Bats of the YUS Conservation Area, Papua New Guinea: Result 5 Task 3.2.

Carbon and climate field science associated with the YUS conservation area: YUS climate and biodiversity transect, elevational survey of the "micro-bat" fauna (Microchiroptera).

April 20, 2012

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April 20, 2012

i. Executive summary

This project provides the first description of bat community structure across a complete elevational gradient in Papua New Guinea (from sea-level to 3000m), assembles the largest reference collection of echolocation calls for Papua New Guinean bats (22 species, a valuable tool for species inventory work), and provides species accounts for all 22 microchiropteran (& 4 megachiropteran) bats captured in the YUS Conservation Area.

Microchiropteran bat communities vary across elevational gradients, with greatest species abundance at lowland sites, and greatest individual abundance at mid-altitude sites. Despite the reduction in species with increasing elevation there is still a significant number of potential high-altitude species (6) occurring at or above 3000m.

Acoustic monitoring techniques proved to be a cost and labour effective method of surveying bat communities, revealing twice the number of microbats with only one half the surveying effort of traditional capture techniques.

When implemented in concert, traditional survey techniques based on captures (using mist nets and harp traps) and more recently developed techniques (acoustic monitoring) significantly advance our understanding of the bat fauna of the YUS Conservation Area, the Huon Peninsula and Papua New Guinea, resulting in 22 new species-specific echolocation call types for YUS and the Huon Peninsula, 2 new species records for the Huon Peninsula and 5 elevational range extensions for Papua New Guinea. Species accumulation curves indicate that the total number of bat species detected in the YUS Conservation Area will increase with greater sampling effort.

Extensive baseline faunal surveys such as those conducted here provide critically important starting points for long term monitoring of community changes on a local, national and global scale. The reference collection of bat calls in concert with additional acoustic surveys provides a valuable opportunity for effective and efficient ongoing monitoring of bat communities in the region, and highlights the value of the YUS Conservation Area for answering questions of changes in community structure of a global significance.

Contents

1. Introduction & rationale

Large-scale studies of the composition of communities are becoming increasingly important for assessing the patterns and process underlying global changes in biological communities (Walther et al. (2002), Parmesan & Yohe (2003), Root et al. (2003), Dunn et al. (2009), Pounds et al. (2006)).

Studies of attitudinal patterns of community structure are particularly important for assessing the impacts of global changes such as climate change. The changes in community structure with altitude as a function of changing local environmental characteristics such as temperature and precipitation are thought to provide suitable predictive models for more widespread global environmental changes. Numerous taxa such as terrestrial insects (Hodkinson 2005), ants (Kaspari et al. 2004) and amphibians (Pounds et al.1999) have been examined in this context, but bats remain poorly represented despite their significant contribution to diversity (they comprise approx: 20% of all mammal species). In part, this reflects the difficulties of sampling small and cryptic nocturnal flying animals.

The island of Papua New Guinea contains a rich mammal fauna that itself comprises approximately 8% of the world's bat fauna (Bonaccorso 1998). With its diverse biological and geographical systems, Papua New Guinea represents an ideal environment in which to describe the relationships between bat community structure and altitude. Records of bats are typically nested within larger mammal fauna studies (e.g., Wright *et al*, (1998), Helgen (2007), Aplin and Opiang (2011) and although some recent bat surveys have targeted particular regions or locations (e.g., Muller Ranges, Western Highlands (Armstrong & Aplin 2011), western PNG (Leary & Pennay (2011) no study has as yet examined bat community structure across a complete elevational gradient from sea-level to the highest relevant elevation of the region.

The recent development of acoustic survey techniques for bats has significantly improved our ability to survey and monitor bat communities. Ultrasound recording methods such as that used by the AnaBat® system allow extremely efficient and often remote sensing of bat communities based on the detection of species or taxon-specific echolocation calls produced by foraging bats. Again, the bat fauna of PNG is ideally suited for implementing such an approach.

This report details **Result 5: Carbon and climate field science associated with the YUS conservation area, Task 3.2: YUS climate and biodiversity transect, elevational survey of the "micro-bat" (*Microchiropteran)* fauna**.

The project achieved the following outcomes:

- Provided the first descriptions of the community structure of bats in the Huon Peninsula and the first descriptions of how bat community structure varies across an elevational gradient in Papua New Guinea, using the YUS conservation area as a study system,
- Accumulated the largest reference collection of echolocation calls of microchiropterans of PNG and highlighting the role of acoustic monitoring as an additional and important survey technique for bats, &
- Provided species accounts of those bats detected in the YUS conservation area as a guide for future studies of bats in the region and in Papua New Guinea.

2. Methods

2.1 Survey effort

Bat presence and activity was monitored at 11 distinct elevations along the YUS transect, spanning from sea level to 3000m elevation, during two visits to the YUS transect in July 2010 and June/July 2011 (Figure 1). Together, these two trips represent a total of 240 and 103 trap and acoustic recording (AnaBat) nights respectively (Table 1).

Survey effort, and species accumulation, across elevations was estimated using the program EstimateS Version 8.2 (Colwell, 2006), a re-sampling program that provides diversity estimates and their confidence limits based on the sampling effort performed during the study.

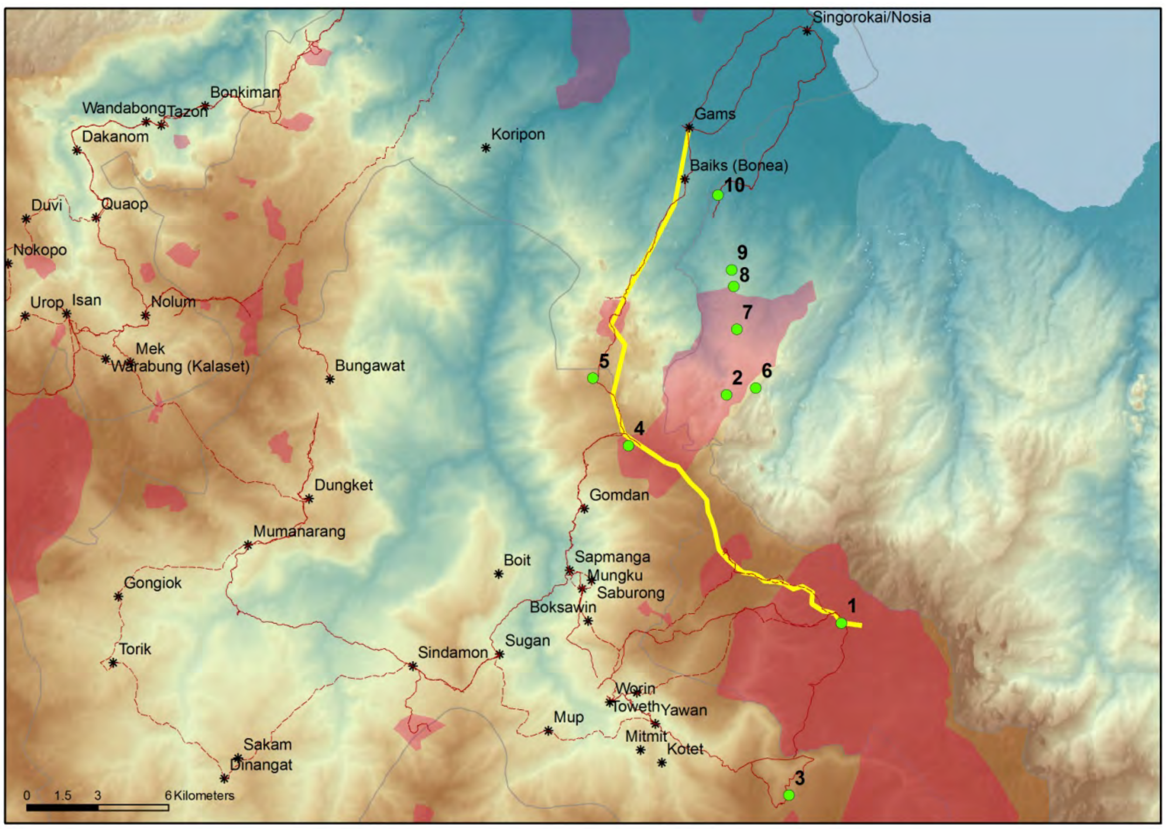
2.2 Acoustic monitoring

Data was collected using ultrasonic acoustic detectors (AnaBat SD1®, Titley Electronics, Ballina, Australia) and examined using AnalookW software (version 3.7w). Surveying was conducted for a period of four nights at elevations 2350m, 2050m, 1150m, 750m, and 350m, three nights at 1550m and 3000m, and one night each at 2800m, 2550m, 950m and sea level (Table 1).

Detectors were set to record passively from pre-dusk to post-dawn each night. Detectors were moved within the surveying area in order to maximise detection potential, and placed in areas most likely to obtain calls such as flyways or orientated towards open areas.

Calls were identified to species using reference calls collected during this survey (see Section 3.3 & 4). This involved determining whether the call was of constant frequency (flat calls with little variability in frequency) or frequency modulated (sloping calls often with high variability in frequency) type. The characteristic frequency, the flattest, and often longest part of each pulse, was then determined. Additional call characteristics, such as droops or up and down sweeps, which may be species specific, were also noted. Additional species were identified using other call libraries developed for Papua New Guinea (Armstrong and Aplin, 2011; Leary and Pennay, 2011). Calls that could not be confidently identified to species were assigned a code name detailing their shape (cf, fm or sfm) and characteristic frequency.

Figure 1. Survey sites within the YUS conservation area, Papua New Guinea



2.3 Monitoring via mist nests and harp traps

Mist nets and harp traps were used in addition to AnaBat ultrasound detectors. Four 5-bank harp traps and four mist nets were used at each elevation. Trapping was conducted in conjunction with passive recording. Traps were erected before dusk each night, and were left open for a minimum of five hours. Trap positions were moved every night in order to avoid any trapping bias from trap-familiar animals.

Table 1. Location, duration and type of bat sampling on the YUS transect

Start date	Camp	Lat.	Elev. (m)	# nights	# harp traps & nets	# Ana Bats	Total trap nights	Total AnaBat nights	# AnaBat files
22 June 2010	Wasaunon	-06.09530 146.91556	3000	3	8	2	24	6	730
25 June 2010	Camp 13 (YD)	-06.00788 146.87122	2800	1	8	2	8	2	77
28 June 2011	Plot Y3	-06.16436 146.89419	2550	1	8	1	8	1	0
22 June 2011	Camp 12	-06.02756 146.83376	2350	4	8	4	32	16	42
26 June 2011	Camp 11	-06.00138 146.82063	2050	4	8	4	32	16	439
02 June 2011	Sompom	-06.00505 146.88272	1550	3	8	4	24	12	317
05 July 2011	Camp 950m	-05.98282 146.87534	1150	4	8	4	32	16	825
09 July 2011	Camp 950m	-05.96624 146.87498	950	1	8	1	8	1	69
12 July 2011	Camp 950m	-05.95932 146.87431	750	4	8	4	32	16	1028
13 July 2011	Camp 6	-05.93076 146.86761	250	4	8	4	32	16	265
17 July 2011	Singorokai	-05.86768 146.91211	9	1	8	1	8	1	4
TOTAL			**11**	**30**	**88**	**31**	**240**	**103**	**3796**

Morphological parameters were taken in order to identify individuals to species. Data recorded included sex, reproductive condition, forearm (FA), ear (E), tail (TL) and tibia (TB) length, weight (W), the width between outer canine (OCW), and details of age (adult or juvenile) and reproductive condition. The most informative parameters (sex, age, forearm length, and weight) are presented in each species account. These have been compared with morphological measurement recorded by Flannery (1995) and Bonaccorso (1998).

Reference calls were recorded for each microchiropteran species using the methods described in Section 3.2, and are presented in the relevant species accounts. Copies of AnaBat calls can be obtained from Simon.Robson@jcu.edu.au.

3. Outcomes

3.1 Microbats of the YUS Conservation Area

A total of 11 microbat species from 5 microchiropteran subfamilies were captured and identified during this study (Table 2). When compared to predicted bat presence based on the details provided by Flannery (1996) and Bonaccorso (1998), these captures represent at least 50% of the microchiropteran species likely to be present. However it is worth noting that this study also detected another potential 11 species based on unique echolocation calls (se Section 3.3 & 3.4). If these currently unidentified species are already represented in the lists provided by previous studies of PNG bats, then the total number of species detected in this study (22) exceeds the total predicted species pool.

An additional four species of megabat (58 individuals) were also captured during the survey. Species accounts of these species can be found in Appendix 1.

Examination of the species accumulation curves of microchiroptera sampled using both capture and acoustic recording techniques suggest that further sampling will be rewarded with the detection of more species. The species accumulation curve (Figure 2) has yet to reach an asymptote and hence the current best estimate of the number of 21$\pm$ 5 species (mean + 95% confidence limits) is likely to be an underestimate of total species numbers.

3.2 Elevational patterns in microbat assemblages of the YUS Conservation Area

The relationship between the number of microchiropteran individuals captured and altitude is shown in Figure 4. The highest abundance of individuals occurs at mid-altitude sites (1150 m), which is surprising given the highest species abundance at lower-elevation sites and the strong relationship typically found between species and individual abundance.

It should also be noted that the patterns of species and individual abundance shown here may reflect some inequalities in the sampling effort across the entire elevational gradient. The 900m site for example, stands out as having very low numbers of species and individuals when compared to neighbouring elevations (Fig. 3, 4) but unfortunately the sampling effort at this site was much lower than at its neighbours (Table 1).

Table 2. Microchiropteran species predicted to be within the YUS.

Family	Genus species	Common name	Flannery (1996)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
Emballonuridae	*Emballonura beccarii*	Beccari's Sheath- tailed bat	x	x		
	Emballonura nigrescens	Lesser Sheath- tailed bat	x			
	Saccolaimus spp.	Naked-rumped Sheath- tailed bat		x		
Molossidae	*Chaerephon jobensis*	Northern Mastiff bat	x	x		
	Mormopterus beccarii	Beccari's Mastiff bat	x	x		
	Otomops secundus	Mantled Mastiff bat	x			
Hipposideridae	*Aselliscus tricusidatus*	Trident Horseshoe bat			x	x
	Hipposideros ater	Dusky Horseshoe bat		x		
	Hipposideros calcaratus	Spurred Horseshoe bat	x	x	x	
	Hipposideros cervinus	Fawn Horseshoe bat	x	x	x	x
	Hipposideros diadema	Diadem Horseshoe bat	x	x		x
	Hipposideros maggietaylorae	Maggie Taylor's Horseshoe bat	x	x		x
	Hipposideros muscinu	Fly river Horseshoe bat	x			
	Hipposideros semoni	Greater wart-nosed Horseshoe bat		x		

Rhinolophidae	*Rhinolophus euryotis*	New Guinea Horseshoe bat	x	x	x	x
	Rhinolophus megaphyllus	Eastern Horseshoe bat	x	x		x
Vespertilionidae	*Kerivoula muscina*	Fly River Trumpet-eared bat				x
	Miniopterus	Little Bent-winged bat	x	x		
	Miniopterus australis	Small Melanesian Bent-winged bat		x		
	Miniopterus magnater	Western Bent-winged bat	x	x		
	Miniopterus medius	Javan Bent-winged		x		
	Miniopterus propitristis	Large Melanesian Bent-winged bat	x	x		
	Miniopterus schreibersii	Common Bent-winged bat	x	x		
	Murina florium	Insectivorous Tube-nose bat	x	x		x
	Myotis adversus	Large Footed Mouse-eared bat	x			
	Nyctophilus	Small Eared Nyctophilus		x	x	x
	Nyctophilus microtis	Greater Nyctophilus	x	x		
	Philetor brachypterus	Rohu's bat	x	x		
	Pipistrellus angulatus	New Guinea Pipistrelle		x		x
	Pipistrellus collinus	Mountain Pipistrelle	x	x		x
	Pipistrellus papuanus	Papuan Pipistrelle	x	x	x	
		TOTAL	**22**	**18**	**6**	**11**

Figure 2. The relationship between sampling effort and the estimated number of microchiropteran species at YUS

