

## Research Article

# Bats of Waigeo Island, Indonesia, with new distributional records

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**ABSTRACT.** A bat survey on Waigeo Island was conducted from May to June 2007 as a part of the Widya Nusantara Expedition. A total of 15 species of bats comprising ten Megachiropterans and five Microchiropterans were recorded. Five species are new records for Waigeo Island, i.e. *Pteropus conspicillatus*, *Dobsonia* cf. *minor*, *Nyctimene* cf. *cyclotis*, *Paranyctimene raptor* and *Hipposideros papua*. Based on this survey and previous published records, 24 species of bats are found on Waigeo Island. The record of the montane species *N. cf. cyclotis* in a lowland area gives new information relating to its ecology and systematics.

**Keywords:** Chiroptera, new distributional records, Indonesia, Waigeo Island.

## INTRODUCTION

Waigeo is the largest island in the Raja-Ampat Archipelago with a length of 125 km and 50 km in width. The island is located between West Papua and the Moluccas Archipelago and is a transitional zone which gives an opportunity for species to migrate from mainland Papua to the Wallacea region, or the reverse. These conditions effect the distribution of fauna, including bats. Waigeo Island is mainly composed of limestone from fossilized coral reefs (Meinig, 2002) that provide a lot of caves as potential roosting sites for bats. More than half of the Indonesian microchiropteran roost

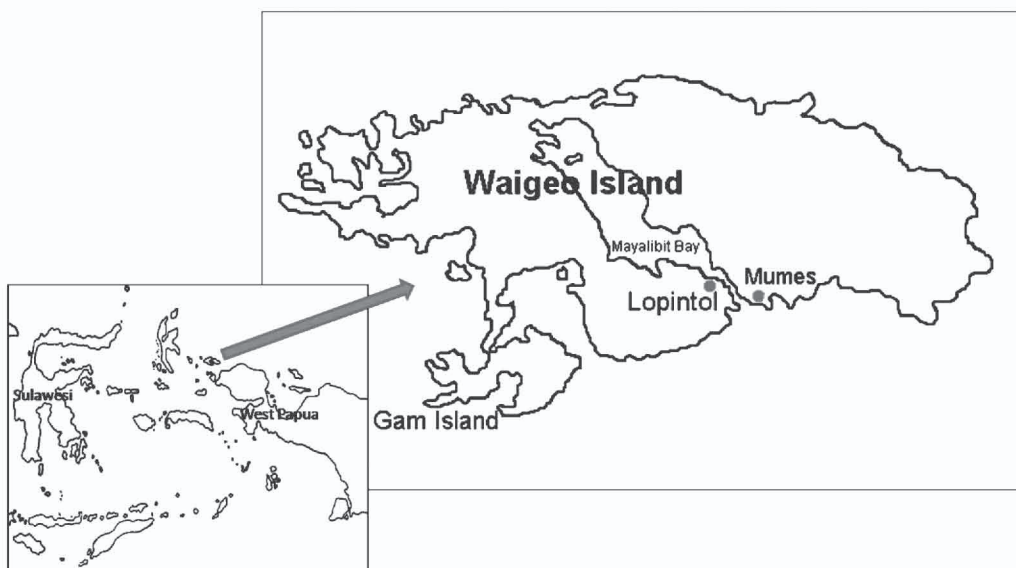
in caves (Suyanto, 2001).

Previous records of bats on Waigeo have been published by Flannery (1995a, b) who recorded four species; Bergmans (1975, 2001) added four species to the island and two of them were new species (*Dobsonia beauforti* Bergmans, 1975 and *Nyctimene* (*Paranyctimene*) *tenax marculus* Bergmans, 2001) and the recent publication by Meinig (2002) recorded ten species as new for Waigeo. The present bat survey on Waigeo was conducted in May-June 2007 by the Museum Zoologicum Bogoriense (MZB). The survey was a part of the Widya Nusantara Expedition conducted by the Indonesian Institute of Sciences. This paper documents the results of the bat survey on Waigeo Island and compares the results with previous publications.

## MATERIALS AND METHODS

### Survey sites

The survey covered localities which represent all the different habitats in Waigeo Island and which were possible bat roosting sites, foraging area and fly ways. The survey sites consisted of caves and non cave habitats (Figure 1; Table 1). A total of 19 caves were surveyed and 15 of these contained bats. The non-cave habitats surveyed were classified as secondary forests, mangroves and orchards.



**Figure 1.** Map of Waigeo Island.

### Sampling methods

Ten standard mist nets (two ply polyester 75d) with 31 mm mesh size, 2.7 m in height with various lengths (9 and 12 m) were deployed in each location at non-cave habitats. Mist nets were set along forest trails, across a river and around fruit trees. All nets were opened at 1730 hours and left open until 0600 hours the next morning. Direct collecting with a hand-net was used in caves.

Body measurements of captured bats were taken by a digital caliper in the field: weight (W), head and body length (HB), tail length (T), ear length (E), tibia length (Tb), forearm length (FA) and hind foot length (HF). Sex and age were also recorded. Skull measurements were measured in the laboratory: greatest skull length (GSL), condylobasal length (CBL), condylocanine length (CCL), zygomatic breadth (ZB), upper canine to third molar length (CM<sup>3</sup>), outside upper canine breadth (C'C'), braincase width (BW) and braincase height (BH). All specimens were identified and deposited in the Museum Zoologicum Bogoriense (MZB).

