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Research Article

Brief Mist-netting and Update of New Record of Bats at Tumunong Hallu in Silam Coast Conservation Area (SCCA), Lahad Datu, Sabah, Malaysia.

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Abstract

A bat survey was conducted at Tumunong Hallu in Silam Coast Conservation Area (SCCA), Lahad Datu, Sabahfollowing the Silam Scientific Expedition 2015 from 7th July until 5th August 2015. A total of nine bat species belonging to two families were captured at SCCA. Among the noteworthy species recorded from this survey were *Rhinolophus sedulus* and *Pteropus vampyrus*, which are listed as Near Threatened in the IUCN Red List.

Keywords: Chiroptera, Sabah, Tumunong Hallu, Silam Coast Conservation Area (SCCA).

Introduction

Silam Coast Conservation Area (SCCA) is one of the conservation areas managed by Yayasan Sabah Group along with Danum Valley Conservation Area (DVCA), Maliau Basin Conservation Area (MBCA) and Imbak Canyon Conservation Area (ICCA). Initially, the area covered 580 hectares before it was expanded to 2,770 hectares in 2014 after its management was handed over to Yayasan Sabah Group in 1997. The SCCA is located in Darvel Bay, which is globally known as a region with marine-rich biodiversity and also a part of the Priority Conservation Area of the Sulu-Sulawesi Marine Eco-region. It is mainly covered by mixed swamp and beach vegetation, secondary forest and mangrove forest. From land to the sea, the diversity and the mix of flora and fauna in SCCA makes it an ideal conservation area for both the marine and terrestrial environments.

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A scientific expedition was carried out from the 10th to 18th May 2015, to officiate scientific data collection prior to designing a holistic Conservation and Management Plan for SCCA. To complement the data of this scientific expedition and the previous study by Ketol et al. (2009), another bat survey was conducted at various areas in SCCA including Pandanus Beach, Sungai Dewata and few orchard plots within the conservation area to update the list of bat species in SCCA. Currently, six newly-recorded species have been documented and the results of the survey are presented herein.

Material and Methods

Study area

The bat surveys were conducted in selected localities (Table 1) Sungai Dewata, Pandanus Beach and two orchard plots within SCCA (Figure 1). Most sampling occasions were done in orchard-based habitats with presence of local fruit

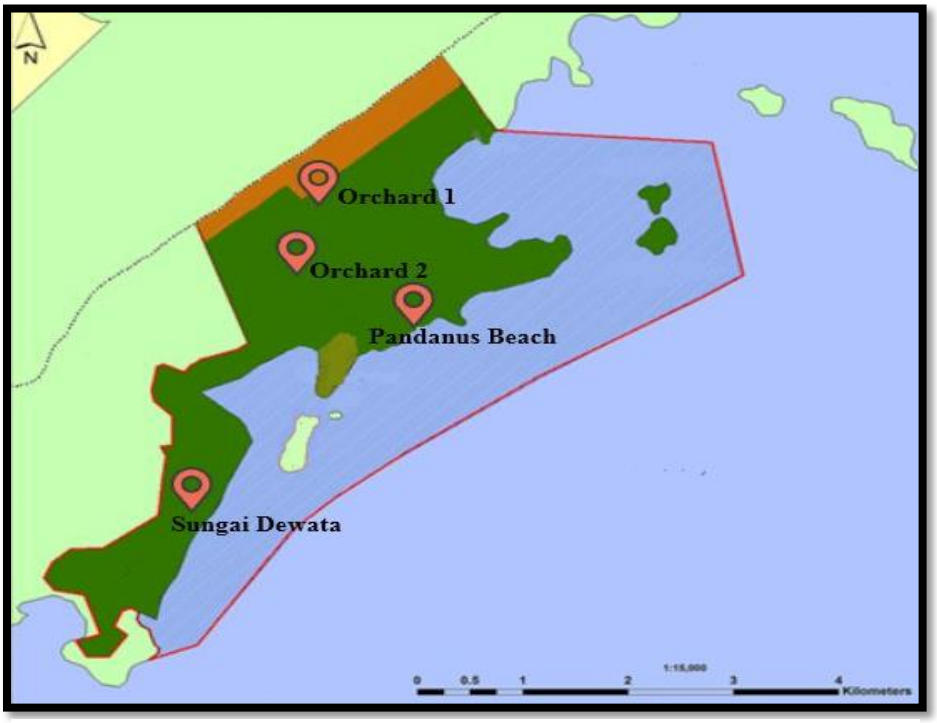

Figure 1. Map of Silam Coast Conservation Area (SCCA) with sampling sites.

trees such as mango (*Mangifera indica*), durian (*Durio zibethinus*), tarap (*Artocarpus odoratissimus*), kuini (*Mangifera odorata*), rambutan (*Nephelium lappaceum*) langsat (*Lansium domesticum*), jackfruit (*Artocarpus heterophyllus*) and longan (*Dimocarpus longan*) except for the sampling site at Pandanus Beach. The areas with orchard vegetation were split into three sites which are Orchard 1, Orchard 2 and Sungai Dewata. Orchard 1 is near the main road and human settlements whereas in Orchard 2, there is a small flowing stream. Meanwhile, the site in Sungai Dewata was surrounded with an oil palm plantation. The sampling site at Pandanus beach is near the coastline and the habitat includes beach vegetation, secondary forest, and few patches of mangroves and rattans. There are also flowering fig trees (*Ficus* sp.) scattered around the survey areas.