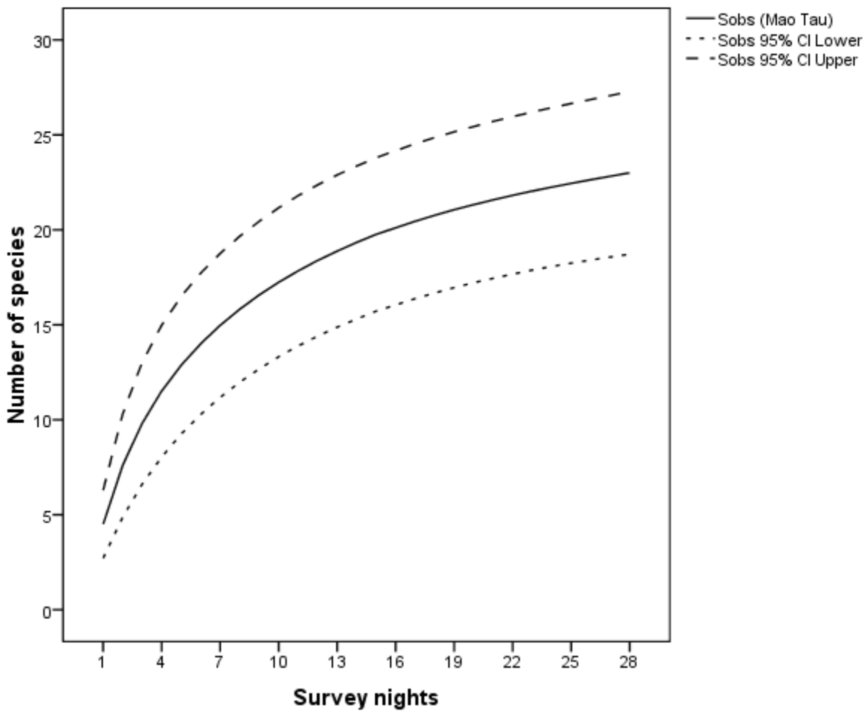


Figure 3. The relationship between the number of microchiropteran species and elevation at YUS

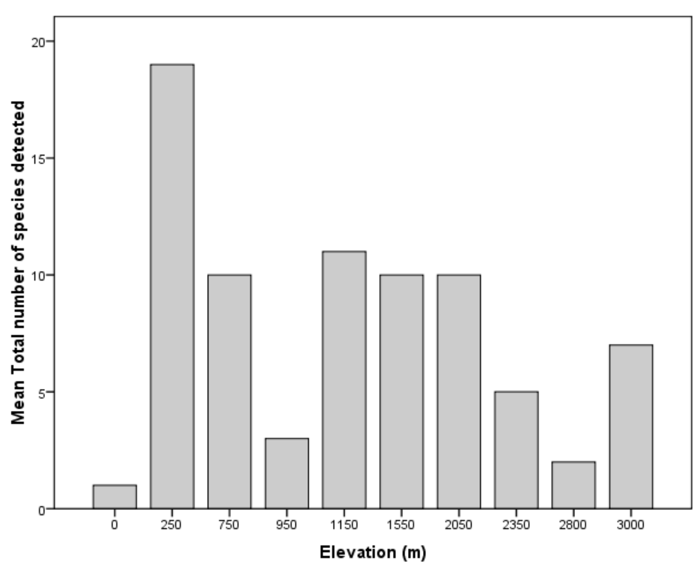
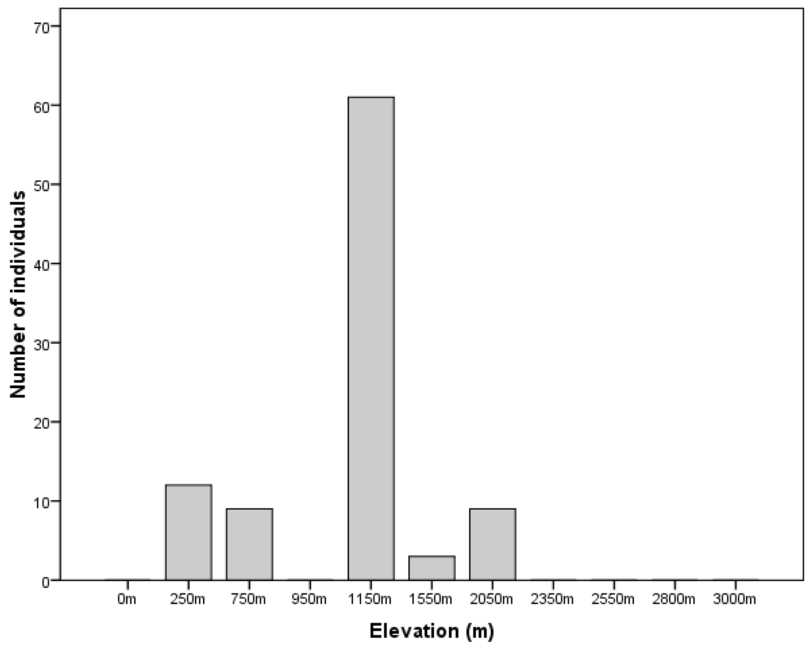


Figure 4. The total number of microchiropterans captured along the YUS transects



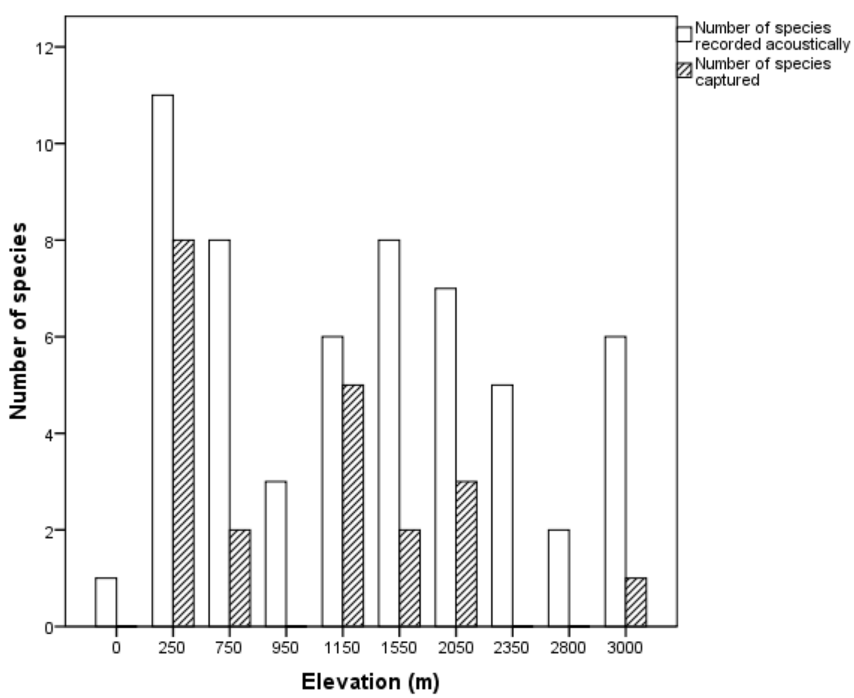
3.3 The role of acoustic monitoring in microbat surveys

Acoustic monitoring provides a valuable addition to the standard ‘capture method’ approach to surveying bats, providing evidence of a greater diversity of bats and over a greater elevational range than that provided by capture methods alone (Figure 5).

Traditional capture methods (harp traps and mist nets) captured a total of 96 individuals from 9 different species and 5 families (Figure 5). The majority of individuals were trapped at 1150m elevation (61 individuals) while the majority of species were caught around 250m (8 species). Acoustic monitoring techniques recorded 18, 254 sound files of which 3,792 contained bat calls. From these files 21 distinct bat species were recognised, of which 11 could be assigned to individual bat species from 5 families. The majority of individuals were detected at 1150m elevation, while the majority of species were detected at 250 m (11 species). Acoustic surveys therefore detected a greater number of microchiropteran species than traditional capture methods, even though the total number of acoustic-sampling nights was less than half that of the total number of capture nights (Table 1). And although both methods indicate higher numbers of species at lower elevations, acoustic methods are clearly more capable of detecting bats at higher elevations than capture methods alone (and with less sampling effort). The ability to accurately sample bats at higher elevations is particularly important, given that high altitude species are more likely to suffer the effects of rising temperature due to global climate warming. Capture techniques for example identified only 6 microchiropteran species at or above 1550 m, compared to 28 for acoustic methods.

The ability of acoustic surveys to quickly detect new species is also evident when comparing the two species accumulation curves for acoustic and capture surveys. Species accumulation curves are predicted to increase with greater sampling effort and currently predict a total number of microchiropteran species of 16 $\pm$ 7) (Figure 6). Species accumulation curves based on capture data only, while yet to asymptote, suggest a much lower total species number (8 $\pm$ 5) (Figure 7).

Figure 5 Comparisons of the number of bat species surveyed at each altitude, as a function of the survey method used (capture or acoustic).



The value of adding acoustic surveys to bat monitoring efforts are further illustrated in Table 3. Although many species were both physically captured and detected acoustically, over half of the 22 species found at YUS (12 species, 55%) could only be identified by detecting their echolocation calls. And while some of these species may be quite rare as they were detected at only single elevations (sfm22 and cf35 for example), others such as smf45 and smf42 were detected across almost the entire elevation gradient. Future studies determining the species identity of these currently unknown calls would be highly valuable.

In conclusion, acoustic monitoring represents a valuable addition to traditional bat survey techniques, and together with capture methods represents an effective method of surveying bats across all elevations. Acoustic methods appear particularly suitable for detecting bats at higher elevations which much less effort than capture methods such as harp traps and mist nets, but capture methods are also required to provide the species identities to the calls detected through acoustic surveys. Together they provide a powerful method for surveying bats. Great value could be added through future studies in the YUS area designed to provide the missing species identities to the 11 species currently only known from their echolocation calls.

Figure 6. Species accumulation curves based on acoustic surveys

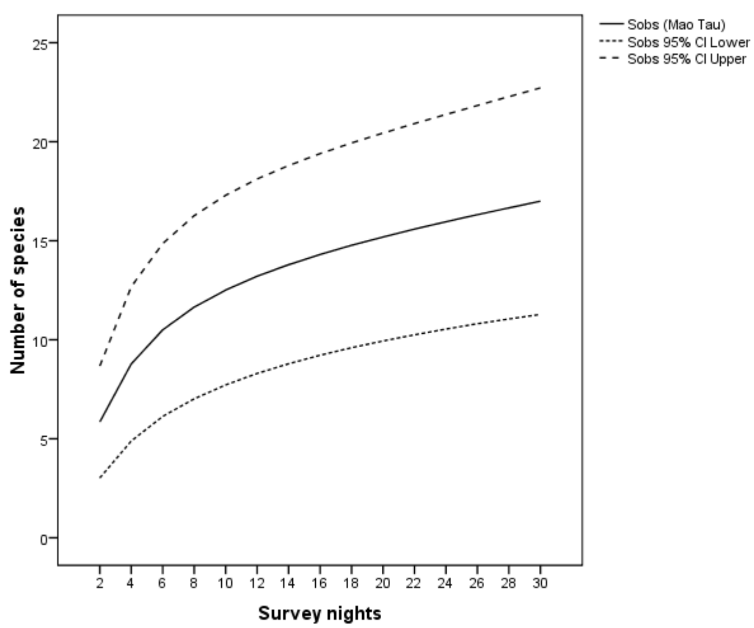


Figure 7. Species accumulation curves based on capture surveys

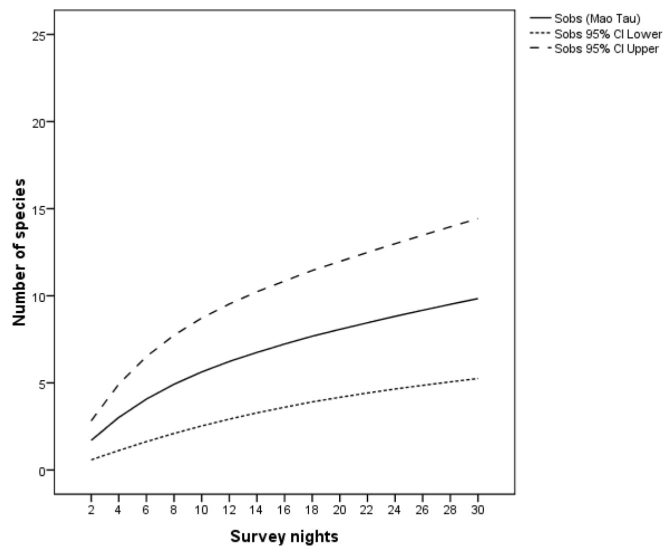


Table 3. Microchiroptera detected during surveys of the YUS transect along with an indication of the type of surveying technique used to detect them (■ = detected acoustically, ■ =captured (mist nests and/or harp traps), ■ = both methods (acoustic & capture)).

	Altitude (m)										
	0	**250**	**750**	**950**	**1150**	**1550**	**2050**	**2350**	**2800**	**3000**	**# of sites**
sfm22			[acoustic]								1
cf35		[acoustic]									1
cffm46		[acoustic]									1
sfm9										[acoustic]	1
fm12										[acoustic]	1
sfm14										[acoustic]	1
Hipposideros maggietaylorae		[captured]									1
Pipistrellus collinus							[captured]				1
Murina florium					[captured]						1
Hipposideros cervinus		[captured]			[captured]						2
fm55		[acoustic]				[acoustic]	[acoustic]				3
Hipposideros diadema		[both]		[acoustic]			[acoustic]				3
sfm55			[acoustic]				[acoustic]	[acoustic]		[acoustic]	4
Aselliscus tricuspidatus		[both]			[acoustic]	[acoustic]		[acoustic]			4
fm52		[acoustic]	[acoustic]					[acoustic]	[acoustic]	[acoustic]	5
Mosia nigrescens	[acoustic]	[acoustic]	[acoustic]		[acoustic]	[acoustic]					5
Rhinolophus megaphyllus		[both]			[both]	[both]	[both]	[acoustic]			5
sfm45		[acoustic]	[acoustic]	[acoustic]	[acoustic]	[acoustic]	[acoustic]				6
Nyctophilus microtis		[both]	[both]		[both]	[acoustic]	[captured]			[captured]	6
sfm42			[acoustic]			[acoustic]	[acoustic]	[acoustic]	[acoustic]	[acoustic]	6
Rhinolophus euryotis		[both]	[both]	[acoustic]	[both]	[both]	[acoustic]				6

4. Species accounts

The following pages include species accounts for each of the 22 species recorded in the YUS conservation area, as a summary of work conducted and an aid for the identification of bats in future studies.

Accounts for those species that were captured include species descriptions and photographs, details of altitudional records and morphometrics from this and other studies provided for comparative and identification purposes, and an example of the echolcation call if recorded.

Accounts for those species that were recorded based on echolocation calls only, include details of altitudional records and echolcation calls.

Embedding the results of this study into previous research, particulalry with reference to into the elevational distribution of bats in PNG and a greater understanding of within- and between-species variability in echolocation calls, was a major goal. To highlight the contributions of this study to these areas in particular, all accounts provide an indication whether the findings of this study represent new location records for the Huon Peninsula, new altitude records for PNG, new echolcation calls for the Huon Peninsula or new echolcation calls for PNG.

4.1 *Aselliscus tricuspidatus,* Trident Leaf-nosed Bat

The smallest of the Hipposideridae found in Papua New Guinea, where two subspecies are known to occur. *Aselliscus tricuspidatus novaguinea* occurs on the mainland, while *A. tricuspidatus koopmani* occurs on small islands to the north east (Bonaccorso, 1998).

A total of 62 files containing calls from this species were recorded during the course of this survey, with one individual being captured. Capture was made in a harp trap, at 250m elevation.

This species was also acoustically detected at 250m, 1150m and 1550m elevation. Previous studies have recorded this species from sea level up to 900m in elevation (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003). This survey significantly extends the known elevational range of this species in Papua New Guinea (Table 4).

A distinctive characteristic of this species is the three projections on the top ridge of the nose leaf (Figure 8). Fur was bicoloured with brownish tips over a paler base. Fur around the muzzle had a slight yellowish hue, extending into the ventrum fur. Morphological parameters recorded were in accordance with previous records (Table 5).

Five reference calls were collected from this species during handling and upon release. The call is of a constant frequency and relatively short duration typical of *Hipposideros*. The characteristic frequency is around 115kHz with each pulse ending with a long down sweeping tail dropping around 5kHz in frequency. The call is displayed below as an uncompressed file in F7 magnification (Figure 9). This species call was also detailed by Leary and Pennay (2011). Calls recorded during this survey match the shape of the ones recorded by Leary and Pennay, but are of a slightly higher frequency (115kHz vs. 112kHz).