### RESULTS

A total of 15 species comprising ten megachiropterans and five microchiropterans were recorded during this survey. Five species are new records for Waigeo Island. They are: *Pteropus conspicillatus*, *Dobsonia* cf. *minor*, *Nyctimene* cf. *cyclotis*, *Paranyctimene raptor* and *Hipposideros papua*. Notes on the species collected are recorded below.

#### Species accounts

Family Pteropodidae

*Pteropus conspicillatus* Gould, 1850

(Spectacled Flying Fox)

*Specimen examined*: one male, MZB 30037, coll. S. Wiantoro & N. Supriatna, 12 June 2007.

*Remarks*: A single specimen was caught in the mangrove habitat at the lower course of the Waisaboi River. There was a colony of this species in mangroves which consisted of about 30 individuals.

Strahan (1995) and Duncan *et al.* (1999) recorded this species as being found in lowland swamps, mangroves and tropical moist forest

Table 1. Sampling sites, coordinates and ecological notes on the study areas on Waigeo Island.

No	Sites	GPS coordinates	Note
<b>Caves</b>			
1	Kalepale	S 00°17' 18" E 130°49'15"	Cave entrance on the bank facing the sea, 10 m above sea level and about 7 m high and 15 m wide. Full of stalactites, floor covered by water. Temperature about 26 C. Four species of bat were recorded, <i>D beauforti</i> , <i>A. tricuspidatus</i> , <i>H. papua</i> and <i>E. raffrayana</i> .
2	Aleg Afni	S 00°18'29.8" E 130°54'25.4"	This cave has large chamber with about 15 m high with some openings in the ceiling. The floor covered by guano with millions of Isopoda living on it. Two species of bats roost here, <i>D. magna</i> and <i>H. maggietylorae</i> .
3	Wailepe 1	S 00°19'02.6" E 130°53'38.1"	Near to Lopintol Village. Entrance and passages are small with total length about 50 m. Floor is wet and muddy. <i>Hipposideros papua</i> was found in this cave with the population below 100 individuals.
4	Wailepe 3	S 00°18'56.6" E 130°53'18.4"	There is a climb of about 5 m from the sea level to reach the entrance. Total length of passage about 8 m. Only one species was found, <i>Emballonura raffrayana</i> .
5	Muliale 1	S 00°18'32.3" E 130°54'00.4"	Entrance very large being about 3 m high, total length of passage about 50 m. One species of bat was found, <i>H. papua</i> .
6	Muliale 2	-	Near to the Muliale 1 with entrance about 2 m from sea level and has 5 m total length. One species was found, <i>E. raffrayana</i> .
7	Monfaya	S 00°18'18.2" E 130°54'04.5"	Cave at the bank, about 5 m above the sea level. Total length of passage about 25 m. <i>Emballonura raffrayana</i> was recorded in this cave.
8	Bayon	S 00°18'21.7" E 130°51'07.1"	Near to the lower course of Bayon River. Total length about 10 m with only one chamber. A lot of <i>E. raffrayana</i> were found here.

9	Waemanila	S 00°17'44.3" E 130°52'57"	0 m above sea level, this cave was like a tunnel and sea water entered the cave. <i>E. raffrayana</i> was recorded here.
10	Waerabiae	-	Near to the Wairabiae River, a small cave with only one species recorded, <i>E. raffrayana</i> .
11	Mamahmon	S 00°17'54.4" E 130°47'57.9"	This cave was in the Wailukum area and was formed by crack in the bank. Two species were recorded, <i>Dobsonia magna</i> and <i>E. raffrayana</i> .
12	Mantafi	-	This cave in the Wailukum area, was small with an entrance 1 m high and 0.5 m wide. One species was recorded, <i>E. raffrayana</i> .
13	Mantafipo	-	Near to Mantafi Cave. Floor covered by water. One species was recorded, <i>E. raffrayana</i> .
14	Waepale	-	This cave located in the Wailukum area. Floor covered by water. One species was recorded, <i>E. raffrayana</i> .
15	Abanalio	S 00°21'15" E 130°58'57"	This cave was found in the Munes area. Entrance was about 2 m above sea level. Parts of a human and a <i>Sus</i> sp. skull were found here. One species of bat was recorded, <i>E. raffrayana</i> .
16	<b>Non caves</b> Secondary forest Lopintol	S 00°19' E 130°53'	Located at the west of Lopintol Village. Vegetation was dominated by <i>Ficus</i> sp. and some palm trees.
17	Secondary forest Wairabiae	-	Located at the coast of Mayalibit. Sampling site was near to the Wairabiae River. Vegetation was dominated by <i>Ficus</i> sp.
18	Orchard Lopintol	S 00°19' 02.9" E 130°53'42.7"	Around the Lopintol Village. Dominated by <i>Syzygium</i> sp.
19	Mangrove Waisaboi	-	Located at the Wailukum area. Lower course of the Waisaboi River.

habitats. Identification was based on morphological characters and the description by Flannery (1995a, b). This species has a distinctive yellow mantle, which contrasts strongly with the black fur of the back and yellow green fur surrounding the eyes. The single specimen from Waigeo was very large (forearm 190 mm), whereas Flannery (1995a, b) recorded the range of forearm length as 158–188.5 mm). No previous records for this species exists from Waigeo (Flannery, 1995a, b; Bergmans, 2001; Meinig, 2002).

