossus bartoni*), Calaby's Pademelon (*Thylogale calabyi*), the Giluwe Rat (*Rattus giluwensis*), the Subalpine Giant-Rat (*Mallomys istapantap*), an unnamed species of bandicoot (*Microperoryctes* sp.), and the unnamed genus and species of rodent discussed above. The last species is the only mammal currently thought to be endemic to the Kaijende Highlands, although many of the other species occur in only a few other subalpine and alpine landscapes in New Guinea.

The concentration of mammal species associated with alpine and subalpine habitats suggests that the expansive *Cyathea* tree fern savannas and tussock grasslands of the Kaijende Highlands have a long history as natural formations, even if they are facilitated in part by anthropogenic impacts today (Walker and Flenley 1979; see Takeuchi, this volume). Because of the unique fauna they support, these habitats are of profound conservation value. The area of extent and environmental quality of these open alpine habitats and the status of the mammals they support are prime subjects for a long-term monitoring study.

Many mammal species in the Kaijende Highlands are clearly valued by local Enga communities as entities with both practical (i.e. as sources of food, hides, and bone tools) and/or spiritual value (i.e. as prestige trophies, totems, and characters in traditional belief systems). New Guinean communities often provide a great deal of important knowledge (both traditionally inherited and personally acquired) to visiting biologists, regarding the basic biology and local use of fauna and flora. Their often intricate knowledge of wildlife and wildlife habitats attests to the importance of this biota in the daily lives of local people. However, New Guinean villagers are often unaware of the distribution or importance of individual species outside of this local context. As scientists, we can complement the natural history knowledge and assistance of local communities by illuminating the importance of familiar natural elements in a wider perspective—perspective gained by systematic study of fauna and flora from many other localities and of museum specimens from many different areas. I suspect that many villagers would be glad to learn, for example, that the Kaijende Highlands are one of only three or four areas where a rare species of kangaroo (*Thylogale calabyi*) can be found, and one of only two areas where a rodent that is a common and easily recognizable animal in the Kaijende Highlands (*Rattus giluwensis*) is known to occur. It may also be valuable for local communities to learn that unsustainable hunting in many other areas of Papua New Guinea has resulted in the local loss of important mammals such as echidnas and tree kangaroos. Armed with this greater perspective regarding the comparative importance of Kaijende species and habitats, it is possible that greater value might be attached to these and other animals, even beyond the traditional economic and spiritual importance that may be imparted to them. Thus, providing local communities with information about the basic natural history of local mammals could be one of the most important steps that might be taken toward the long-term conservation of larger, rarer, or geographically restricted mammals in the region. PJV and Conservation International would be well-advised to commission and disseminate posters, fact sheets, and/or small field guides that illustrate local wildlife, discuss its significance to local communities, and emphasize such concepts as rarity and sustainable hunting. The impact and educational value of such postings and publications could be vastly increased by including relevant text in Tok Pisin, English, and Ibile or other appropriate local languages. This is one positive step for environmental management and community outreach that is not incumbent on additional, extensive background research.

Apart from such environmental outreach initiatives, few concrete steps can be taken with regard to conservation, management, and/or protection of native mammals in the vicinity of Porgera, without a better understanding of their distribution, abundance, and threats that they face. Only once data from broader survey efforts and more focused research on individual focal species are available can more specific recommendations for conservation and management be made. Research on biodiversity conservation in the Kaijende Highlands has just begun.

REFERENCES

American Society of Mammalogists. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. J. Mammal. 79: 1416–1431.

Aplin, K. P. 1998. Vertebrate zoogeography of the Bird's Head of Irian Jaya, Indonesia. *In*: Miedema, J., C. Odé, and R. A. C. Dam (eds.). Perspectives on the Bird's Head of Irian Jaya, Indonesia. Amsterdam: Rodopi. Pp. 803–890.

Aplin, K. P., J. M. Pasveer and W. E. Boles. 1999. Late Quaternary vertebrates from the Bird's Head Peninsula, Irian

Jaya, Indonesia, including descriptions of two previously unknown marsupial species. Rec. West. Aust. Mus. Suppl. 57: 351–387.

Beehler, B. M., T. K. Pratt and D. A. Zimmermann. 1986. Birds of New Guinea. Princeton University Press. Princeton, New Jersey.

Bonaccorso, F. J. 1998. Bats of Papua New Guinea. Conservation International Tropical Field Guide Series, Conservation International. Washington, D.C.

Bowyer, J. C., G. R. Newell, C. J. Metcalfe and M. B. D. Eldridge. 2003. Tree-kangaroos *Dendrolagus* in Australia: are *D. lumholtzi* and *D. bennettianus* sister taxa? Aust. Zool. 32: 207–213.