Table 4. Elevational records of *Aselliscus tricuspidatus* in Papua New Guinea

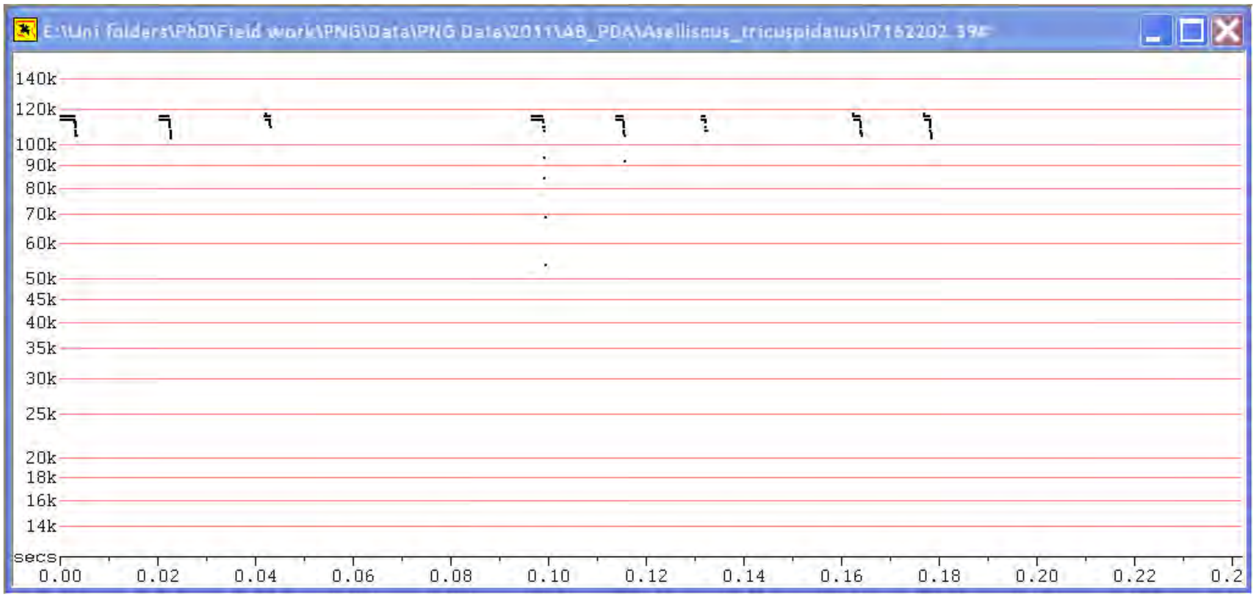
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				
2800m				
2500m				
2350m				X
2050m				
1550m				X
1150m				X
950m			X (900m)	
750m		X (600m)	X	
250m	X (360m)	X	X	X
0m	X	X		

Table 5. Morphological parameters records of *Aselliscus tricuspidatus* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	41.30	40.00	42.00	4	-	39.40	41.90	5	-	-	-	0
	F	42.00	41.00	43.00	3	-	40.10	43.60	12	42.8	-	-	1
	J	-	-	-	-	-	-	-	-	-	-	-	-
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	3.80	3.00	4.10	4	-	3.50	-	1	-	-	-	0
	F	5.00	4.00	7.00	3	-	-	4.00	1	4.5	-	-	1
	J	-	-	-	-	-	-	-	-	-	-	-	0

Figure 8. *Aselliscus tricuspidatus* with distinctive projections from the top of the nose leaf

Figure 9. Call recording from the release of *Aselliscus tricuspidatus* (F7, uncompressed)



4.2 *Hipposideros cervinus*, Fawn Leaf-nosed Bat

A small leaf nosed bat. Four subspecies exist but only one of these, *H. c. cervinus*, is present in Papua New Guinea (Bonaccorso, 1998).

This species was not acoustically detected during passive surveying. Eight individuals were captured during this survey using harp traps. Individuals were captured at 250m and 1150m elevation. Previous studies have recorded this species from sea level up to 1400m in elevation (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003) (Table 6).

This species has a simple nose leaf structure without central projections. It has a raised ridge at the top of the nose leaf, and two tiny lateral leaflets to the side of the horseshoe (Figure 10). This species ears are small and funnel like, rounding to an outward pointing tip. Fur is bicoloured with brownish tips over a paler base, with ventrum fur only slightly paler than the dorsum. Morphological parameters recorded were in accordance with previous records (Table 7).

Reference calls were collected from all eight individuals during handling and upon release. A total of 21 call files were recorded. The call is of a constant frequency and relatively short duration typical of Hipposideros. The characteristic frequency is around 135kHz with each pulse ending with a long down sweeping tail dropping around 20kHz in frequency. The call is displayed below as an uncompressed file in F7 magnification (Figure 11). This species call was also detailed by Leary and Pennay (2011). Calls recorded during this survey matched the ones recorded by Leary and Pennay, who also recorded lower harmonics. Calls recorded for this species from Papua New Guinea are of a considerably higher frequency than those recorded in Australia (120kHz) (Churchill, 2008).

Table 6. Elevational records of *Hipposideros cervinus* in Papua New Guinea

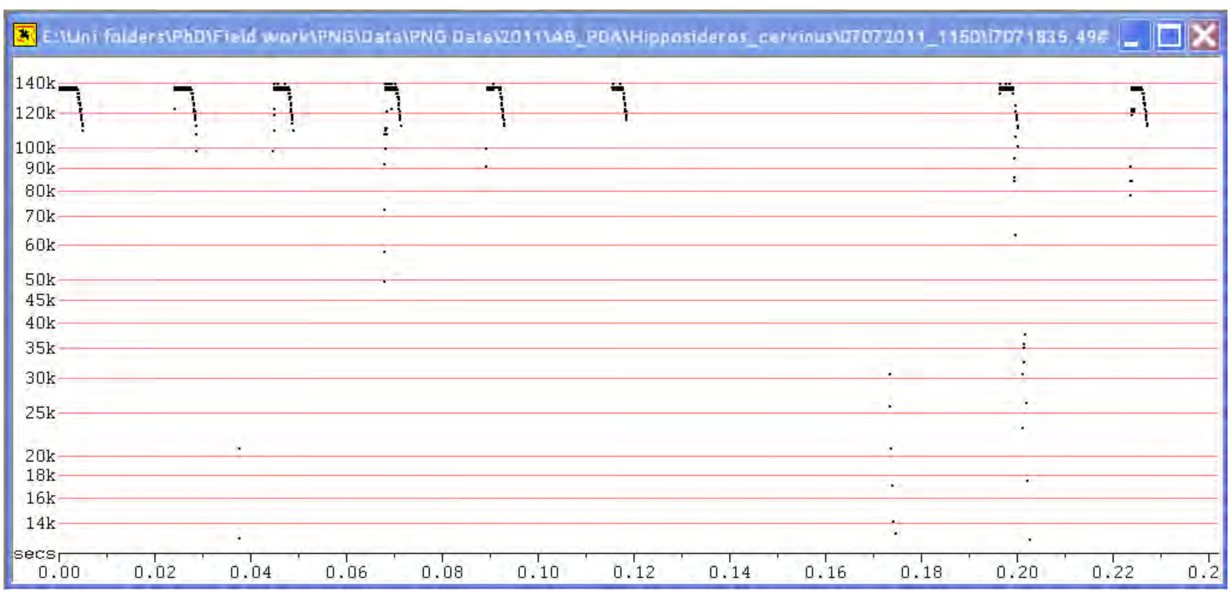
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				
2800m				
2500m				
2350m				
2050m				
1550m				
1150m	X (1360m)	X (1400m)		X
950m	X	X	X (900m)	
750m	X	X	X	
250m	X	X	X	X
0m	X	X		

Table 7. Morphological parameters of *Hipposideros cervinus* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	48.90	48.70	49.00	2	-	44.30	49.20	17	46.59	-	-	1
	F	49.00	-	-	1	-	46.40	50.70	20	48.06	46.30	48.80	7
	J	-	-	-	-	-	44.80	-	1	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	9.40	8.80	9.90	2	-	6.00	10.00	26	7.5	-	-	1
	F	13.00	-	-	1	-	7.00	9.80	19	10.0	7.0	17.0	7
	J	-	-	-		-	-	-	-	-	-	-	0

Figure 10. ***Hipposideros cervinus*** **characterised by the two lateral leaflets visible at the bose of the nose**

Figure 118. Call recording from the release of *Hipposideros cervinus* (F7, uncompressed)



4.*3 Hipposideros diadema*, Diadem Leaf-nosed Bat

The largest Hipposideros in Papua New Guinea. Four subspecies exist, though *H. diadema griseus* is the only on to occur on the mainland (Bonaccorso, 1998).

A total of 67 files containing calls from this species were recorded during passive acoustic surveying, with only two individuals being captured. Both were captured in mist nets set at 250m elevation. This species was also acoustically detected at 250m, 950m and 2050m elevation. Previous studies have recorded this species from sea level up to 1300m in elevation (Flannery, 1995; Bonaccorso, 1998). This survey extends the known Elevational range of this species in Papua New Guinea (Table 8).

This species is easily recognisable by its considerable size. Fur is mottled grey and white in colouration with distinctive dark strips on the head and back (Figure 12). Forearm parameters recorded were in accordance with records made by Flannery (1995) and Bonaccorso (1998), however maximum weight was slightly higher than previously recorded (Table 9).

A total of 72 reference call files were recorded from two individuals during handling and upon release. The call is of a constant frequency and of slightly longer duration than is typical of Hipposideros. The characteristic frequency is around 58kHz with pulses sometimes ending with a down sweeping tail dropping around 8kHz in frequency. The call is displayed below as an uncompressed file in F7 magnification (Figure 13). This species call was also detailed by Leary and Pennay (2011). Calls recorded during this survey were similar in frequency to those recorded by Churchill (2008) and Leary and Pennay but were of the much flatter shape typical of Rhinolophids.

Table 8. Elevational records of *Hipposideros diadema* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	This study
3000m			
2800m			
2500m			
2350m			
2050m			X
1550m			
1150m	X (1210m)	X (1300m)	

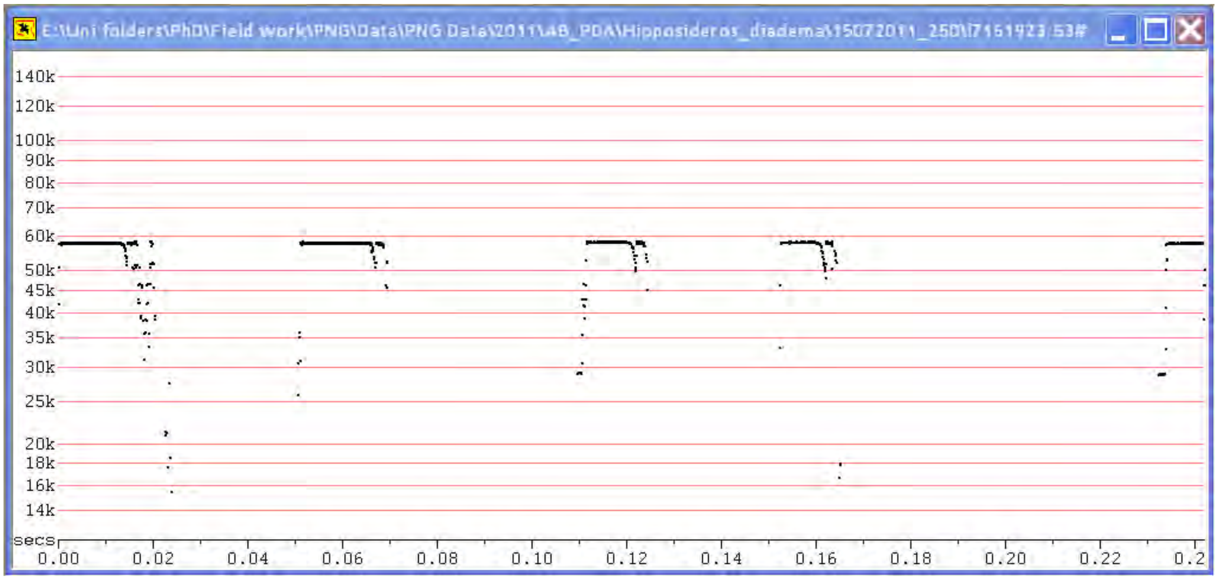
950m	X	X	X
750m	X	X	
250m	X	X	X
0m	X (50m)	X	

Table 9. Morphological parameters of *Hipposideros diadema* in Papua New Guinea

		Flannery (1995)				**Bonaccorso (1998)**				**This study**			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	77.70	75.40	81.20	5	-	75.40	81.20	16	-	-	-	0
	F	81.10	77.90	82.20	2	-	72.60	82.20	6	80.95	79.90	82.0	2
	J	-	-	-	-	-	71.80	72.70	2	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	36.50	33.50	42.50	5	-	33.50	42.50	14	-	-	-	0
	F	38.80	34.05	43.00	2	-	34.50	43.00	5	45.25	41.5	49.0	2
	J	-	-	-	-	-	26.70	27.80	2	-	-	-	0

Figure 12. *Hipposideros diadema* with distinctive stripped pattern

Figure 13. Call recording from the release of *Hipposideros diadema* (F7, uncompressed)



4.4 *Hipposideros maggietaylorae*, Maggie Taylor's Leaf-nosed Bat

This species is endemic to Papua New Guinea, where two subspecies exist. *Hipposideros maggietaylorae erroris* occurs on the mainland, while *H. m. maggietaylorae* occurs on the Bismarck Archipelago (Bonaccorso, 1998). This species was not acoustically detected during passive surveying, and only one individual was captured. Capture was made in a harp trap erected at 250m elevation. Previous studies have recorded this species from sea level up to 360m in elevation (Flannery, 1995; Bonaccorso, 1998) (Table 10).

Nose leaf is of simple structure with no projections or lateral leaflets. Fur of the individual captured was long and woolly with a mottled grey brown colour with a yellowish tinge. Fur on the head was a darker brown with an orangish tinge (Figure 14). In field identification of this species was problematic with some identifying characteristics matching more so to *Hipposideros calcartus*. Bonaccorso (1998) lists the presence of four tail vertebrae as an identifying characteristic of this species. However, this individual was found to have five tail vertebrae as detailed for *H. calcartus*. In addition, ear size and shape matches that of *H. calcartus,* while the ribbing on the outer margin of the inner ear matches that of *H. maggietaylorae* (Bonaccorso, 1998) (Figure 14). Positive identification of this species was eventually confirmed based on its echolocation call, with the reference call recorded upon release of the individual matching one positively identified as *H. maggietaylorae* by Leary and Pennay (2011). Forearm parameters recorded were in accordance with records made by Flannery (1995) and Bonaccorso (1998), however weight was slightly lower than previously recorded (Table 11).

A total of 7 reference call files were recorded during handling and upon release. The call is of a constant frequency and of short duration as is typical of Hipposideros. The characteristic frequency is around 121kHz, with pulses ending with a long down sweeping tail dropping around 30kHz in frequency. The call is displayed below as an uncompressed file in F7 magnification (Figure 15). Calls recorded during this survey matched the ones recorded by Leary and Pennay (2011).

Table 10. Elevational records of *Hipposideros maggietaylorae* in Papua New Guinea

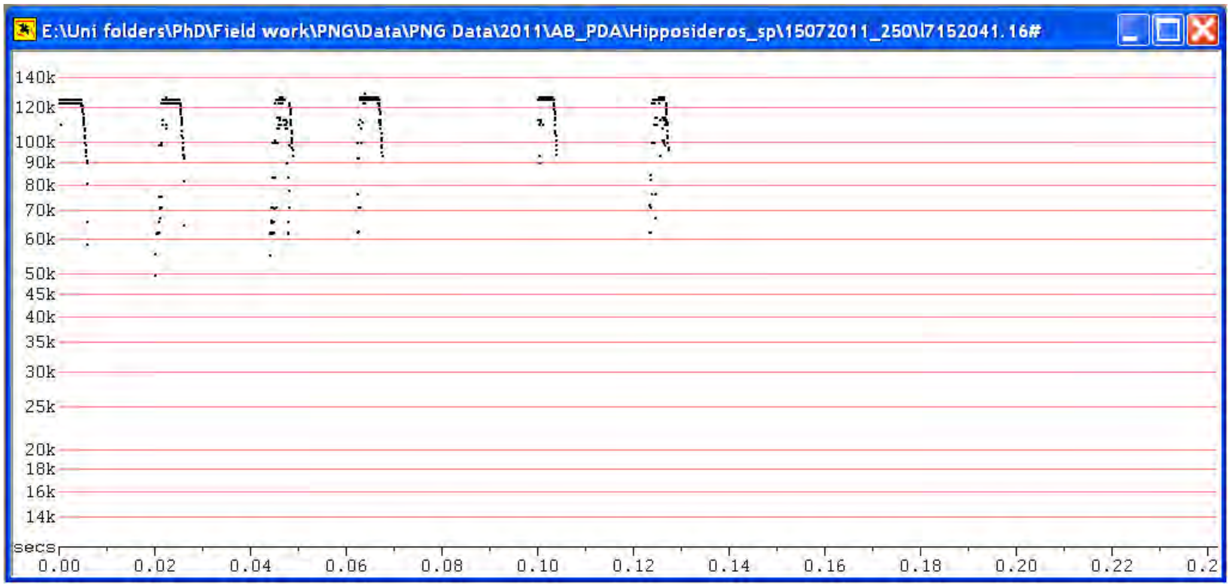
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	This study
3000m			
2800m			
2500m			
2350m			
2050m			
1550m			
1150m			
950m			
750m			
250m	X (360m)	X (300m)	X
0m	X	X	

Table 112. Morphological parameters of *Hipposideros maggietaylorae* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
FA	M	54.00	53.00	56.00	3	-	52.50	58.20	23	-	-	-	0
	F	56.50	55.70	57.00	2	-	52.50	58.50	27	57.9	-	-	1
	J	-	-	-	-	-	52.20	57.20	2	-	-	-	0
	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
WT	M	15.80	14.50	17.00	2	-	14.50	20.00	11	-	-	-	0
	F	19.30	18.00	20.50	2	-	13.00	23.40	10	16.0	-	-	1
	J	-	-	-	-	-	-	-	-	-	-	-	0

Figure 14. *Hipposideros maggietaylorae* with ribbing on the outer margin of the inner ear visible.