Table 1. List of study areas, habitat types and GPS readings.

No.	Study Area	Habitat	GPS reading
1.	Orchard 1	Orchard plots	N 04°55'0'' E 118°09'52.1''
2.	Orchard 2	Orchard plots and a small flowing stream	N 04°55'53.0'' E 118°09'11''
3.	Sungai Dewata	Oil palm plantation; riverine and orchard plots	N 04°54'9'' E 118°10'9''
4.	Pandanus Beach	Beach vegetation, few patches of mangroves, rattan, *Pandanus* sp., secondary forest and few individual fig trees (*Ficus* sp.)	N 04°55'03.6''E118°10'38.3''

Field method

The survey was carried out using four-shelves mist nets (9 m x 2.5 m, 25 mm mesh size) that were erected at areas identified as potential bat flyways. In order to enhance the species list of SCCA, high nets (12 m above the ground) were also used to catch high flyers or open-spaced bats. Mist nets were set up from 1700 hours and monitored until 2100 hours at an interval of 15 to 30 minutes. Before the last inspection at 0600 hours, mist nets were re-opened to capture bats that are active towards the dawn. Additional methods include using aerial nets to opportunistically catch bats that were observed roosting in old buildings. Captured bats were immediately removed from the nets to avoid casualties and to reduce stress induced from mist nettings. Each bat were kept inside separate cloth bags, weighed, measured and identified before being released.

Species identification

All individuals were identified following Payne et al. (1985) and Francis (2008). Standard measurements such as forearm (FA), ear (E), tibia (TB), hind-foot (HF), tail (T), head-body (HB) and weight (Wt) were taken using digital calliper (Mitutoyo 500 - 133 CD-6"B) prior to species identification based on Abdullah et al. (2010) and weighed using a Camry portable weighing scale. Selected individuals were taken as voucher specimens (wet specimen; preserved in 70 % alcohol) and deposited at the Yayasan Sabah Museum. Photographs of chosen species were taken for reference.

Results

A total of 91 individuals of bats, represented by two families and nine species were recorded from this survey (Table 2).

Table 2. Taxonomic list of chiropterans recorded from Silam Coast Conservation Area, Lahad Datu, Sabah.

No.	Family Species	Common name	IUCN Red List status	Relative abundance (%), N
	PTEROPODIDAE			
1	*Cynopterus brachyotis*	Lesser dog-faced fruit bat	LC	61.5 (56)
2	*Eonycteris spelaea*	Dawn bat	LC	9.9 (9)
3	*Eonycteris major*	Greater dawn bat	DD	1.1 (1)
4	*Macroglossus minimus*	Dagger-toothed long-nosed fruit bat	LC	2.2 (2)
5	*Penthetor lucasi*	Lucas's short-nosed fruit bat	LC	8.8 (8)
6	*Pteropus vampyrus*	Large flying fox	NT	1.1 (1)
7	*Rousettus amplexicaudatus*	Geoffroy's rousette bat	LC	13.2 (12)
	RHINOLOPHIDAE			
8	*Rhinolophus borneensis*	Bornean horseshoe bat	LC	1.1 (1)
9	*Rhinolophus sedulus*	Lesser woolly horshoe bat	NT	1.1 (1)
No. individuals		**91**		
Total number of families		**2**		
Total number of species		**9**		
Trapping effort (Net/trap-nights)		**56**		
Capture rate (Bats/effort)		**1.625**		

Note: LC- Least concern, DD- Data deficient and NT- Near threatened

Cynopterus brachyotis was the most abundant species captured in the Silam Coast Conservation Area (61.5 %) followed by *Rousettus amplexicaudatus* (13.2 %). Although *Pteropus vampyrus* were observed abundant in the area, only one individual was captured with the height of ground level mist net ranging from three to four metres height. Other than that, *Eonycteris major*, *Rhinolophus borneensis* and *Rhinolophus sedulus* were caught as singleton species. The recorded species were mostly pteropodid bats while capture of insect-eating bats was very poor, representing only 2 % of the total observed species. Based on previous studies done in SCCA and Gunung Silam (Ketol et al., 2009; Azniza et al., 2015) there are seven species recorded in these areas. Overall, six newly-recorded species have been added into the list of chiropteran species found in SCCA (Table 3).

Table 3. Comparison of chiropteran data in this study and other authors.