Brass, L. J. 1964. Results of the Archbold Expeditions. No. 86. Summary of the Sixth Archbold Expedition to New Guinea (1959). Bull. Amer. Mus. Nat. Hist. 127: 145–215.

Bulmer, R. H. and J. I. Menzies. 1972. Karam classification of marsupials and rodents. J. Polynesian Soc. 81: 472–499.

Cole, R. E., A. Engilis, Jr. and F. J. Radovsky. 1997. Report on mammals collected during the Bishop Museum Expedition to Mt. Dayman, Milne Bay Province, Papua New Guinea. Bishop Mus. Occas. Pap. 51: 1–36.

Flannery, T. F. 1992. Taxonomic revision of the *Thylogale brunii* complex (Macropodidae: Marsupialia) in Melanesia, with description of a new species. Aust. Mammal. 15: 7–23.

Flannery, T. F. 1994. Possums of the world: a monograph of the Phalangeroidea. GEO Productions. Sydney.

Flannery, T. F. 1995. Mammals of New Guinea. Revised edition. Reed Books. Chatswood, New South Wales.

Flannery, T. F. 1999. The Pleistocene mammal fauna of Kelangurr Cave, central montane Irian Jaya, Indonesia. Rec. West. Aust. Mus. Suppl. 57: 341–350.

Flannery, T. F., K. P. Aplin, C. P. Groves and M. Adams. 1989. Revision of the New Guinean genus *Mallomys* (Muridae: Rodentia), with descriptions of two new species from subalpine habitats. Rec. Aust. Mus. 41: 83–105.

Flannery, T. F., and C. P. Groves. 1998. A revision of the genus *Zaglossus* (Monotremata, Tachyglossidae), with description of new species and subspecies. Mammalia 62: 367–396.

Flannery, T. F., R. Martin and A. Szalay. 1996. Tree kangaroos: a curious natural history. Reed Books. Melbourne.

Flannery, T. F. and L. Seri. 1990. The mammals of southern West Sepik Province, Papua New Guinea: their distribution, abundance, human use, and zoogeography. Rec. Aust. Mus. 42: 173–208.

George, G. G. 1978. The status of endangered Papua New Guinea mammals. *In*: Tyler, M. J. (ed.). The status of endangered Australasian wildlife. Adelaide: Royal Zoological Society of South Australia. Pp. 93–100.

Groves, C. P. and T. F. Flannery. 1994. A revision of the genus *Uromys* Peters, 1867 (Muridae: Mammalia) with descriptions of two new species. Rec. Aust. Mus. 46: 145–169.

Grubb, P. J. and P. F. Stevens. 1985. The forests of the Fatima Basin and Mt. Kerigomna, Papua New Guinea, with a review of montane and subalpine rainforests in Papuasia. Australian National University. Canberra.

Helgen, K. M. 2005a. A new species of murid rodent (genus *Mayermys*) from south-eastern New Guinea. Mamm. Biol. 70: 61–67.

Helgen, K. M. 2005b. The amphibious murines of New Guinea (Rodentia, Muridae): the generic status of *Baiyankamys* and description of a new species of *Hydromys*. Zootaxa 913: 1–20.

Helgen, K. M. 2007a. A reassessment of taxonomic diversity and geographic patterning in the Melanesian mammal fauna. Ph.D. thesis. Adelaide: University of Adelaide.

Helgen, K. M. 2007b. A taxonomic and geographic overview of the mammals of Papua. *In*: Marshall, A. J., and B. Beehler (eds.). The ecology of Papua (Ecology of Indonesia series Volume VI). Singapore: Periplus Editions. Pp. 689–749.

Helgen, K. M. and T. F. Flannery. 2004. A new species of bandicoot, *Microperoryctes aplini*, from western New Guinea. J. Zool. (London) 264: 117–124.

Hide, R. 2004. Pig husbandry in New Guinea: a literature review and bibliography. Australian Centre for Agricultural Research. Canberra.

Hide, R. L., J. C. Pernetta and T. Senabe. 1984. Exploitation of wild animals. *In*: Hide, R. L. (ed.). Studies in demography, nutrition, and subsistence (Research Department 6 Simbu Land Use Project). Port Moresby, Papua New Guinea; Institute of Applied Social and Economic Research. Pp. 291–380.

Hope, J. H. 1981. A new species of *Thylogale* (Marsupialia: Macropodidae) from Mapala rock shelter, Jaya (Carstenz) Mountains, Irian Jaya (Western New Guinea), Indonesia. Rec. Aust. Mus. 33: 368–387.

Hyndman, D. C. and J. I. Menzies. 1990. Rain forests of the Ok Tedi headwaters, New Guinea: an ecological analysis. J. Biogeogr. 17: 241–273.