Figure 15. Call recording from the release of *Hipposideros maggietaylorae* (F7, uncompressed)



4.5 *Rhinolophus euryotis*, New Guinea Horseshoe Bat

The largest Rhinolophid in Papua New Guinea, where only one of the five subspecies occurs (Bonaccorso, 1998).

This species was the most commonly detected during the survey. A total of 1842 files containing calls from this species were recorded during passive acoustic surveying. A total of 60 individuals were trapped, with eight of these being captured in mist nets. Individuals were captured between 250m and 1550m elevation. This species was also acoustically detected at 250m, 750m, 950m, 1150m, 1550m and 2050m elevation. Previous studies have recorded this species from sea level up to 1800m in elevation (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003). This survey extends the known Elevational range of this species in Papua New Guinea (Table 12).

Nose leaf is of a complex structure with the hairy, rounded tip of the lancet rising above the top of the head. A distinctive white stripe runs down the centre of the nose lead to the lip (Figure 16). Fur is bicoloured with medium brown tips over a lighter grey brown base. Forearm parameters recorded were in accordance with records made by Flannery (1995) and Bonaccorso (1998), however maximum female weight was slightly higher than previously recorded (Table 13).

A total of 296 reference call files were recorded from 60 individuals during handling and upon release. The call is of a constant frequency of moderate duration typical of Rhinolophids. The characteristic frequency is around 58kHz with pulses beginning and ending with a down sweeping tail dropping around 8kHz in frequency. Although the call of this species is similar in shape and frequency to that of *Hipposideros diadema* their calls can be separated due to the longer pulse duration and the presence of a downwards sweep at the beginning of *R. euryotis* calls. The call is displayed below as an uncompressed file in F6 magnification (Figure 17). This species call was also detailed by Leary and Pennay (2011). Calls recorded during this survey matched the ones recorded by Leary and Pennay (2011).

Table 12. Elevational records of *Rhinolophus euryotis* in Papua New Guinea

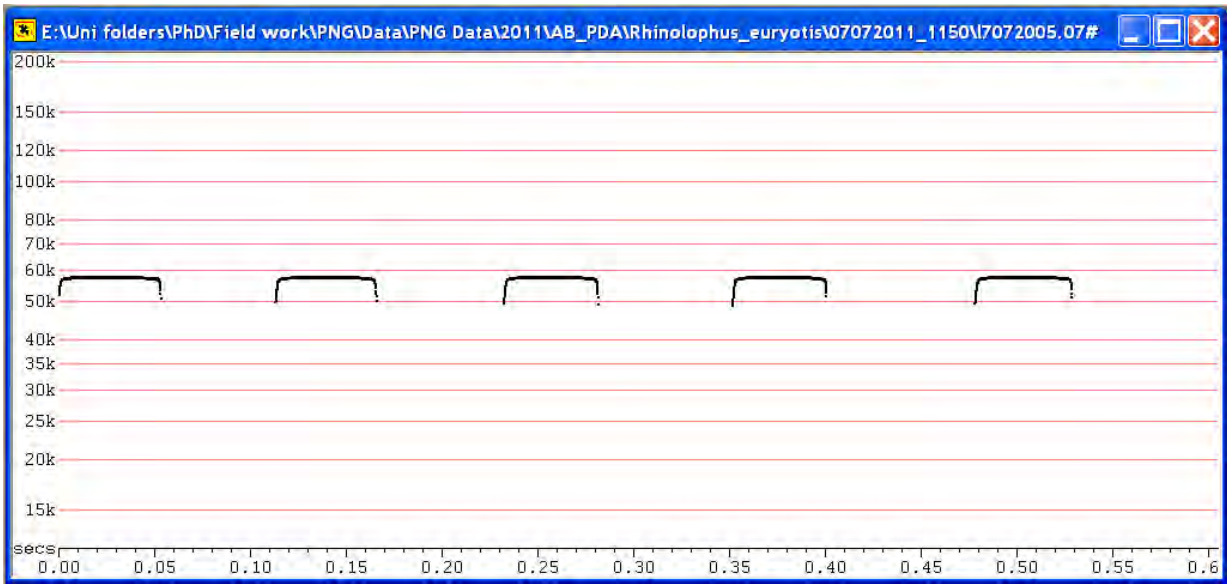
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				
2800m				
2500m				
2350m				
2050m				X
1550m	X (1720m)	X (1800m)		X
1150m	X	X		X
950m	X	X	X (900m)	X
750m	X	X	X	X
250m	X	X	X	X
0m	X (165m)	X		

Table 13. Morphological parameters of *Rhinolophus euryotis* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	-	-	-	-	-	50.00	58.50	33	56.97	51.47	59.96	12
	F	56.70	53.90	59.10	4	-	53.00	58.00	22	56.98	54.81	59.3	48
	J	-	-	-	-	-	-	-	-	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	-	-	-	-	-	14.20	19.30	8	18.04	16.5	20	12
	F	16.60	16.00	17.00	4	-	17.80	21.50	4	18.52	15	27.5	48
	J	-	-	-	-	-	-	-	-	-	-	-	0

Figure 16. ***Rhinolophus euryotis*** **with distinctive white stripe on the nose leaf**

Figure 17. Call recording from the release of *Rhinolophus euryotis* (F6, uncompressed)



4.6 *Rhinolophus megaphyllus*, Eastern Horseshoe bat

The smallest Rhinolophid in Papua New Guinea. Three of the five subspecies occur in Papua New Guinea, though only *R. megaphyllus fallax* occurs on the mainland (Bonaccorso, 1998).

A total of 320 files containing calls from this species were recorded during passive acoustic surveying. A total of 13 individuals were captured during this survey, with all of these being captured in harp traps. Individuals were captured between 250m and 2050m elevation. This species was also acoustically detected at 250m, 1150m, 1550m, 2050m, and 2350m elevation. Previous studies have recorded this species from sea level up to 1600m in elevation (Flannery, 1995; Bonaccorso, 1998). This survey extends the known elevational range of this species in Papua New Guinea (Table 14).

Nose leaf is of a complex structure with a long, narrow, hairless tip. In all individuals captured, the nose leaf had a distinctive yellowish colour (Figure 18). Fur is mottled brown grey all over. Forearm parameters and weights were slightly higher than previously recorded (Flannery, 1995; Bonaccorso, 1998) (Table 15)..

A total of 120 reference call files were recorded from 13 individuals during handling and upon release. The call is of a constant frequency of moderate duration typical of Rhinolophids. The characteristic frequency is around 68kHz with pulses often ending with a down sweeping tail dropping around 8kHz in frequency. The call is displayed below as an uncompressed file in F6 magnification (Figure 19). Calls recorded during this survey matched the ones recorded in Papua New Guinea by Leary and Pennay (2011), and those recorded in Australia (Churchill, 2008).

Table 14. Elevational records of *Rhinolophus megaphyllus* from three different sources

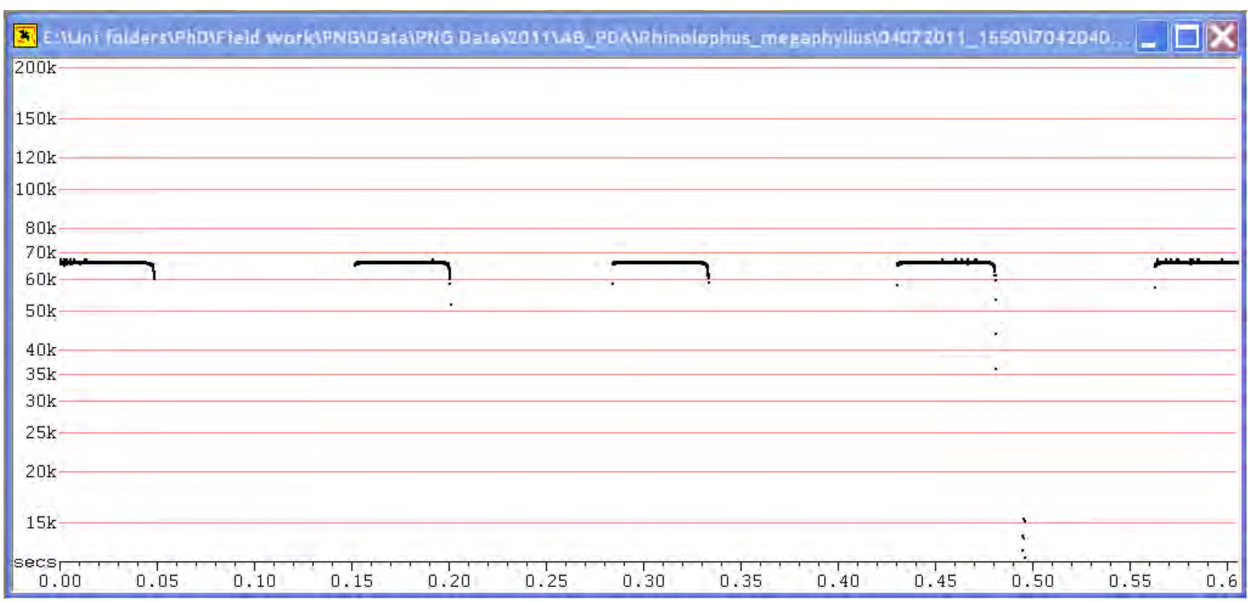
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	This study
3000m			
2800m			
2500m			
2350m			X
2050m			X
1550m		X (1600m)	X
1150m		X	X
950m		X	
750m		X	
250m	X (260 – 360m)	X	X
0m		X	

Table 15. Morphological parameters of *Rhinolophus megaphyllus* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	49.10	-	-	1	-	43.00	49.00	2	48.44	46.04	49.68	3
	F	48.70	-	-	1	-	45.60	47.70	4	49.82	46.47	59.80	10
	J	-	-	-	-	-	-	-	-	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	9.00	-	-	1	-	9.00	-	1	10.33	10	11.00	3
	F	10.50	-	-	1	-	12.00	-	1	10.42	8	12.00	10
	J	-	-	-	-	-				-	-	-	0

Figure 18. ***Rhinolophus megaphyllus*** **with distinctive yellowish nose leaf**

Figure 19. Call recording from the release of *Rhinolophus megaphyllus* (F6, uncompressed)



4.7 *Pipistrellus collinus,* Mountain Pipistrelle

This monotypic species is the largest Pipistrellus in Papua New Guinea (Bonaccorso, 1998).

This species was not conclusively detected during passive acoustic surveying. Only one individual was captured during this survey. To our knowledge, this is the first record of this species for the Huon Peninsula. Capture was made in a harp trap, at 2050m elevation. Previous studies have recorded this species from sea level up to 2950m in elevation (Flannery, 1995; Bonaccorso, 1998) (Table 16).

Fur of the individual captured was bicoloured with light brown tips over a darker base (Figure 20). Dorsum fur was found to be slightly darker than that of the ventrum. The muzzle and ears were relatively hairless, and light brown in colour. The eye is small but conspicuous. Ears are triangular and funnel shaped, with a long slightly inward curved tragus. Morphological parameters recorded were in accordance with previous records (Flannery, 1995; Bonaccorso, 1998) (Table 17).

Five reference call files were collected from this species upon release. The call is frequency modulated, with steep linear pulses ending with a slight curve, and a characteristic frequency around 40kHz. Pulses show upsweeps of between 10kHz and 30 kHz. The call is displayed below as a compressed file in F7 magnification (Figure 21). To our knowledge, this call has not been documented previously.

Table 16. Elevational records of *Pipistrellus collinus* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	This study
3000m			
2800m	X (2950m)	X	
2500m	X	X	
2350m	X	X	
2050m	X (2950m)	X	X
1550m	X (1770m)	X	
1150m		X	

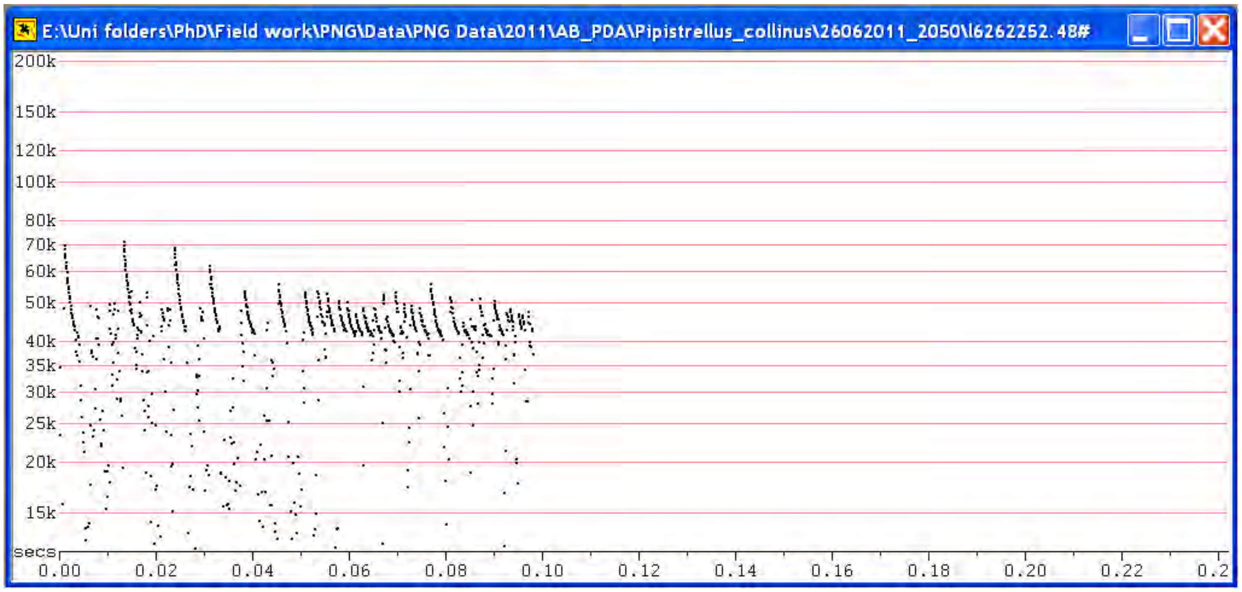
950m		X	
750m		X	
250m			
0m			

Table 17. Morphological records of *Pipistrellus collinus* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	37.20	35.50	38.00	5	-	34.00	38.00	24	-	-	-	0
	F	37.30	36.00	37.80	11	-	33.00	38.50	19	35.58			1
	J	-	-	-	-	-	-	-	-	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	5.50	5.10	5.80	5	-	4.30	7.10	19	-	-	-	0
	F	6.40	5.90	6.90	11	-	4.30	8.50	18	5.6			1
	J	-	-	-	-	-	-	-	-	-	-	-	0

Figure 20. *Pipistrellus collinus* with small conspicuous eye and triangular ear

Figure 21. Call recording from the release of *Pipistrellus collinus* (F7, compressed)



4.8 *Murina florium*, Insectivorous Tube-nosed Bat

Also known commonly as the Flores Murine bat, this species is the only representative of this subfamily (Murininae) present in Papua New Guinea (Bonaccorso, 1998).

This species was not conclusively detected during passive acoustic surveying. Only one individual was captured during this survey. Capture was made in a mist net erected at 1150m elevation. Previous studies have recorded this species from 400m up to 2800m in elevation (Flannery, 1995; Bonaccorso, 1998) (Table 18).

This species is easily distinguished by its tubular nostrils. Fur of the individual captured was thick and woolly with a mottled dark brown to golden brown colour, with silver flecks (Figure 22). Dorsum fur was found to be slightly darker than that of the ventrum. Morphological parameters recorded were in accordance with previous records (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003) (Table 19).

Only two reference call files could be collected from this species upon its release. The call is frequency modulated, with steep linear pulses of highly variable frequencies and a characteristic frequency of around 50kHz. Pulses are clumped closely together. The call is displayed below as a compressed file in F7 magnification (Figure 23). Calls recorded during this survey are similar to those recorded for this species in Australia, though are of a slightly higher frequency (Churchill, 2008).