***Dobsonia beauforti*** Bergmans, 1975  
(Beaufort's Naked-backed Fruit Bat)

*Specimens examined:* Seven adult males, MZB 30000, MZB 30001, MZB 30002, MZB 30003, MZB 30005, MZB 30006 and MZB 30007, and one adult female, MZB 30004, from Lopintol Village and Kalepale Cave; coll. S. Wiantoro & N. Supriatna, 29–31 May 2007.

*Remarks:* Waigeo is the type locality of this species. 14 type specimens were collected from a cave near the village of Nja-Njef (Bergmans, 1975). Meinig (2002) recorded that this species occurred in the dusky entrances of caves at the islands of the Raja-Ampat Archipelago. This species was found roosting in the totally dark zone at Kalepale Cave. The bats occupied a large chamber with *Asseliscus tricuspidatus* which roosted at the side of the chamber. It appears that *D. beauforti* uses the cave as a day roosting site. At night an orchard area and secondary forest were used as foraging areas.

Six of seven adult males (MZB 30000, MZB 30001, MZB 30002, MZB 30003, MZB 30005 and MZB 30007) collected on 29–31 May had enlarged testes, and one adult female (MZB 30004) had swollen nipples. Flannery (1995b) suggested that birth takes place around December on Waigeo, whereas on Batanta many pregnant females were observed in October, and a few females had already given birth.

***Dobsonia cf. minor*** (Dobson, 1879)  
(Lesser Naked-backed Fruit Bat)

*Specimens examined:* One adult male, MZB

30033, and one adult female, MZB 30035 collected in Wairabiae forest, Waigeo Island; coll. S. Wiantoro & N. Supriatna, 4–5 June 2007.

*Remarks:* Two specimens that were collected from Wairabiae are provisionally assigned to *Dobsonia minor*. Body measurements (Table 2) are larger than *D. minor* but smaller than *D. beauforti*. Forearm length 98–99 mm versus 80–86 mm (Flannery, 1995a, b) and <95 mm (Corbet & Hill, 1992) compared to *D. minor*. Whereas, the forearm length of *D. beauforti* lies between 105–110 mm (Flannery, 1995b). Both specimens have tiny teeth which are smaller compared to other bare-backed fruit bats. The adult male (MZB 30033) had slightly larger teeth compared to the adult female (MZB 30035). I agree with Flannery (1995b) that in the field it is difficult to differentiate *D. minor* and sub adult *D. beauforti*. There are very few records of this species which is categorized as rare (Flannery, 1995b). No previous records for the species exists from Waigeo Island (Flannery, 1995a, b; Bergmans, 2001; Meinig, 2002).

***Dobsonia magna*** Thomas, 1905  
(New Guinea Naked-backed Fruit Bat)

*Specimens examined:* One adult male, MZB 30036, from Lopintol Village, 8 June 2007; two adult females, MZB 30009 from a secondary forest at Lopintol, 29 May 2007 and MZB 30012, Wairabiae, 5 June 2007; coll. S. Wiantoro & N. Supriatna.

*Remarks:* This species was also recorded in Aleg Afni and Mamahmon caves (Table 1). Body measurements of three specimens showed them to be the largest naked-backed fruit bats with a forearm length of 151.5; 162 and 161 mm and thus fall into the range of *D. magna*. Although, Bonaccorso (1998) regarded *D. magna* as a subspecies of *D. moluccensis*, here, I follow Bergmans & Sarbini (1985) findings that *D. magna* from New Guinea is distinct from *D. moluccensis*. *D. magna* becomes the available name for the New Guinean population, while *D. moluccensis* is reserved for the central Moluccan populations.

The recent record of *D. moluccensis* from Waigeo by Meinig (2002) is predicted to be *D. magna*. Simmons (2005) also noted that *D. magna* was distributed on Waigeo. Further taxonomic research is needed to solve the status of these two species. Adult male (MZB 30036) had enlarged testes. It is predicted that June may be the breeding season for this species.

***Nyctimene albiventer* (Gray, 1863)**

(Common Tube-nosed Fruit Bat)

**Specimens examined:** Four adult males, MZB 30020 from an orchard near Lopintol Village, 31 May 2007, two, MZB 30022 and MZB 30024 from a secondary forest at Lopintol, 31 May 2007, and MZB 30026 from Wairabiae, 4 June 2007; coll. S. Wiantoro & N. Supriatna.

**Remarks:** *N. albiventer* is a common and widespread species. It is one of the most abundant fruit bats found in the primary rainforests of Papua New Guinea (Bonaccorso, 1998; Flannery, 1995a). The four specimens from Waigeo were captured in secondary forests. Body measurements (Table 2) are larger than specimens collected by Flannery (1995a, b) and Meinig (2002).

***Nyctimene cf. cyclotis* K. Andersen, 1910**

(Round-eared Tube-nosed Fruit Bat)

**Specimen examined:** Single adult female, MZB 30021 collected in an orchard near Lopintol with an elevation of about 5 m asl; coll. S. Wiantoro & N. Supriatna, 31 May 2007.

**Remarks:** According to Petersen (1992), Bonaccorso (1998) and Flannery (1995a, b) this species is restricted to higher elevations between 780 and 1400 m asl. Contrary to this, Meinig (2002) recorded five specimens that were netted 5 m asl in primary forest in Mansuar Island. These data support Bergmans (2001) findings that the taxonomy of *Nyctimene* in the region is still under consideration. Based on morphological characters, the single specimen from Waigeo was identified as *N. cyclotis*. It differs from the other *Nyctimene* species by having short, rounded ears with a thickened rim (Flannery, 1995a, b). Skull measurements (Table 3) fall

into the range of *N. cyclotis*. The condylobasal length of 26.8 mm differs from *N. certans* which has a larger skull (condylobasal length 28.5–31.0 mm) (Flannery, 1995a). No previous records for the species exist from Waigeo Island (Flannery, 1995a, b; Bergmans, 2001; Meinig, 2002).