Jackson, K. L. and P. A. Woolley. 1993. The diet of five species of New Guinean rodents. Science in New Guinea 19: 77–86.

Koler-Matznick, J., I. L. Brisbin Jr., M. Feinstein and S. Bulmer. 2003. An updated description of the New Guinea singing dog (*Canis hallstromi*, Troughton 1957). J. Zool. (London) 261: 109–118.

Krajewski, C., S. Wroe and M. Westerman. 2000. Molecular evidence for the timing of cladogenesis in dasyurid marsupials. Zool. J. Linn. Soc. 130: 375–404.

Laurie, E. M. O. 1952. Mammals collected by Mr. Shaw Mayer in New Guinea, 1932–1949. Bull. Brit. Mus. (Nat. Hist.) 1: 271–318.

Lawrence, M. A. 1991. Biological observations on a collection of New Guinea *Syconycteris australis* (Chiroptera:

Pteropodidae) in the American Museum of Natural History. American Museum Novitates, Number 3024.
Leary, T. and L. Seri. 1997. An annotated checklist of mammals recorded in the Kikori River Basin, Papua New Guinea. Science in New Guinea 23: 79–100.
Leonard, J. A., R. K. Wayne, J. Wheeler, R. Valadez, S. Guillen and C. Vila. 2002. Ancient DNA evidence for Old World origin of New World dogs. Science 298: 1613–1616.
Lidicker, W. Z., Jr. and A. C. Ziegler. 1968. Report on a collection of mammals from eastern New Guinea, including species keys for fourteen genera. Univ. California Publ. Zool. 87: 1–60.
Martin, R. 2005. Tree-kangaroos of Australia and New Guinea. CSIRO Publishing. Collingwood, Victoria.
Menzies, J. I. 1977. Fossil and subfossil fruit-bats from the mountains of New Guinea. Aust. J. Zool. 25: 329–336.
Menzies, J. I. 1991. A handbook of New Guinea marsupials and monotremes. Kirsten Press. Madang, Papua New Guinea.
Menzies, J. I. 1996. A systematic revision of *Melomys* (Rodentia: Muridae) of New Guinea. Aust. J. Zool. 44: 367– 426.
Menzies, J. I. and E. Dennis. 1979. Handbook of New Guinea Rodents. Wau, Papua New Guinea. Wau Ecology Institute.
Menzies, J. I. and J. C. Pernetta. 1986. A taxonomic revision of cuscuses allied to *Phalanger orientalis* (Marsupialia: Phalangeridae). J. Zool. (London) ser. B, 1: 551–618.
Morren, G. E. B., Jr. 1989. Mammals of the East Miyanmin area, Telefomin District, Papua New Guinea, with notes on folk knowledge and taxonomy. Science in New Guinea 15: 119–135.
Musser, G. G. and M. D. Carleton. 2005. Family Muridae. *In*: Wilson, D. E., and D. M. Reeder (eds.). Mammal species of the world: a taxonomic and geographic reference. Third Edition. Baltimore, Maryland: Johns Hopkins University Press. Pp. 894–1531.
Musser, G. G., K. M. Helgen and D. P. Lunde. 2007. New Guinea rodents (Muridae, Murinae): systematic review of *Leptomys* with descriptions of two new species. American Museum Novitates in press.
Simmons, N. B. 2005. Order Chiroptera. *In*: Wilson, D. E., and D. M. Reeder (eds.). Mammal species of the world: a taxonomic and geographic reference. Third Edition. Baltimore, Maryland: Johns Hopkins University Press. Pp. 312–529.
Taylor, J. M., J. H. Calaby and H. M. Van Deusen. 1982. A revision of the genus *Rattus* (Rodentia, Muridae) in the New Guinean region. Bull. Amer. Mus. Nat. Hist. 173: 177–336.
Thomas, O. 1907. On three new mammals from British New Guinea. Ann. Mag. Nat. Hist. (ser. 7) 20: 70–74.
Van Dyck, S. 2002. Morphology-based revision of *Murexia* and *Antechinus* (Marsupialia: Dasyuridae). Mem. Qld. Mus. 48: 239–330.
Walker, D. and J. R. Flenley. 1979. Late Quaternary vegetational history of the Enga Province of upland Papua New Guinea. *Phil. Trans. R. Soc. Lond. Ser. B, Biol. Sci.* 286: 265–344.
Woolley, P. A. 1989. Nest location by spool-and-line tracking of dasyurid marsupials in New Guinea. J. Zool. (London) 218: 689–700.
Woolley, P. A., S. A. Raftopolous, G. J. Coleman and S. M. Armstrong. 1991. A comparative study of the circadian activity patterns of two New Guinean dasyurid marsupials, *Phascolosorex dorsalis* and *Antechinus habbema.* Aust. J. Zool. 39: 661–671.