Table 18. Elevational records of *Murina florium* in Papua New Guinea

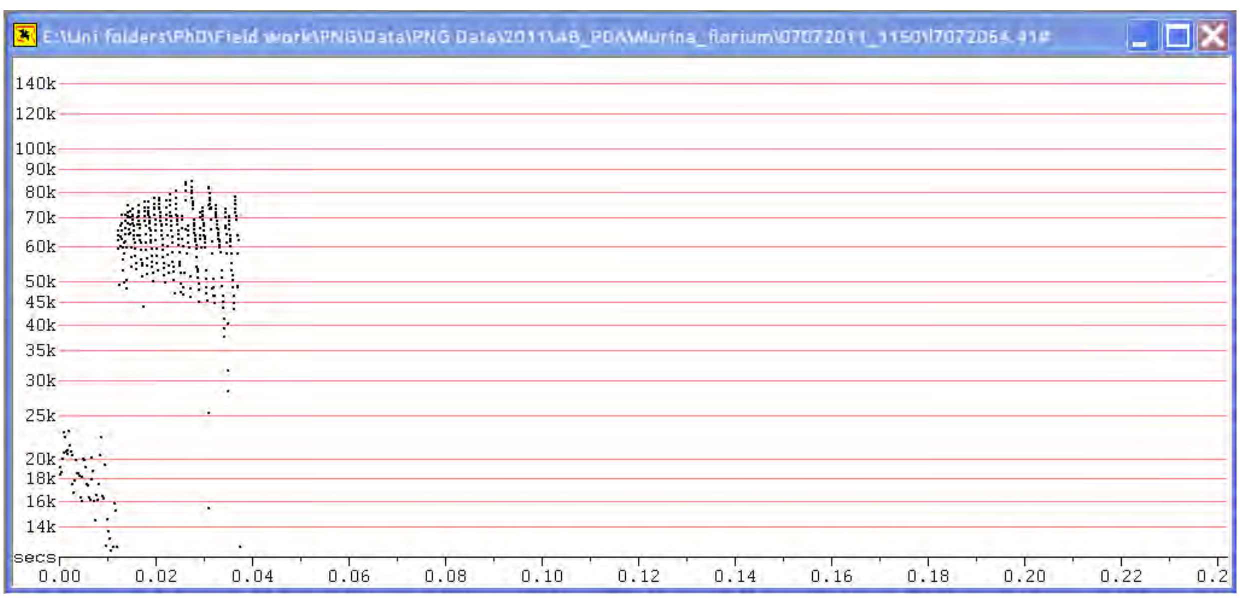
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				
2800m		X		
2500m		X	X (2600m)	
2350m		X	X (2300m)	
2050m	X (2200m)	X		
1550m	X	X		
1150m	X	X		X
950m	X	X		
750m	X (700m)	X (400m)		
250m				
0m				

Table 19. Morphological parameters of *Murina florium* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
FA	M	33.20	-	-	1	-	33.00	36.20	4	-	-	-	0
	F	35.00	-	-		-	33.00	35.70	8	35.07			1
	J	-	-	-	-	-	-	-	-	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	6.20	-	-	1	-	6.00	6.90	3	-	-	-	0
	F	4.25	-	-	1	-	4.30	8.80	5	8.5			1
	J	-	-	-	-	-	-	-	-	-	-	-	0

Figure 22. ***Murina florium*** **with distinctive tubular nostrils**

Figure 23. Call recording from the release of ***Murina florium*** **(F7, compressed)**



4.9 *Nyctophilus microtis*, Papuan Big-eared Bat

This species is endemic to Papua New Guinea (Bonaccorso, 1998). This species is also commonly known as the Small eared Nyctophilus (Flannery, 1995).

A total of 91 files containing calls from this species were recorded during passive surveying, and seven individuals were captured. Four individuals were caught using harp traps while three were captured in mist nets. Captures were made between 250m and 3000m elevation (Table 18). This species was also acoustically detected at 250m, 750m, 1150m, and 1550m elevation. Previous studies have recorded this species from sea level up to 2600m in elevation (Flannery, 1995; Bonaccorso, 1998)

This survey extends the known elevational range of this species in Papua New Guinea (Table 20). To our knowledge, this is the first record of this species for the Huon Peninsula.

Distinctive features of this genus are the presence of large folded ears joined by a membrane above the head, and a squarish muzzle with simple nose leaf defined by a prominent upper ridge (Figure 24). The ear of *N. microtis* is slightly narrower and more tapered than other species, and is lightly haired. The tragus is long and almost rectangular in shape, narrowing only slightly at the tip. Fur is bicoloured with a dark base under medium brown tips, with the ventrum being slightly paler. Morphological parameters recorded for males were in accordance with previous records, though females captured during this survey were found to be slightly larger in forearm and weight (Flannery, 1995; Bonaccorso, 1998) (Table 21).

A total of 10 reference call files were collected from seven individuals upon release. The call is frequency modulated, with linear pulses of highly variable frequencies and a characteristic frequency of around 40kHz. Pulses have a slight leftwards lean to them, but no curve is present. The call is displayed below as a compressed file in F7 magnification (Figure 25). To our knowledge, this call has not been documented previously.

Table 20. Elevational records of *Nyctophilus microtis* in Papua New Guinea

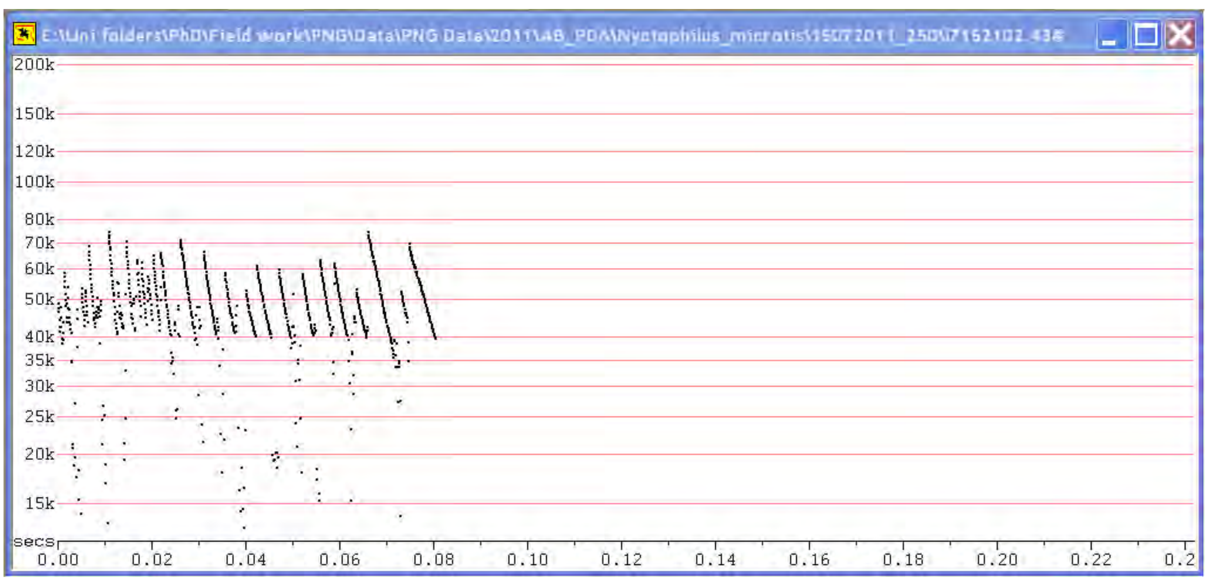
Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				X
2800m				
2500m				
2350m				
2050m	X (2600m)			X
1550m	X			X
1150m	X	X (1450m)	X (1280m)	X
950m	X	X		
750m	X	X		X
250m	X (200m)	X		X
0m		X		

Table 21. Morphological parameters of *Nyctophilus microtis* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	39.00	38.30	39.80	4	-	37.00	40.10	16	39.96	39.05	40.95	5
	F	38.00	-	-	1	-	38.00	40.90	11	41.55	41.5	41.6	2
	J	-	-	-	-	-	-	-	-	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	6.70	6.00	8.00	4	-	5.80	9.50	9	7.99	7.4	9	5
	F	7.50	-	-	1	-	6.00	8.00	5	9.5	8.5	10.5	2
	J	-	-	-	-	-	-	-	-	-	-	-	0

Figure 24. ***Nyctophilus microtis*** **with distinctive nose ridge and large folded ears**

Figure 25. Call recording from the release of ***Nyctophilus microtis*** **(F7, compressed)**



4.10 *Kerivoula muscina*, Fly River Woolly Bat

This species is endemic to Papua New Guinea (Bonaccorso, 1998). This species is also commonly known as the Fly River Trumpet-eared bat (Flannery, 1995).

Two individuals were captured during this survey. To our knowledge, this is the first record of this species for the Huon Peninsula. Both individuals were caught using harp traps erected at 300m. Previous studies have recorded this species from sea level up to 1600m in elevation (Flannery, 1995; Bonaccorso, 1998) (Table 22).

This species is easily distinguished by its small size and distinctive orange glands located on the forehead on either side of the nose (Figure 26). The ear is broad and funnel like, and is lightly haired. The tragus is long and points at the tip, with a slight inwards curve in towards the head. Fur is bicoloured with a dark base under light orangey brown tips, with the ventrum being slightly greyer. Morphological measurements are in accordance with previous records (Flannery, 1995; Bonaccorso, 1998) (Table 23).

No reliable reference call could be obtained from this species, thus we are unable to determine if this species was present during passive acoustic surveying.

Figure 26. ***Kerivoula muscina*** **with distinctive orange glands above nose**

Table 22. Elevational records of *Kerivoula muscina* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	This study
3000m			
2800m			
2500m			
2350m			
2050m			
1550m	X (1600m)	X (1600m)	
1150m	X	X	
950m	X	X	
750m	X	X	
250m	X	X	
0m	X (20m)	X	X

Table 23. Morphological parameters of *Kerivoula muscina* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	32.40	31.80	33.00	3	-	32.00	33.00	5	33.50	33.50	33.50	1
	F	34.20	-	-	1	-	32.40	36.00	7	35.30	35.30	35.30	1
	J	-	-	-	-	-	-	-	-	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	4.70	4.00	5.40	2	-	4.00	5.00	3	4.50	4.50	4.50	1
	F	5.10	-	-	1	-	-	5.00	2	5.00	5.00	5.00	1
	J	-	-	-	-	-	-	-	-	-	-	-	0

4.11 *Mosia nigrescens,* Lesser Sheath-tailed Bat

The smallest of the emballonurids found in Papua New Guinea where two of its three subspecies occur (Bonaccorso, 1998). *Mosia nigrescens papuana* occurs on the mainland, while *M. n. solomonis* is only found on islands to the north east.

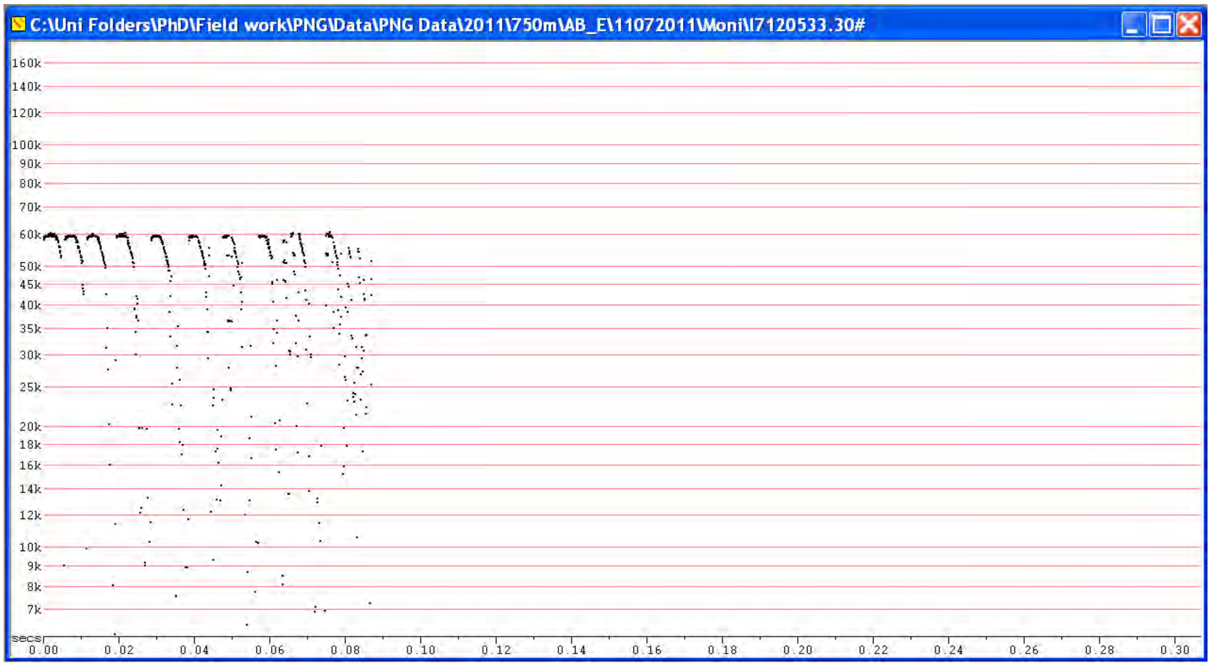
Presence of this species was determined by positive identification of echolocation calls recorded during passive acoustic monitoring, based on calls characterised by Armstrong and Aplin (2011), and Leary and Pennay (2011). A total of 136 files containing calls from this species were recorded during passive surveying. No individuals were captured. This species was detected at 0m, 250m, and 750m in elevation. Previous studies have recorded this species from sea level up to 1600m in elevation (Bonaccorso, 1998; Armstrong and Aplin; Leary and Pennay, 2011) (Table 24).

The call is frequency modulated, consisting of short linear pulses followed by a steep decrease in frequency around 10 kHz. Characteristic frequency is approximately 60kHz. The call is displayed below as a compressed file in F7 magnification. (Figure 27).

Table 24. Elevational records of *Mosia nigrescens* in Papua New Guinea

Elevation (m asl)	Armstrong and Aplin (2011)	Leary and Pennay (2011)	Bonaccorso (1998)	This study
3000m				
2800m				
2500m				
2350m				
2050m				
1550m	X (1600m)		X (1600)	X
1150m			X	X
950m			X	
750m	X (500m)		X	X
250m		X (270m)	X	X
0m			X	X

Figure 27. Calls identified as *Mosia nigrescens* (F7, compressed)



4.12 *sfm9*

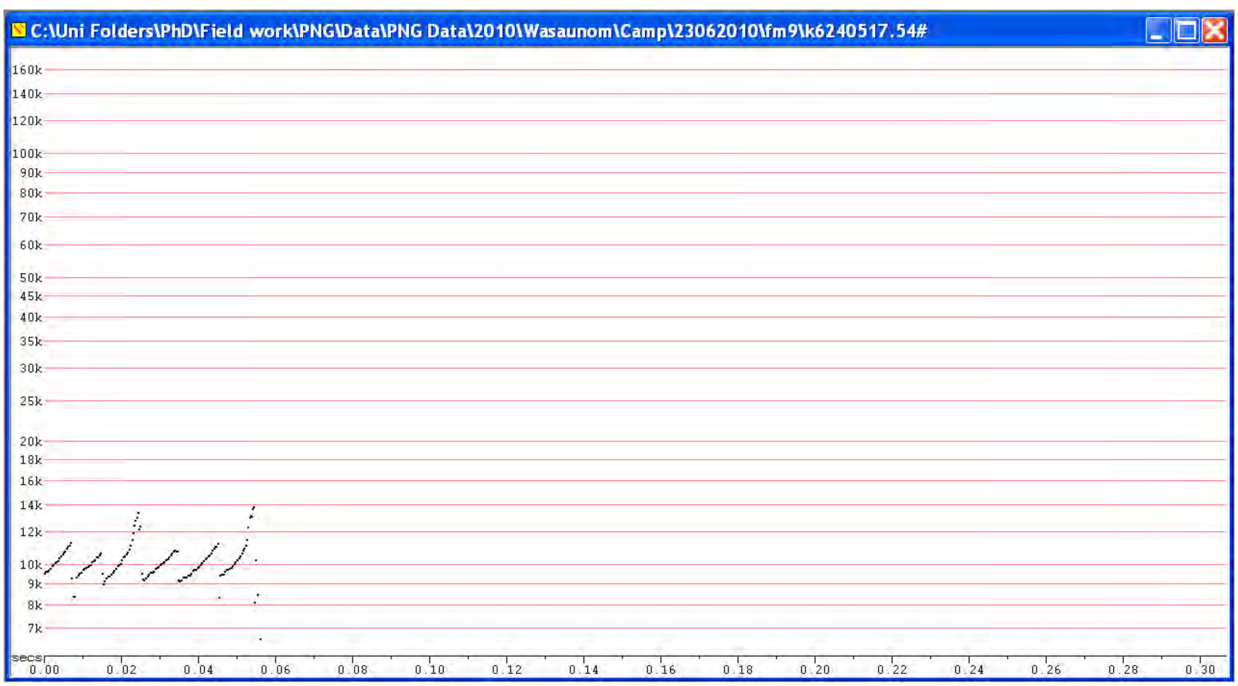
Only two files containing calls of this species were recorded during this survey. Calls were collected at 3000m elevation, from detectors places in open areas around Wasaunon camp (Table 25). No individuals emitting calls of this frequency were captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of sfm9, detailing its steep frequency modulated shape (sfm) and characteristic frequency. The fact that the frequency sweep of the call increases with time is very unusual for bats, and further observations are required to confirm the identity of this high frequency sound..