***Paranyctimene raptor* Tate, 1942**

(Unstriped Tube-nosed Fruit Bat)

**Specimens examined:** Two adult males, MZB 29997 from an orchard near Lopintol Village, 29 May 2007 and MZB 29998 from a secondary forest near Lopintol, 31 May 2007; one adult female, MZB 29999 from a secondary forest at Lopintol, 31 May 2007; coll. S. Wiantoro & N. Supriatna.

**Remarks:** This species differs from other tube-nosed fruit bats by having no dorsal stripe and the canines being extraordinarily long (Flannery, 1995b). Furthermore, Tate (1942) segregated this species as a different genus from *Nyctimene* based on an examination of the skull which has peculiarities of dentition, as well as lacking any trace of a dorsal stripe. The upper and lower canines are exceptionally long, slender and dagger-like which suggest a highly developed grappling or seizing function. The upper and lower third and fourth premolars have high compound blades whose function no doubt supplements that of the canines. Bergmans (2001) suggested that *Paranyctimene* be considered as a subgenus of *Nyctimene* and described as a new species of *Nyctimene* (*Paranyctimene*) *tenax marculus* from Waigeo. He noted that the *tenax* was larger than the *raptor*. Body and skull measurements of three specimens (Tables 2 and 3) are smaller compared to the holotype of *N. (P.) tenax marculus* (MZB 26626; male) and are considered as *P. raptor*. Based on these data, the two species co-exist in Waigeo Island. These three specimens are the first record for Waigeo Island (see Flannery, 1995a, b; Meinig, 2002) and the second record for islands outside of mainland New Guinea. This species was previously known only from New Guinea, but specimens from Salawati Island were recently collected by Boeadi and Flannery (Flannery,

1995b). It is predicted that this species is also distributed on other islands surrounding New Guinea.

***Rousettus amplexicaudatus*** (E. Geoffroy, 1810)

(Geoffroy's Rousette)

***Specimens examined:*** Two adult males, MZB 30015 and 30017 from an orchard near Lopintol village, 31 May 2007; two sub adult males, MZB 30018 and MZB 30019 from Wairabiae, 3 June 2007; one adult female, MZB 30014 from an orchard near Lopintol Village, 31 May 2007; one sub adult female, MZB 30016 from a secondary forest at Lopintol, 31 May 2007; coll. S. Wiantoro & N. Supriatna.

***Remarks:*** This is a widespread species and can be found on every island in the Rajah-Ampat Archipelago (Meinig, 2002). This species has previously been recorded as a cave roosting species, but the species was not recorded from any of the 19 caves surveyed on Waigeo. One male (MZB 30017) netted in an orchard on 31 May showed enlarged testes. Meinig (2002) recorded a male from Waigeo that showed enlarged testes in early July. Flannery (1995a) recorded four females in an advanced stage of pregnancy at Yapsei, Sandaun Province, Papua New Guinea in January 1984. On his return to the area in April 1986, of 13 females, six were lactating and he suggested that breeding is strongly seasonal in this region.

***Macroglossus minimus*** (E. Geoffroy, 1810)

(Dagger-toothed Long-nosed Fruit Bat)

***Specimens examined:*** Two adult males, MZB 29991 and MZB 29995 and five adult females MZB 29981, MZB 29992, MZB 29993, MZB 29994 and MZB 29996, all from an orchard and secondary forest at Lopintol, 29-31 May 2007; coll. S. Wiantoro & N. Supriatna.

***Remarks:*** *M. minimus* is a widespread species. According to Simmons (2005) this species is distributed from Thailand to the Philippines, Indonesia, Papua New Guinea, Solomon Islands and Northern Australia. In the present survey, one adult male (MZB 29991) collected

on 29 May showed enlarged testes and three females (MZB 29981, MZB 29993 and MZB 29994) collected on 29-31 May had swollen nipples. Previously, Bergmans & Rozendaal (1988) noted that Sulawesi females collected on 10-11 February and 27 March were pregnant, while a female caught on 8 November had large nipples. One female they examined from Sangihe Island which was caught on 14-15 May, was pregnant. These data suggests that the reproductive biology of this species differs from one locality to another. It is predicted that habitat condition and fruit availability will affect the reproductive biology of this species.

***Syconycteris australis*** (Peters, 1867)

(Southern Blossom Bat)

***Specimens examined:*** Three adult males, MZB 29984, MZB 29988 from secondary forest Lopintol, 31 May 2007 and MZB 29990 from Wairabiae, 6 June 2007, six adult females, MZB 29980, MZB 29982, from an orchard near Lopintol Village, 31 May 2007, and MZB 29983, MZB 29986, MZB 29987, MZB 29989 from a secondary forest at Lopintol, 31 May-1 June 2007; coll. S. Wiantoro & N. Supriatna.

***Remarks:*** This species is also known as the Common Blossom Bat (Flannery, 1995b), and is similar in appearance to *Macroglossus* but *Syconycteris* has no interfemoral membrane and larger incisors (Corbet & Hill, 1992). In Waigeo Island, it co-occurs with the other nectar-feeding bat, *Macroglossus minimus*. Of the nine individuals caught, two adult females: MZB 29987 was pregnant, and MZB 29980 had recently ceased lactating.