The call consists of a series of linear pulses with a characteristic frequency of around 9kHz. Pulses have a slight rightwards lean to them, with an upwards sweep of around 2kHz. The call is displayed below as a compressed file in F7 magnification (Figure 28).

Table 25. Elevational records of *sfm9* in Papua New Guinea

Elevation (m asl)	Detected
3000m	X
2800m	
2500m	
2350m	
2050m	
1550m	
1150m	
950m	
750m	
250m	
0m	

Figure 28. Unidentified species coded *sfm9* (F7, compressed)



4.13 *fm12*

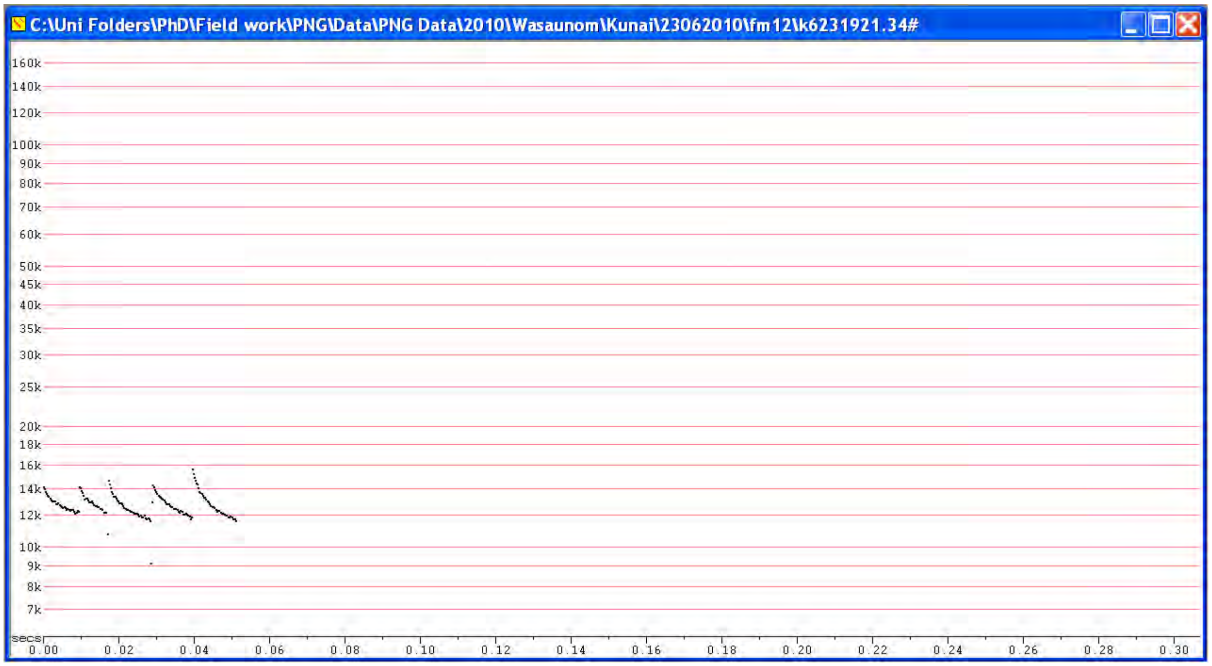
A total of 150 files containing calls of this species were recorded during this survey. Calls were collected at 3000m elevation, from detectors places in open kunai areas around Wasaunon camp (Table 26). No individuals emitting calls of this frequency were captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of fm12, detailing its frequency modulated shape (fm) and characteristic frequency.

The call consists of a series of leftward curving pulses with a characteristic frequency of around 12kHz, with an upwards sweep of around 2kHz. The call is displayed below as a compressed file in F7 magnification (Figure 29).

Table 26. Elevational records of *fm12* in Papua New Guinea

Elevation (m asl)	Detected
3000m	X
2800m	
2500m	
2350m	
2050m	
1550m	
1150m	
950m	
750m	
250m	
0m	

Figure 29. Unidentified species coded *fm12* (F7, compressed)



4.14 *sfm14*

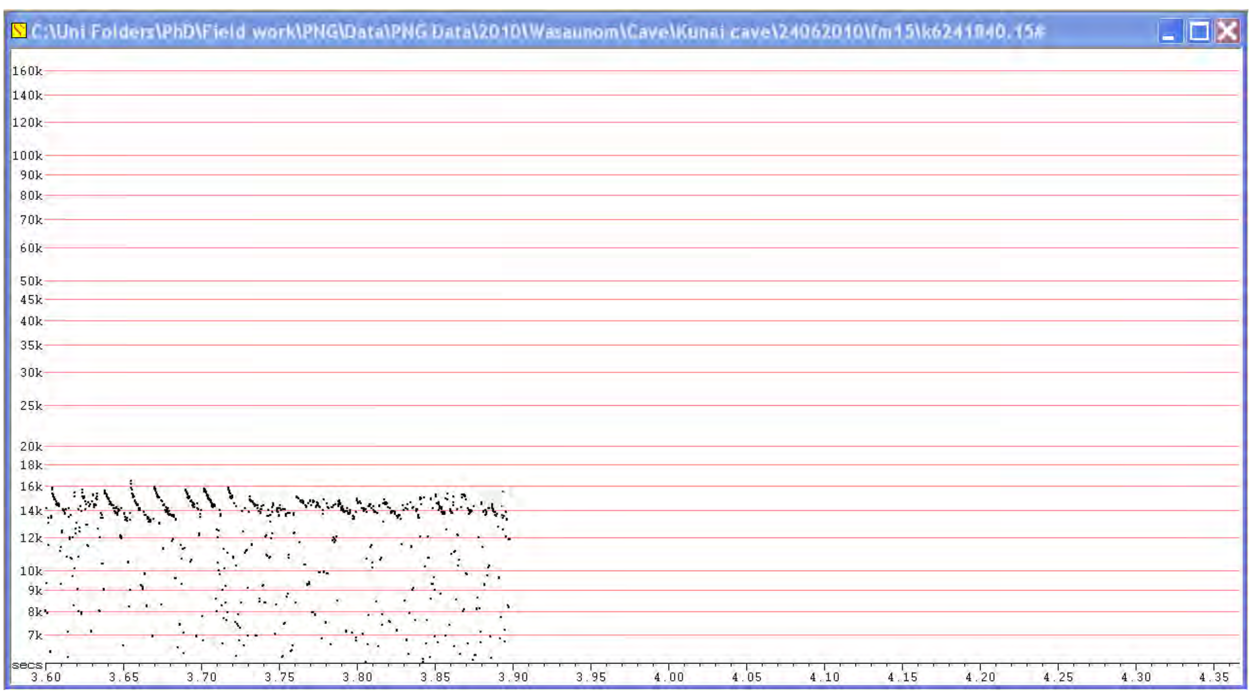
Only four files containing calls of this species were recorded during this survey. Calls were collected at 3000m elevation, from detectors places in open areas around Wasaunon camp (Table 27). No individuals emitting calls of this frequency were captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of sfm14, detailing its steep frequency modulated shape (sfm) and characteristic frequency.

The call consists of a series of leftward curving pulses with a characteristic frequency of around 14kHz, with an upwards sweep of around 2kHz. This call is similar in shape to unidentified call coded fm12, but at a slightly higher frequency. The call is displayed below as a compressed file in F6 magnification (Figure 30).

Table 27. Elevational records of *sfm14* in Papua New Guinea

Elevation (m asl)	Detected
3000m	X
2800m	
2500m	
2350m	
2050m	
1550m	
1150m	
950m	
750m	
250m	
0m	

Figure 30. Unidentified species coded *sfm14* (F6, compressed)



4.15 *sfm22*

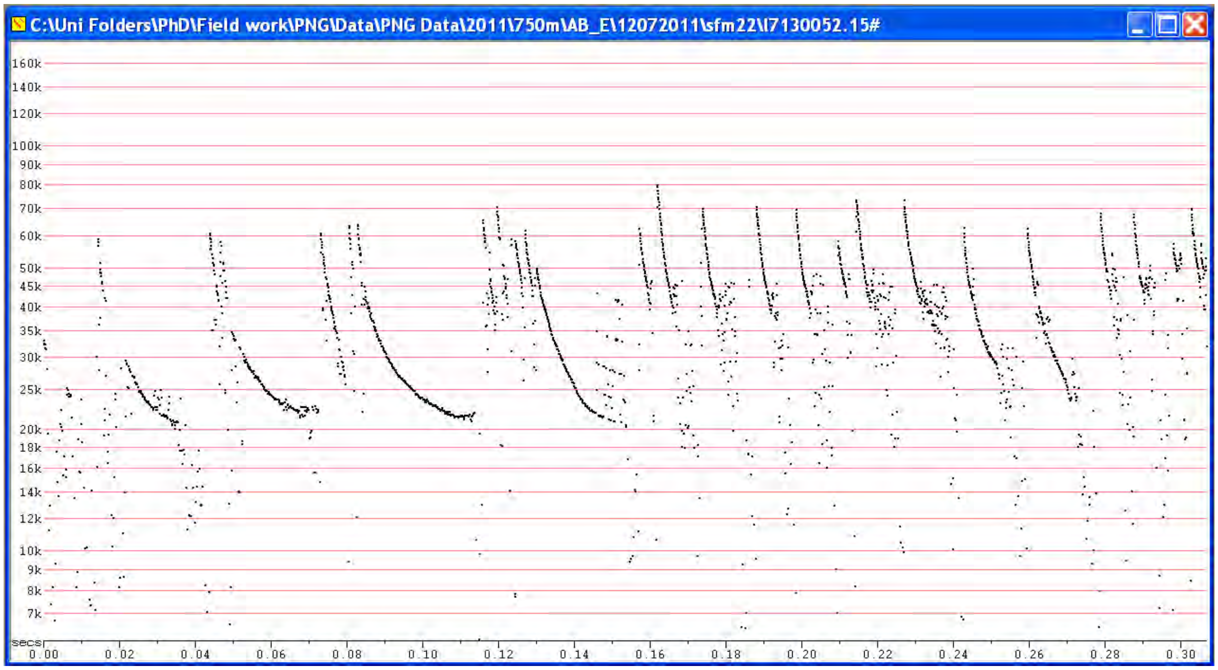
A total of 47 files containing calls of this species were recorded during this survey. Calls were collected at 250m and 750m elevation (Table 28). No individuals emitting calls of this frequency were captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of sfm22, detailing its steep frequency modulated shape (sfm) and characteristic frequency (Figure 31).

The call consists of a series of linear pulses of highly variable frequencies ending in a slight curve with a characteristic frequency of around 22kHz. Pulses have a slight leftwards lean with upwards sweeps of between 10kHz and 25kHz. The call is displayed below as a compressed file in F7 magnification (Figure 31).

Table 28. Elevational records of *sfm22* in Papua New Guinea

Elevation (m asl)	Detected
3000m	
2800m	
2500m	
2350m	
2050m	
1550m	
1150m	
950m	
750m	X
250m	X
0m	

Figure 31. Unidentified species coded *sfm22* (F7, compressed)



4.16 *cf35*

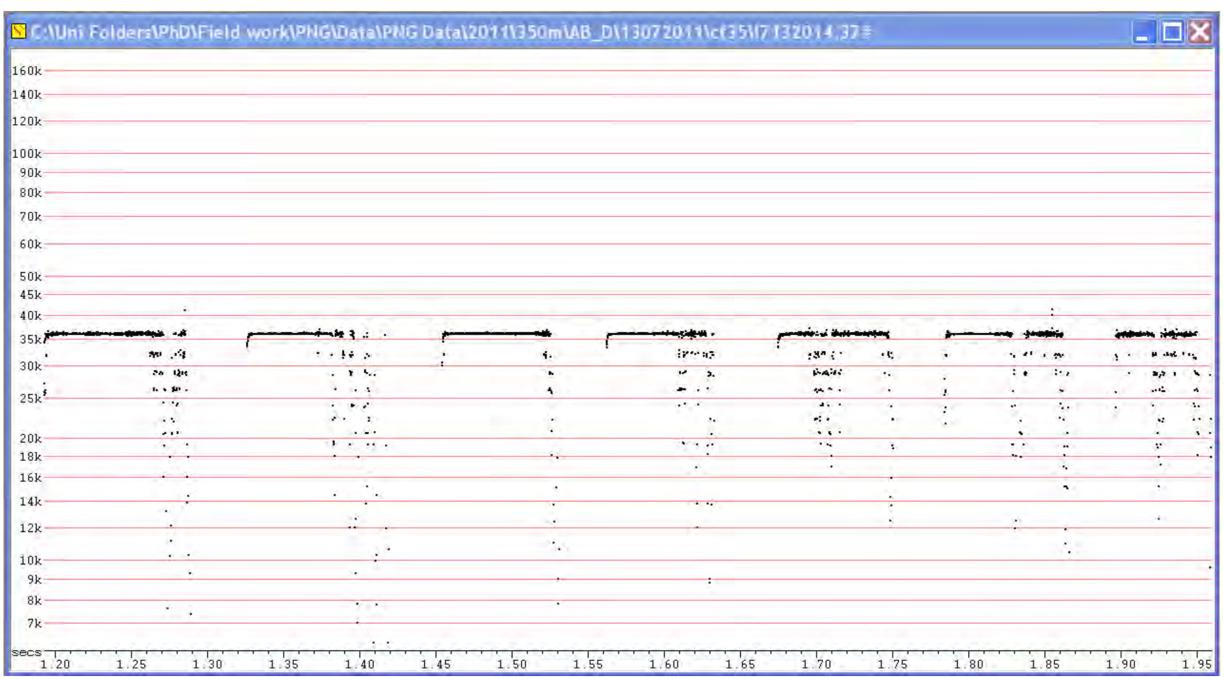
Only one file containing calls of this species were recorded during this survey. Calls were collected at 250m elevation (Table 29). No individuals emitting calls of this frequency were captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of cf35, detailing its constant frequency shape (cf) and characteristic frequency (Figure 32).

The call is of a constant frequency of moderate duration typical of Rhinolophids. The characteristic frequency is around 35kHz with pulses often beginning with a down sweeping tail dropping very slightly in frequency. The call is displayed below as an uncompressed file in F6 magnification (Figure 32).

Table 29. Elevational records of *cf35* in Papua New Guinea

Elevation (m asl)	Detected
3000m	
2800m	
2500m	
2350m	
2050m	
1550m	
1150m	
950m	
750m	
250m	X
0m	

Figure 32. Unidentified species coded *cf35* (F6, uncompressed)



4.17 *sfm42*

A total of 925 files containing calls of this species were recorded during this survey. Calls were collected at 750m, 1550m, 2050m, 2350m, 2800m, and 3000m elevation (Table 30). No individuals emitting calls of this frequency could be confidently assigned to any species captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of sfm42, detailing its steep frequency modulated shape (sfm) and characteristic frequency (Figure 33).

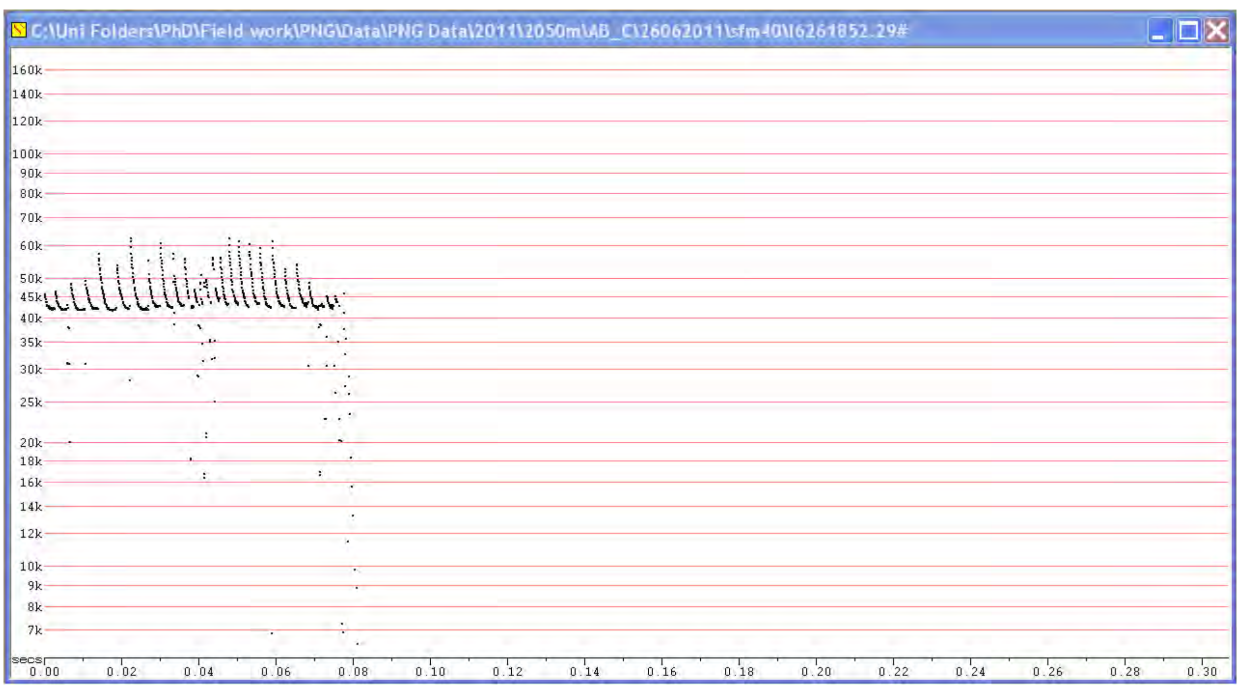
The call consists of a series of linear pulses of highly variable frequencies ending in a slight curve, with a characteristic frequency of around 42kHz. Pulses have upwards sweeps of between 5kHz and 20kHz. The call is displayed below as a compressed file in F7 magnification (Figure 33).

It is possible that these calls may be attributed to *P. collinus* or *N. microtis* captured during this study, as the call shapes and characteristic frequencies are similar. However, calls collected from individuals of these species upon release had much steeper pulses of greater variability in frequency, with no bottom curve. Armstrong and Aplin collected similar shaped calls of a slightly higher frequency during their surveys in Papua New Guinea (2011). They were unable to identify this call to species so coded it *44st.cFM*. They commented that calls of this shape and frequency could be attributed to *Pipistrellus* angulatus, or a species of vespertilionid or *Miniopterus* (Armstrong and Aplin, 2011).

Table 30. Elevational records of *sfm42* in Papua New Guinea

Elevation (m asl)	Detected
3000m	X
2800m	X
2500m	
2350m	X
2050m	X
1550m	X
1150m	
950m	
750m	X
250m	
0m	

Figure 33. Unidentified species coded *sfm42* (F7, compressed)



4.18 *sfm45*

A total of 48 files containing calls of this species were recorded during this survey. Calls were collected at 250m, 750m, 950m, 1150m, and 2050m elevation (Table 31). No individuals emitting calls of this frequency could be confidently assigned to any species captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of sfm45, detailing its steep frequency modulated shape (sfm) and characteristic frequency (Figure 34).

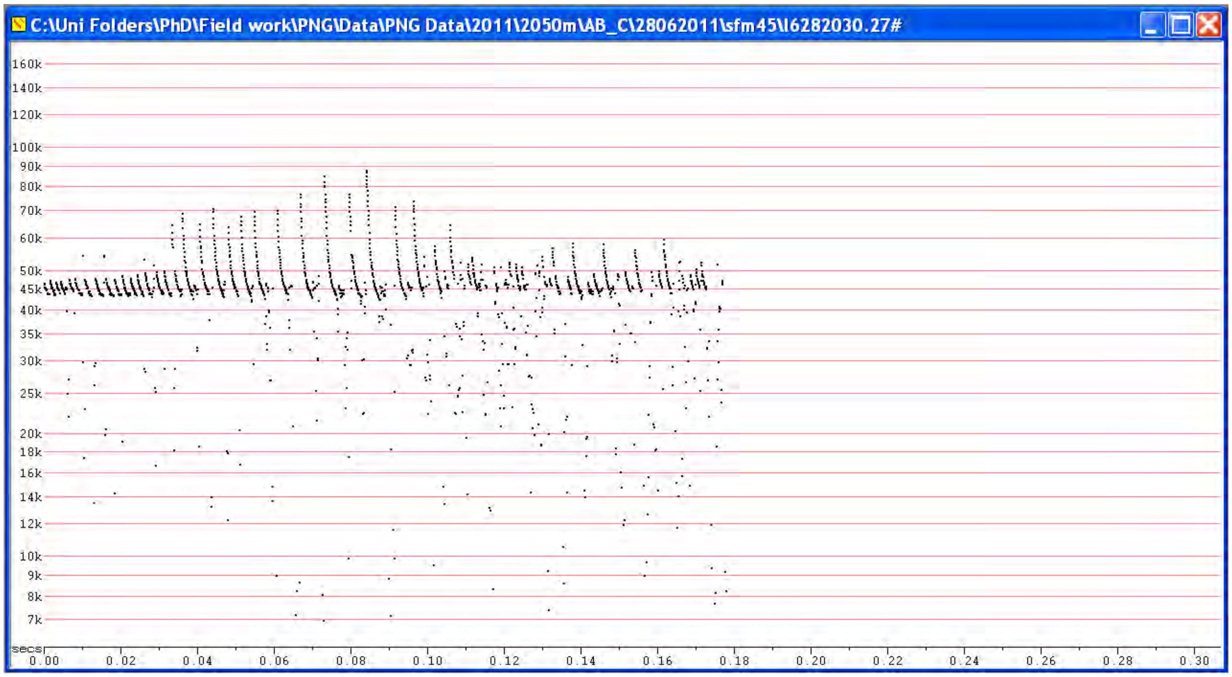
The call consists of a series of linear pulses of highly variable frequencies ending in a slight curve, with a characteristic frequency of around 45kHz. Pulses have upwards sweeps of between 2kHz and 40kHz. The call is displayed below as a compressed file in F7 magnification (Figure 34).

It is possible that these calls may be attributed to *P. collinus* captured during this study, as the call shapes and characteristic frequencies are similar. However, calls collected from *P. collinus* upon release had a slightly lower characteristic frequency at 40kHz.

Table 31. Elevational records for *sfm45* in Papua New Guinea

Elevation (m asl)	Detected
3000m	
2800m	
2500m	
2350m	
2050m	X
1550m	
1150m	X
950m	X
750m	X
250m	X
0m	

Figure 34. Unidentified species coded *sfm45* (F7, compressed)



4.19 *cffm46*

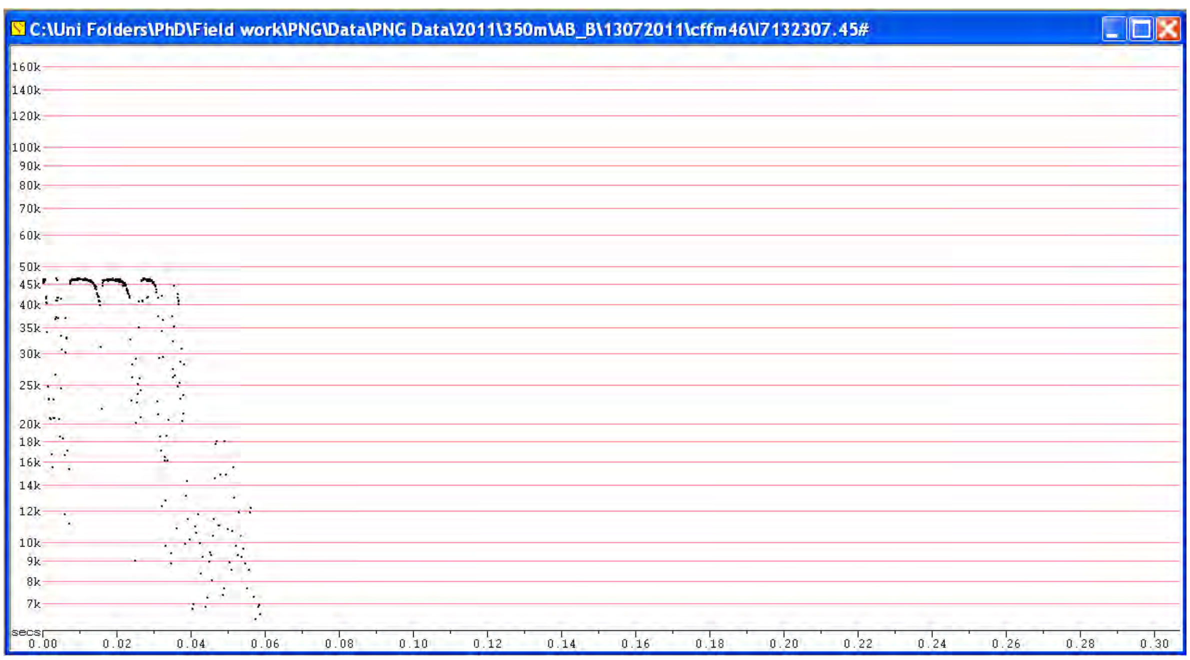
Only 4 files containing calls of this species were recorded during this survey. Calls were only collected at 250m elevation (Table 32). No individuals emitting calls of this frequency could be confidently assigned to any species captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of cffm46, detailing its almost constant frequency shape but frequency modulated nature (cffm) and characteristic frequency (Figure 35).

The call consists of a series of very flat pulses, with a characteristic frequency of around 46kHz, ending in a down sweep of around 5kHz. The call is displayed below as a compressed file in F7 magnification (Figure 35). Armstrong and Aplin collected similar shaped calls of a slightly lower frequency during their surveys in Papua New Guinea (2011). They were able to identify this call to genus so coded it 43 *i.fFM.d Emballonura sp.*. They commented that there appears to be high variation in characteristic frequencies of this call type across PNG, and that this may be due to high variability in calls among individuals of a single species, or may be multiple similar species (Armstrong and Aplin, 2011).

Table 32. Elevational records of *cffm46* in Papua New Guinea

Elevation (m asl)	Detected
3000m	
2800m	
2500m	
2350m	
2050m	
1550m	
1150m	
950m	
750m	
250m	X
0m	

Figure 35. Unidentified species coded *cffm46* (F7, compressed)



4.20 *fm52*

A total of 12 files containing calls of this species were recorded during this survey. Calls were collected at 250m, 750m, 2350m, and 3000m elevation (Table 33).

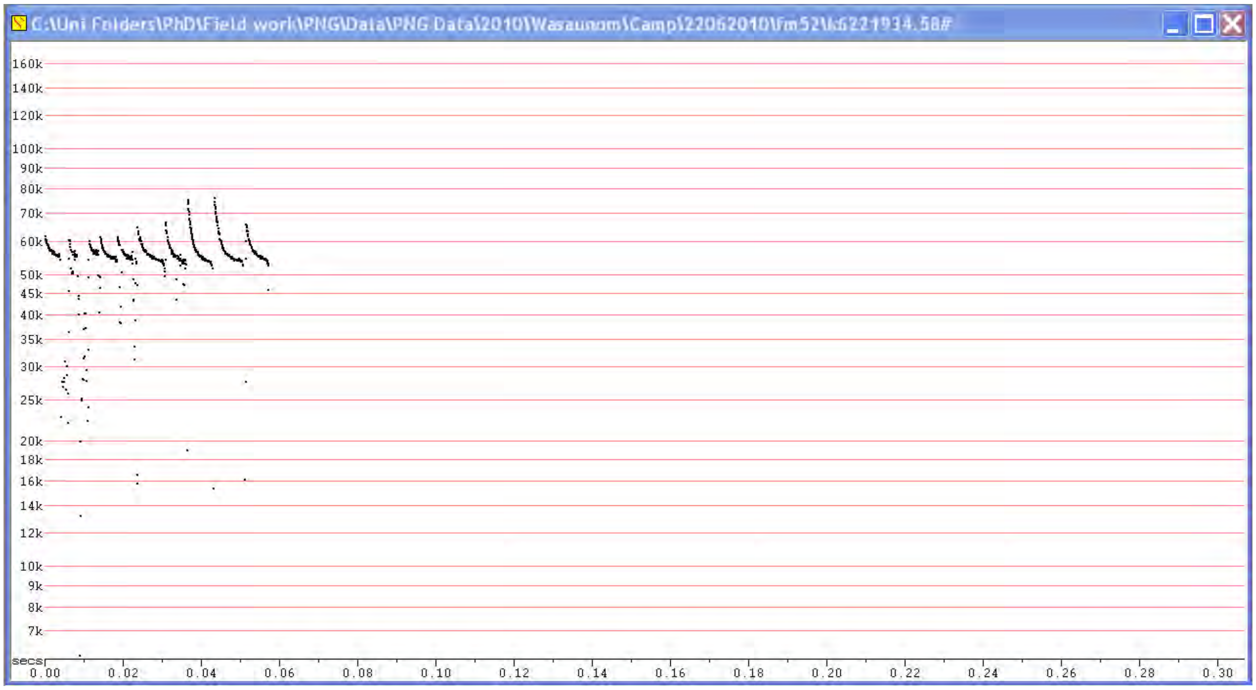
No individuals emitting calls of this frequency could be confidently assigned to any species captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of fm52, detailing its frequency modulated shape (fm) and characteristic frequency. The call consists of a series of curving pulses, ending in a slight downward droop, with a characteristic frequency of around 52kHz . Pulses vary only slightly in frequency with upwards sweeps ranging between 7kHz and 20kHz. The call is displayed below as a compressed file in F7 magnification (Figure 36).

Armstrong and Aplin (2011) collected calls with a similar terminal droop, though with much steeper pulses, during their surveys in Papua New Guinea (2011). They were unable to identify this call to species so coded it 53*st.cFM.d*. They commented that pulses with this characteristic droop are likely to be from a species of *Miniopterus* or less likely a species of vespertilionid (Armstrong and Aplin, 2011).

Table 33. Elevational records of *fm52* in Papua New Guinea

Elevation (m asl)	Detected
3000m	X
2800m	
2500m	
2350m	X
2050m	
1550m	
1150m	
950m	
750m	X
250m	X
0m	

Figure 36. Unidentified species coded *fm52* (F7, compressed)



4.21 *fm55*

A total of 25 files containing calls of this species were recorded during this survey. Calls were collected at 250m, 1550m, and 2050m elevation (Table 34). No individuals emitting calls of this frequency could be confidently assigned to any species captured during this survey, and calls could not be matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of fm55, detailing its frequency modulated shape (fm) and characteristic frequency (Figure 37).

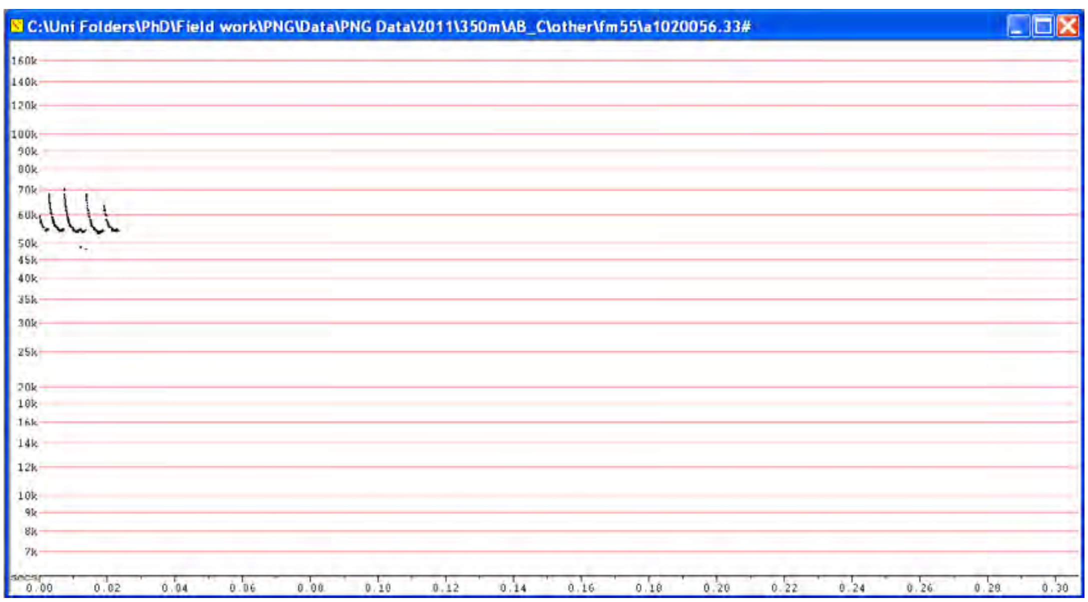
The call consists of a series of slightly leftwards leaning curved pulses, with upwards sweeps ranging between 5kHz and 15kHz, and a characteristic frequency of around 52kHz. The call is displayed below as a compressed file in F7 magnification (Figure 37).