Family Emballonuridae

***Emballonura raffrayana*** Dobson, 1879

(Raffray Sheath-tailed Bat)

***Specimens examined:*** 16 adult males, MZB 30056, MZB 30057, MZB 30059, MZB 30060, MZB 30061, MZB 30062, MZB 30064, MZB 30066, MZB 30067, MZB 30068, MZB 30069, MZB 30071, MZB 30073, MZB 30074, MZB 30075, MZB 30099 and three adult females MZB 30055, MZB 30058, MZB 30070; coll. S. Wiantoro & N. Supriatna.

**Remarks:** All specimens were caught in caves; Wailepe 1, Wailepe 3, Kalepale, Monfaya, Waemanila, Bayon, Mamahmon and Abanalia (Table 1). The species was also recorded in other caves, namely Muliale 1, Muliale 2, Wairabiae 1, Mantafi, Mantafipo and Waipale, but no specimens were taken from these caves. *E. raffrayana* was recorded sharing their roost with other bat species at two caves. In Kalepale Cave, this species occurred with *D. beauforti*, *A. tricuspидatus* and *H. papua*, and in Mamahmon Cave with *D. magna*. Although *E. raffrayana* occupied caves with other bat species, it usually roosted at or near the entrance and in the twilight zone, and did not roost in the totally dark zone. Of three adult females caught, two (MZB 30055 and MZB 30058) had recently ceased lactating and another (MZB 30070) was lactating and was netted together with a baby on 2 June.

#### Family Hipposideridae

*Aselliscus tricuspидatus* (Temminck, 1835)  
(Temminck's Asian Trident Bat)

**Specimens examined:** Three adult males, MZB 30077 and MZB 30078 from Kalepale cave, 31 May 2007, and MZB 30080 from an orchard near Lopintol village, 3 June 2007, one adult female, MZB 30079 from Kalepale cave, 31 May 2007; coll. S. Wiantoro & N. Supriatna.

**Remarks:** This species roosted with *D. beauforti* in the same chamber in Kalepale Cave. More than 100 individuals roosted at the side of the chamber on the wall and usually hung individually. Some of the bats were recorded hanging on cave ornaments, i.e. at stalactites and gordynes. The single specimen which was misnetted in an orchard was predicted to roost in a cave near Lopintol Village, such as Kalepale Cave. The adult female from Kalepale Cave (MZB 30079) was pregnant. A previous study by Meinig (2002) recorded a pregnant female from Waigeo on 06 July 2000.

*Hipposideros maggietaaylorae* Smith and Hill, 1981

(Maggie Taylor's Leaf-nosed Bat)

**Specimens examined:** One adult male, MZB

30053 and five adult females, MZB 30049, MZB 30050, MZB 30051, MZB 30052 and MZB 30054 collected from Aleg Afni Cave; coll. S. Wiantoro & N. Supriatna, 31 May 2007.

**Remarks:** All six specimens were collected from one location, Aleg Afni Cave, but the species was not recorded at other cave during the present survey. *H. maggietaaylorae* co-occured with *D. magna* at this cave, but it occupied a small chamber and bell holes near the entrance. Sometimes, identification of this species was confused with *H. calcaratus*. Based on external body and skull measurements (Tables 2 and 3), the forearm length of four were in the range of the larger *H. calcaratus*, while the others fell into *H. maggietaaylorae* (Smith & Hill, 1981; Flannery, 1995b). I followed Smith & Hill (1981) and identified all six specimens as *H. maggietaaylorae*. The calcar was long, more than half the length of the tibia. The fifth tail vertebra was short and not equal to the other four tail vertebrae. The upper canines were large and bulbous at the base with the posterior supplementary cusp strong, well developed and extending from base at least one third along the length of the tooth.

Of the five adult females caught on 31 May, two (MZB 30051 and MZB 30052) had recently ceased lactating, while the others had swollen nipples. The adult male did not show active testes.

*Hipposideros papua* (Thomas and Doria, 1886)

(Biak Leaf-nosed Bat)

**Specimens examined:** Four adult males, MZB 30038, MZB 30040, MZB 30042 and MZB 30046 and seven adult females, MZB 30039, MZB 30041, MZB 30043, MZB 30044, MZB 30045, MZB 30047 and MZB 30048 from caves; coll. S. Wiantoro & N. Supriatna, 30-31 May 2007.

**Remarks:** This species was caught in three caves on Waigeo; Waelepe 1, Kalepale and Muliale 1. This species co-occured with *E. raffrayana*, *A. tricuspидatus* and *D. beauforti* in

Table 2. Body measurements (all in mm) of adult specimens collected from Waigeo Island.