It is possible that these calls may be made by the same species as calls coded fm52 as the call shapes and characteristic frequencies are similar (see 3.5.9). However, due to the lack of the distinctive terminal droop, this could not be confidently confirmed.

Table 34. Elevational records of *fm55* in Papua New Guinea

Elevation (m asl)	Detected
3000m	
2800m	
2500m	
2350m	
2050m	X
1550m	X
1150m	
950m	
750m	
250m	X
0m	

Figure 37. Unidentified species coded fm55 (F7, compressed)



4.22 *sfm55*

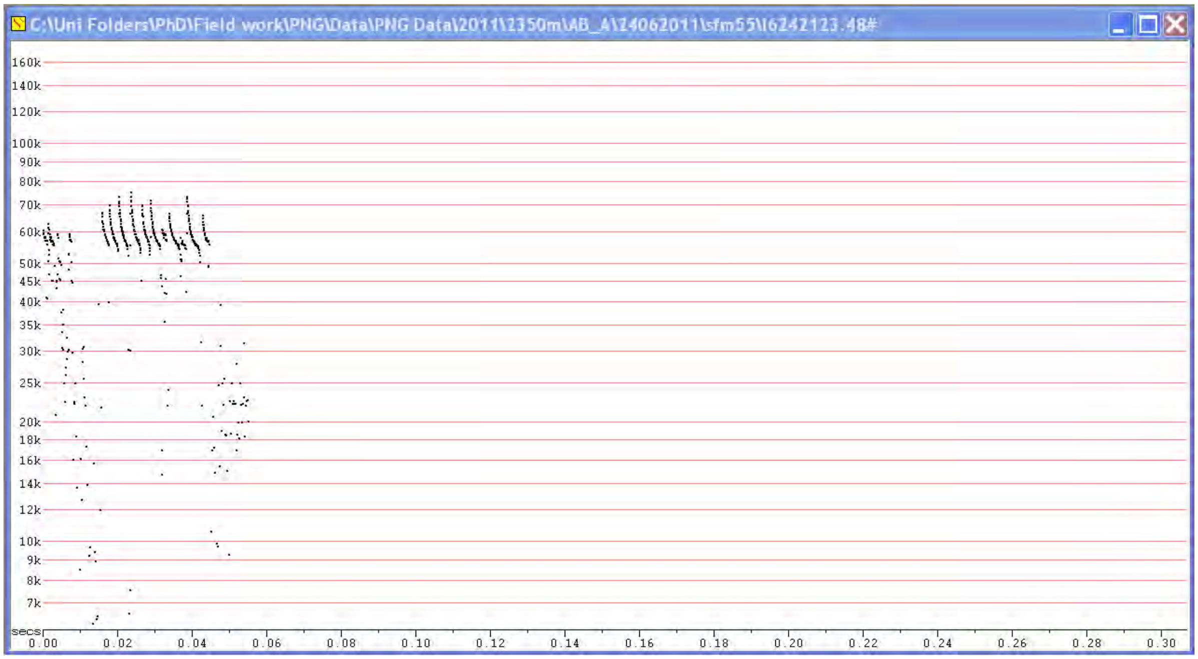
A total of 55 files containing calls of this species were recorded during this survey. Calls were collected at 250m, 750m, 2050m, 2350m, and 3000m elevation (Table 35).

No individuals emitting calls of this frequency could be confidently assigned to any species captured during this survey, and calls could not be confidently matched to any species identified in other existing call libraries. Therefore, positive identification to species could not be made. This species was thus assigned a species code of sfm55, detailing its steep frequency modulated shape (sfm) and characteristic frequency (Figure 38). The call consists of a series of linear pulses ending in a slight downward droop, with a characteristic frequency of around 55kHz. Pulses have an upwards sweep of around 15kHz. The call is displayed below as a compressed file in F7 magnification (Figure 38).It is possible that these calls may be made by the same species as calls coded fm52, due to the presence of the terminal droop. However, pulses of calls coded sfm55 are much steeper than those of fm52 (see 3.5.9). Armstrong and Aplin collected calls with a similar frequency, shape and terminal droop during their surveys in Papua New Guinea (2011). They were unable to identify this call to species so coded it 53*st.cFM.d*. They commented that pulses with this characteristic droop are likely to be from a species of *Miniopterus* or less likely a species of vespertilionid (Armstrong and Aplin, 2011).

Table 35. Elevational records for *sfm55* in Papua New Guinea

Elevation (m asl)	Detected
3000m	X
2800m	
2500m	
2350m	X
2050m	X
1550m	
1150m	
950m	
750m	X
250m	X
0m	

Figure 38. Unidentified species coded *sfm55* (F7, compressed)



6. Acknowledgments

We gratefully acknowledge the funding provided by Conservation International and we especially thank Jonah of Boksawin, Keston of Gormdan, Mala of Worin, and Robin of Ninea for their assistance with, and enthusiasm for, our bat work. We also thank their respective villages for allowing us to work and stay on their land.

April Reside provided invaluable field assistance and moral support during our time on the transect and provided all of the photographs. Thanks April!

Special thanks to Mark Ziembicki, Gabriel Porolak, Bruce Beehler, Trond Larsen, Jen Mandeville, Suzanne Tomassi, Ben Freeman, and Alexandra Class for their help during field work.

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8. Appendix: Megachiroptera captured in the YUS Conservation area

8.1 Nyctimene albiventer, Common Tube-nosed Bat

A member of the genus *Nyctimene*, the tube nosed fruit bats, which are characterised by their tubular like nostrils. This subfamily is endemic to the Indo-Australian region (Bonaccorso, 1998).

Three individuals were caught during this survey. All three were trapped using mist nets. Captures were made between 250m and 1150m elevation (Table 36). Previous studies have recorded this species from sea level up to 1860m in elevation (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003) (Table 36).

For all individuals trapped during this study, the dorsum fur was found to be bicoloured, with dark brown tips and a whitish base, while ventrum fur was whitish. A distinctive characteristic of this species is the presence of a thin, dark stripe in the middle of the back extending from the shoulder blades to the base of the tail (Figure 39). Morphological parameters recorded from trapped individuals were in accordance with previous records, with the exception of a juvenile record added by this study (Table 37). As this species does not echolocate, no call recording is available.

Table 36. Elevational records of *Nyctimene albiventer* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				
2800m				
2500m				
2350m				
2050m				
1550m	X (1860m)	X (1700m)		
1150m	X	X		X
950m	X	X	X (900m)	
750m	X	X	X	X
250m	X	X	X	X
0m	X	X		

Figure 39. ***Nyctimene albiventer*** **with distinctive dorsal stripe**

Table 37. Morphological parameters of *Nyctimene albiventer* in Papua New Guinea.

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	53.60	49.40	56.50	7	-	49.00	58.30	38	58.0	-	-	1
	F	57.40	-	-	1	-	51.00	58.80	33	59.82	-	-	1
	J	-	-	-	-	-	-	-	-	56.8	-	-	1
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	29.70	27.0	33.0	7	-	20.00	38.00	30	33	-	-	1
	F	32.0			1	-	22.00	35.00	11	33	-	-	1
	J	-	-	-	-	-	-	-	-	34	-	-	1

8.2 *Paranyctimene raptor*, Green Tube-nosed Bat

A member of the genus *Nyctimene*, the tube nosed fruit bats, which are characterised by their tubular like nostrils. This species is endemic to Papua New Guinea (Bonaccorso, 1998).

Thirteen individuals were caught during this survey. All were trapped using mist nets. Captures were made between 250m and 1550m elevation.

Previous studies have recorded this species from sea level up to 1350m in elevation (Flannery, 1995; Bonaccorso, 1998) (Table 38). This survey extends the known elevational range of this species.

A distinctive characteristic of this species is a yellowish green tinge to wing and ear membranes, often with yellow spotting on edges (Figure 40). This was evident in all individuals trapped during this study. Dorsum fur was generally bicoloured, with brown tips and a paler brown base, with ventrum fur being paler then the dorsum. Maximum forearm length and weight recording during this survey was slightly higher than previously recorded (Table 39). A juvenile record was also added by this study.

As this species does not echolocate, no call recording is available.

Table 38. Elevational records of *Paranyctimene raptor* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	This study
3000m			
2800m			
2500m			
2350m			
2050m			
1550m			
1150m	X (1350m)	X (1200m)	X
950m	X	X	
750m	X	X	X
250m	X	X	X
0m	X	X	

Figure 40. ***Paranyctimene raptor*** **with distinctive yellowish green wing colouring**

Table 39. Morphological parameters of *Paranyctimene raptor* in Papua New Guinea

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	50.20	48.20	53.30	7	-	47.00	58.00	36	51.71	48.86	52.6	6
	F	51.60	49.80	54.40	3	-	47.00	56.00	27	53.96	52.20	59.19	6
	J	-	-	-	-	-	-	-	-	55	-	-	1
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	24.50	21.80	33.0	7	-	18.00	33.00	26	26.25	25.00	27.00	6
	F	25.70	24.30	26.80	3	-	18.00	30.00	19	29.91	25.00	35.00	6
	J	-	-	-	-	-	-	-	-	24.5	-	-	1

8.3 *Macroglossus minimus nanus*, Least Blossom Bat

Representing the blossom bats, a group of bats whose long snouts and tongues are specialised for eating nectar and pollen, the least blossom bat is the smallest of the blossom bats found in New Guinea (Bonaccorso, 1998). Two subspecies occur in the region with *M. minimus nanus* being found on the mainland, and *M. minimus microtis* found on small islands to the east of Papua New Guinea.

Three individuals were caught during this survey. All were trapped using mist nets at 1550m elevation, however, previous studies have recorded this species from sea level up to 1280m in elevation (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003) (Table 40). This survey extends the known elevational range of this species.

The fur of all individuals caught was bicoloured being whitish at the base and light brown at the tips, with a whitish underbelly (Figure 41). Superficially similar to *Syconycteris australis* (see 3.4.4), *M. minimus* can be distinguished by its much quieter temperament. Maximum forearm length of the two females, and weight of all individuals recorded during this survey was higher than previously recorded (Table 41).

As this species does not echolocate, no call recording is available.

Table 40. Elevational records of *Macroglossus minimus* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m				
2800m				
2500m				
2350m				
2050m				
1550m				X
1150m		X (1200m)	X (1280m)	
950m	X (1000m)	X		
750m	X	X		
250m	X	X		
0m	X	X		

Figure 41. ***Macroglossus minimus nanus*** **characterised by its long slender snout**

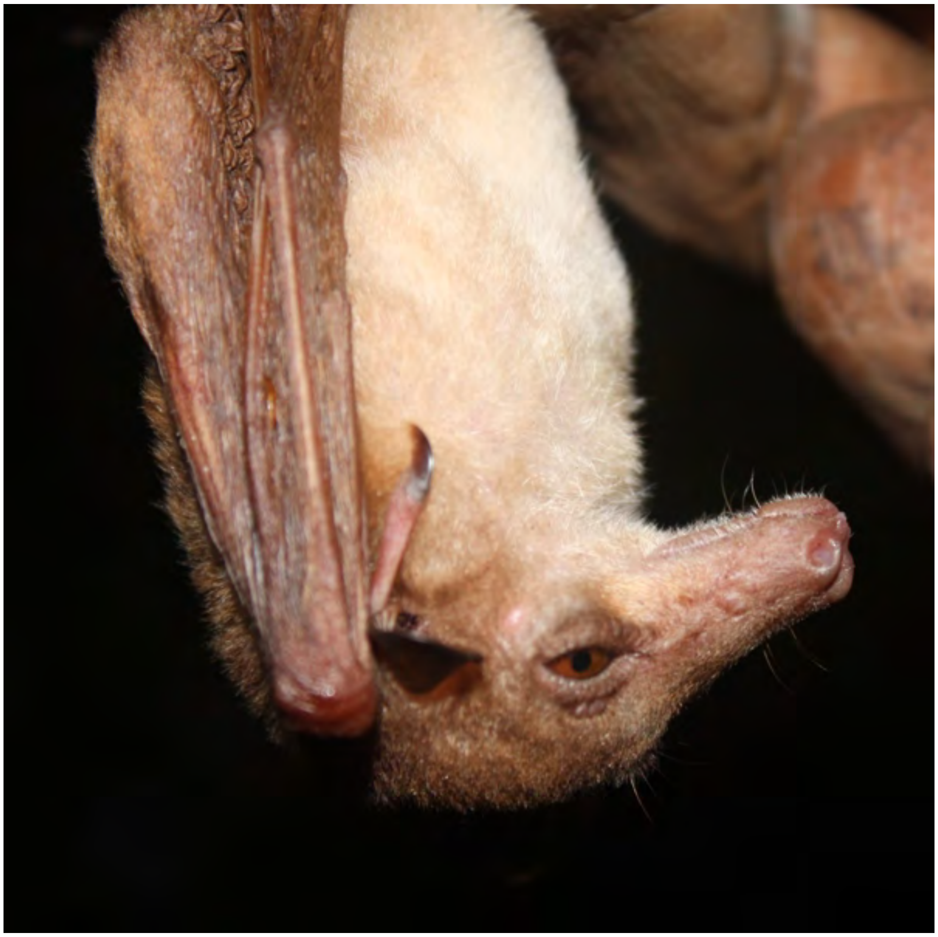

Table 41. Morphological parameters of ***Macroglossus minimus nanus*** **in Papua New Guinea**

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	40.30	38.70	42.40	8	-	37.50	43.40	18	43.37	-	-	1
	F	40.10	37.40	43.20	9	-	37.20	43.20	16	44.69	44.47	44.91	2
	J	-	-	-	-	-	37.40	40.80	5	-	-	-	0
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	16.80	14.00	18.50	6	-	14.10	21.30	14	35.75	-	-	1
	F	18.10	14.50	21.00	7	-	14.50	21.00	14	24.5	24.5	-	2
	J	-	-	-	-	-	11.140	15.00	6	-	-	-	0

8.4 *Syconycteris australis*, Common Blossom Bat

This species has been broken up into seven subspecies, four of which occur in Papua New Guinea (Bonaccorso, 1998). *Syconycteris australis papuan* is likely to be the species found on the Huon Peninsula.

Of the 39 individuals caught during this survey, only one was captured in a harp trap, with the rest being trapped using mist nets. One female, captured at 300m elevation was caught with young attached (Figure 42). Captures were made between 250m and 2050m elevation. Previous studies have recorded this species from sea level up to 3000m in elevation (Flannery, 1995; Bonaccorso, 1998; Dabek, 2001, 2003) (Table 42).

The fur of all individuals caught was bicoloured, being whitish at the base and light brown at the tips, with a whitish underbelly (Figure 42). Superficially similar to *M. minimus* (see 3.4.3), *S. australis* can be distinguished by its raucous temperament. Morphological parameters recorded from trapped individuals were in accordance with previous records (Table 43).

As this species does not echolocate, no call recording is available.

Table 42. Elevational records of *Syconycteris australis* in Papua New Guinea

Elevation (m asl)	Flannery (1995)	Bonaccorso (1998)	Dabek (2001, 2003)	This study
3000m	X	X		
2800m	X	X		
2500m	X	X	X (2600m)	
2350m	X	X	X	
2050m	X	X	X	X
1550m	X	X	X (1800m)	X
1150m	X	X	X (1280m)	X
950m	x	X	X (900m)	X
750m	X	X	X	X
250m	X	X	X	X
0m	X	X		

Figure 42. ***Syconycteris australis*** **female with dependant young**

Table 43. Morphological parameters of *Syconycteris australis* in Papua New Guinea.

		Flannery (1995)				Bonaccorso (1998)				This study			
FA	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	42.70	39.90	44.60	31	-	39.00	46.20	73	44.14	41.19	52.59	18
	F	42.00	38.60	44.00	20	-	38.00	48.00	44	43.67	41.5	46.0	12
	J	-	-	-	-	-	40.20	43.10	6	42.20	39.94	43.73	9
WT	Sex	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N
	M	17.10	15.00	20.20	31	-	14.50	23.50	84	19.48	14.5	22.25	18
	F	17.60	13.30	23.00	20	-	13.00	23.00	43	19.31	16.0	24.0	12
	J	-	-	-	-	-	12.80	19.60	6	17.38	15.0	20.0	9