Species	N	Head and body length	Tail length	Ear length	Forearm length	Tibia length	Hindfoot length
<i>Pteropus conspicillatus</i>	1 ♂	270	0	38.7	190	88	52
<i>Dobsonia beauforti</i>	7 ♂1♀	138.31 (122.36-159.90)	37.63 (23.05-124.44)	25.18 (23.15-26.56)	104.14 (101.46-106.26)	48.08 (44.70-50.62)	22.88 (19.04-27.52)
<i>Dobsonia cf. minor</i>	1 ♂1♀	122.68 (110.90-134.45)	27.90 (26.96-28.84)	26.48 (26.31-26.65)	98.82 (98.56-99.08)	43.85 (43.76-43.95)	23.13 (22.74-23.52)
<i>Dobsonia magna</i>	1 ♂2♀	208.33 (185-225)	31.27 (28.46-33.34)	35.27 (34.35-36.41)	158.17 (151.5-162)	73.1 (65.86-79.49)	36.98 (35.95-37.58)
<i>Nyctimene albiventer</i>	4 ♂	80.25 (78.72-83.2)	23.09 (19.35-27.03)	16.53 (13.22-23.34)	56.58 (55.46-57.49)	22.77 (22.26-23.04)	12.43 (11.58-13.81)
<i>Nyctimene cf. cyclotis</i>	1 ♀	81.76	25.57	15.72	59.79	22.75	12.78
<i>Paranyctimene raptor</i>	2 ♂1♀	73.75 (70.04-78-6)	17.22 (16.96-17.75)	12.42 (11.22-13.02)	50.73 (50.72-50.74)	19.64 (19.38-20.16)	12.16 (12.01-12.47)
<i>Rousettus amplexicaudatus</i>	2 ♂1♀	112.62 (106.4-123.32)	19.44 (15.52-21.78)	21.91 (19.64-26.46)	86.29 (85.88-87.03)	41.1 (37.78-44.7)	19.84 (18.27-22.35)
<i>Macroglossus minimus</i>	2 ♂5♀	65.84 (61.44-72.54)	0	13.45 (11.64-15.73)	40.08 (39.26-42.27)	16.84 (16.2-17.54)	11.55 (10.68-12.7)
<i>Syconycteris australis</i>	3 ♂6♀	66.62 (63.71-69.46)	0	14.76 (14.07-15.61)	45.06 (43.25-46.63)	17.71 (17.15-18.54)	11.09 (10.27-11.99)
<i>Emballonura raffrayana</i>	16 ♂3♀	45.99 (42.8-48.86)	11.55 (7.73-15.16)	11.82 (10.11-13.42)	37.77 (36.21-39.97)	15.45 (14.39-16.21)	7.65 (6.14-8.18)
<i>Aselliscus tricuspidatus</i>	3 ♂1♀	41.39 (40.13-42.62)	21.61 (20.61-23.1)	11.52 (10.35-12.45)	39.43 (37.77-40.85)	14.59 (13.79-15.14)	5.3 (5.06-5.5)
<i>Hipposideros maggietaaylorae</i>	1 ♂5♀	66.28 (65.2-66.72)	37.96 (36.77-39.28)	17.01 (15.65-18.78)	55.52 (54.85-56.28)	24.71 (24.35-25.22)	9.80 (9.31-10.1)
<i>Hipposideros papua</i>	4 ♂7♀	54.16 (48.94-58.9)	26.01 (22.04-29.92)	15.86 (13.3-17.77)	49.47 (48.3-50.86)	18.86 (18.35-19.27)	7.57 (6.8-8.46)
<i>Rhinolophus euryotis</i>	1 ♀	52.6	21.14	19.7	52.8	24.54	11.54

\*Values in parentheses indicate range of minimum to maximum measurements.

**Table 3.** Skull measurements (all in mm) of adult specimens collected from Waigeo Island. Abbreviations: greatest skull length (GSL), condylobasal length (CBL), condylocanine length (CCL), zygomatic breadth (ZB), upper canine to third molar length (CM<sup>3</sup>), outside upper canine breadth (C<sup>1</sup>C<sup>1</sup>), braincase width (BW) and braincase height (BH).

Species	N	GSL	CBL	CCL	ZB	CM <sup>3</sup>	C <sup>1</sup> C <sup>1</sup>	BW	BH
<i>Pteropus conspicillatus</i>	1 ♂	77.10	76.18	70.30	45.60	28.74	15.42	25.20	21.90
<i>Dobsonia beauforti</i>	7 ♂1 ♀	42.73 (41.48-43.62)	40.82 (39.96-42.2)	40.32 (38.72-41.58)	27.15 (26.6-27.56)	16.52 (15.3-17)	8.56 (7.9-8.84)	16.46 (16.08-16.9)	15.48 (14.64-16.1)
<i>Dobsonia cf. minor</i>	1 ♂1 ♀	40.2 (39.22-41.18)	38.99 (38.14-39.84)	38.08 (37.3-38.86)	24.43 (24.24-24.62)	16.05 (15.4-16.7)	7.73 (7.46-8.00)	16.44 (16.38-16.5)	14.49 (14.48-14.5)
<i>Dobsonia magna</i>	1 ♂2 ♀	59.43 (57.72-60.3)	58.46 (55.6-60.18)	57.65 (55.00-59.12)	36.82 (34.52-38.00)	24.84 (24.42-25.1)	11.39 (11.00-11.68)	20.32 (19.52-21.24)	18.70 (17.86-19.62)
<i>Nyctimene cf. cyclotis</i>	1 ♀	27.96	26.08	25.90	18.40	9.10	5.50	12.34	9.90
<i>Paranyctimene raptor</i>	2 ♂1 ♀	24.56 (24.32-24.86)	23.62 (23.24-24.00)	23.34 (23.00-23.8)	16.30 (15.88-16.58)	8.64 (8.54-8.74)	4.50 (4.42-4.58)	11.09 (10.78-11.3)	8.74 (8.54-8.84)
<i>Emballonura raffrayana</i>	16 ♂3 ♀	14.13 (13.2-15.00)	12.78 (12.00-13.44)	11.92 (11.46-12.28)	8.41 (8.00-8.70)	5.07 (4.50-11.72)	3.51 (3.30-3.72)	6.72 (6.28-7.20)	5.33 (5.08-5.76)
<i>Aselliscus tricuspidatus</i>	3 ♂1 ♀	14.34 (14.1-14.62)	12.78 (12.36-13.04)	12.14 (12.00-12.34)	7.11 (7.00-7.20)	4.94 (4.92-5.00)	3.48 (3.44-3.52)	5.77 (5.68-5.80)	4.77 (4.62-4.90)
<i>H. maggietaaylorae</i>	1 ♂5 ♀	24.03 (23.74-24.32)	20.88 (20.70-21.06)	20.01 (19.6-20.5)	12.57 (12.36-12.90)	7.82 (7.46-8.28)	5.21 (5.08-5.40)	9.62 (9.42-9.80)	7.85 (7.60-8.04)
<i>Hipposideros papua</i>	4 ♂7 ♀	19.12 (18.82-19.42)	16.76 (16.4-16.9)	16.21 (16.08-16.58)	10.58 (10.50-10.72)	6.71 (6.50-6.86)	4.55 (4.42-4.78)	7.86 (7.50-8.04)	5.86 (5.60-6.40)
<i>Rhinolophus euryotis</i>	1 ♀	24.92	21.38	20.40	11.48	9.10	6.30	10.36	6.68

\*Values in parentheses indicate range of the minimum to maximum measurements.

Kalepale Cave. A colony of this species occupied a chamber close to the entrance, but deeper than the roosting site of *E. raffrayana*. Muliale 1 Cave is formed by a single large chamber, and this species roosted in the deepest section about 35 m from the entrance. In Waelepe 1 Cave, this species roosted in bell holes located in a small passage in the totally dark zone. Both males and females did not show any reproductive activity. No previous records exist for this species from Waigeo (Flannery, 1995a, b; Bergmans, 2001; Meinig, 2002).

#### Family Rhinolophidae

##### *Rhinolophus euryotis* Temminck, 1835

(Broad-eared Horseshoe Bat)

*Specimen examined*: one adult female, MZB 30081, from Wairabiae; coll. S. Wiantoro & N. Supriatna, 4 June 2007.

*Remarks*: A single specimen was netted at a secondary forest at Wairabiae. A mist net was set up across the Wairabiae River. Meinig (2002) noted that this species was very abundant at a cave near the village of Lopintol. Unfortunately, this cave was not located during the present survey. *R. euryotis* has a very broad nose leaf which is darkly pigmented except for a white stripe running through the middle of the horseshoe to the upper lip (Flannery, 1995b). Body and skull measurements of this single specimen (Tables 2 and 3) fall into the *R. euryotis* (Csorba *et al.*, 2003).

## DISCUSSION

Twenty-four species of bats were recorded from Waigeo Island (Table 4) based on this survey, combined with previous records by Flannery (1995a, b), Bergmans (2001) and Meinig (2002). The present survey by MZB recorded 15 species and five of them were new records for the island, i.e. *P. conspicillatus*, *D. cf. minor*, *N. cf. cyclotis*, *P. raptor* and *H. papua*. Eight species recorded in previous surveys were not found during the present one. Most of these are microchiropterans which were collected from unmapped caves. Results from the present survey suggest that there is

lack of data regarding the bat fauna of Waigeo. Further surveys are likely to find additional species of bats through comprehensive survey techniques, covering all island areas that contain different habitat types.

Some interesting notes on the distributional patterns of bats were recorded. Apart from five new records for Waigeo, the recording of a species that was formerly considered to be distributed at high elevations was significant. *N. cf. cyclotis* was netted at 5 m asl near Lopintol village, Waigeo. Peterson (1992), Bonaccorso (1998) and Flannery (1995a, b) noted that this species is distributed at high elevations (780–1400 m asl), but based on the present survey, the species is not restricted to high elevations. This is supported by the finding of *N. cyclotis* by Meinig (2002) on Mansuar Island who suggests that *N. cyclotis* has a wide distribution from lowlands to higher elevations.

In addition, the recording of *P. raptor*, *D. magna* and *Miniopterus propritristis* gives rise to questions related to their distribution and systematics. Specimens of *P. raptor* from Waigeo are the first record from this island. Bergmans (2001) considered *Paranyctimene* as a subgenus of *Nyctimene* and described *N. (P.) tenax* from Waigeo based on body and skull measurements. The existence of *D. moluccensis* in Waigeo recorded by Meinig (2002) is in doubt. This species is distributed on the Moluccas Islands and does not extend eastwards. From Waigeo, Yapen, Batanta, Misool Islands through New Guinea to Queensland, this taxon is replaced by *D. magna*. According to Simmons (2005), *Miniopterus propritristis* which was found by Meinig (2002) on Waigeo is now synonymised with *M. tristis*. Based on the above data, it is suggested that further studies on the bats of Waigeo are urgently required to resolve problems involving distribution and analysis of phylogenetic relationships.

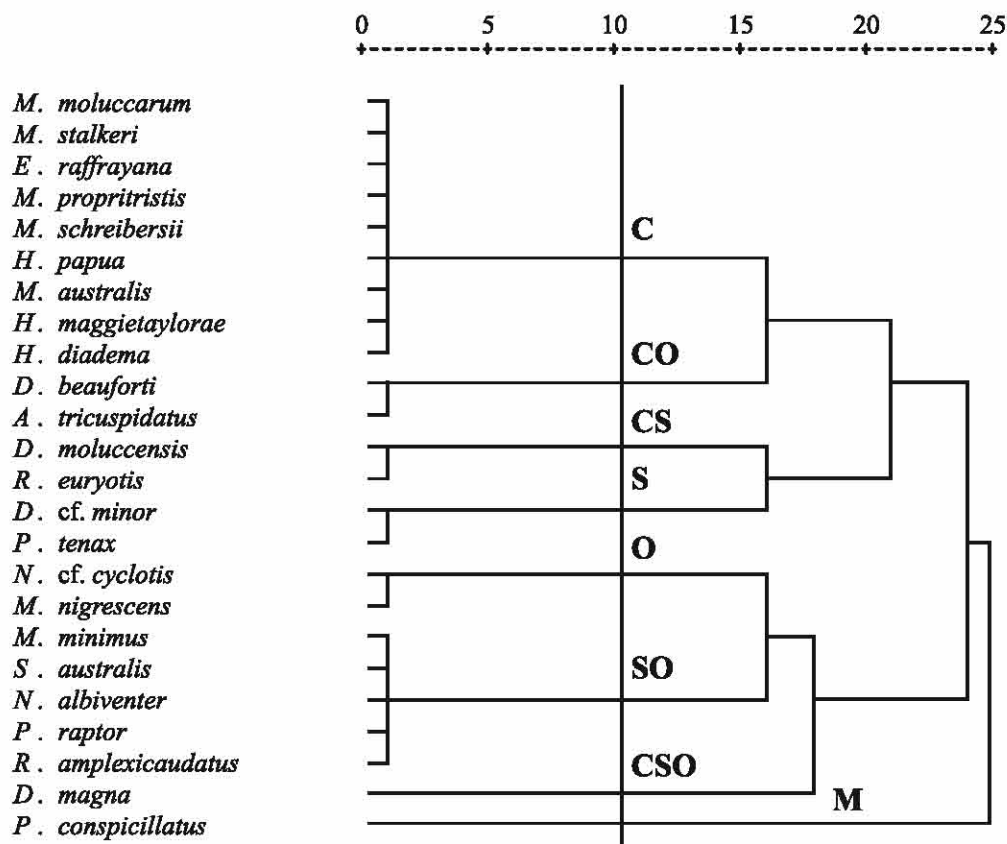
The dendrogram of the relationship among bat species based on habitat types on Waigeo Island was constructed using the Hierarchical

**Table 4.** Checklist of bats species from Waigeo Island based on this survey and previously published records.

Family/ Species	This study	Previous records		
		Meinig (2002)	Bergmans (2001)	Flannery (1995a, 1995b)
<b>Pteropodidae</b>				
<i>Pteropus conspicillatus</i>	+			
<i>Dobsonia beauforti</i>	+	+		+
<i>Dobsonia cf. minor</i>	+			
<i>Dobsonia magna</i>	+			
<i>Dobsonia moluccensis</i> *		+		
<i>Nyctimene albiventer</i>	+		+	
<i>Nyctimene cf. cyclotis</i>	+			
<i>Paranyctimene raptor</i>	+			
<i>Paranyctimene tenax</i>			+	
<i>Rousettus amplexicaudatus</i>	+	+		
<i>Macroglossus minimus</i>	+		+	
<i>Syconycteris australis</i>	+	+	+	
<b>Emballonuridae</b>				
<i>Emballonura raffrayana</i>	+	+		
<i>Mosia nigrescens</i>		+		
<b>Hipposideridae</b>				
<i>Aselliscus tricuspidatus</i>	+	+		+
<i>Hipposideros maggietaaylorae</i>	+	+		
<i>Hipposideros diadema</i>				+
<i>Hipposideros papua</i>	+			
<b>Rhinolophidae</b>				
<i>Rhinolophus euryotis</i>	+	+		
<b>Vespertilionidae</b>				
<i>Miniopterus australis</i>		+		+
<i>Miniopterus propritristis</i> **		+		
<i>Miniopterus schreibersii</i>		+		
<i>Myotis moluccarum</i>		+		
<i>Myotis stalker</i>		+		
TOTAL SPECIES	15	14	4	4
	24			

+ present

\*Need further confirmation, whether *D. moluccensis* or *D. magna*.\*\*Has been synonymised with *M. tristis*.



**Figure 2.** Dendrogram showing the distribution of bats based on habitat types in Waigeo Island. Abbreviations: C (cave), CO (cave and orchard), CS (cave and secondary forest), S (secondary forest), O (orchard), SO (secondary forest and orchard), CSO (cave, secondary forest and orchard) and M (mangroves).

Cluster method implemented in SPSS 12.0 for Windows program (Figure 2). Fourteen species (58.3%) used caves as their roosting site, and most were microchiropterans. Ten species which were dominated by megachiropterans were not found in caves. One species (*P. conspicillatus*) was only found in mangroves. This analysis provides evidence that the existence of caves has an important role for bats living on Waigeo Island. Therefore, caves become one of the main factors in relation to the bat conservation strategy on Waigeo Island. Conservation of other bat habitats, for example secondary forests, primary forests and mangroves, is also needed. Although Meinig

(2002) noted that human activities in villages and other traditional uses related to habitat condition did not seem to disturb the typical diversity in bat species, increasing requirements of human populations must impact animal habitats on Waigeo Island.

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