FAMILY Species	This study	Ketol et al. (2009)	Azniza et al. (2015)
PTEROPODIDAE			
Cynopterus brachyotis	✓	✓	✓
Cynopterus horsfieldii	0	0	✓
Eonycteris spelaea	✓	✓	0
Eonycteris major	✓	0	0
Macroglossus minimus	✓	✓	0
Penthetor lucasi	✓	0	0
Pteropus vampyrus	✓	0	0
Rousettus amplexicaudatus	✓	0	0
HIPPOSIDERIDAE			
Hipposideros diadema	0	0	✓
RHINOLOPHIDAE			
Rhinolophus acuminatus	0	✓	0
Rhinolophus borneensis	✓	0	0
Rhinolophus sedulus	✓	0	0
Rhinolophus trifoliatus	0	0	✓
No. of family	**2**	**2**	**3**
No. of species	**9**	**4**	**4**

Figure 2. Photo of **A** *Rhinolophus borneensis*, **B** *Rhinolophus sedulus*, **C** *Pteropus vampyrus*, **D** *Eonycteris major*, and **E** *Rousettus amplexicaudatus*

Species Account

FAMILY PTEROPODIDAE

Cynopterus brachyotis (Müller, 1838)

Short-nosed fruit bat (Cecadu Pisang)

Cynopterus brachyotis had the highest capture of all chiropterans (56 individuals) and was netted in all sampling areas in this study. This species is one of the common fruit bats in Southeast Asia which occupies a broad variety of habitats from primary forests to disturbed forests and orchards, mangrove forests, cultivated areas, gardens, urban areas and even in anthropogenic settings (Lim, 1966; Medway, 1983; Payne et al., 1985; Boon & Corlett, 1989; Francis, 1990, 1994; Zubaid, 1993, 1994; Tan et al., 1997, 2000; Abdullah, 2003; Mohd Ridwan et al., 2011). Apart from the Payne et al. (1985) description of *C. brachyotis* diet which comprised nectars and fruits, a few authors have suggested that their diet also includes leaves and particular insects (Boon & Corlett, 1989; Funakoshi et al., 1993; Tan et al., 1998; Mohd Ridwan et al., 2011). The individuals caught during the survey were the large-sized *C. brachyotis* that was genetically resolved by Abdullah et al. (2000), Abdullah (2003), Campbell et al. (2004; 2006) and Jayaraj et al. (2004; 2005a).

It is listed as a 'Least Concern' species in the IUCN Red List with an unknown population trend (Csorba et al., 2008a).

Eonycteris spelaea (Dobson, 1871)

Cave Nectar Bat (Cecadu Gua Kecil)

In this study, *Eonycteris spelaea* was netted mainly in the orchard areas similar to previous studies by Lekagul & McNeely (1977), Heideman & Heaney (1989), Kitchener et al. (1990) and Bumrungsri et al. (2013). The largest individual in this study was identified with FA= 73mm measurement. A distinct feature of this species includes the absence of its second digit (Payne et al., 1985). This species can travel as far as 38 km to forage and feeds on at least 31 species of plants (Start & Marshall, 1976; Bumrungsri et al., 2013). It is listed as a 'Least Concern' species in the IUCN Red List with an unknown population trend (Francis et al., 2008a).

Eonycteris major K. Andersen, 1910

Greater Nectar Bat (Cecadu Gua Besar)

Eonycteris major was netted in an orchard within Sungai Dewata. It was the first and only individual captured during the fourth survey (24th July 2015). Its physical features were more or less alike *E. spelaea*, but with darker body fur and larger in size. The individual caught in this study had FA=81.06mm measurement. Although this species is related to primary forest and its distribution is limited to areas with higher elevations (Jayaraj et al., 2011), capture of singleton *E. major* in the present study showed a new encounter of this species in the coastal area as a previous study in Lambir Hills National Park recorded this species in highland localities (Jayaraj et al., 2005b; 2011; Fukuda et al., 2009). It is listed as a 'Data Deficient' species in the IUCN Red List with an unknown population trend (Bates et al., 2008a).

Macroglossus minimus (É. Geoffroy, 1810)

Long-tounged Nectar Bat (Cecadu Madu Bakau)

Macroglossus minimus was netted in the orchards but with a lower occurrence in the mist nets compared to *C. brachyotis, E. spelaea*, and *P. lucasi*. Only two individuals were recorded throughout this study. The first individual was caught on 8th July 2015 and the second individual was captured on 10th July 2015. They were often caught in mist nets together with *C. brachyotis* (Payne et al., 1985). Their diet mainly consists of nectar and pollen, however they also suck juices of soft fruits occasionally (Nowak, 1991). This species is also recorded in coastal mangroves in Malaysia which are present and abundant in SCCA, especially with the presence of *Sonneratia* sp. where the buds also act as their food source (Nowak, 1991). *M. minimus* needle-like teeth, small-sized body and narrow muzzle enabled it to be easily distinguished from the other fruit bats in Borneo (Payne et al., 1985). It is listed as a 'Least Concern'

species in the IUCN Red List with a stable population trend (Francis et al., 2008b).

Penthetor lucasi (Dobson, 1880)

Dusky Fruit Bat (Cecadu Hitam Pudar)

Penthetor lucasi was commonly netted in areas where fruiting and flowering trees are present. Their roosting preference includes sites which are close to total darkness, remote caves and rock shelters (Payne *et al.*, 1985; Francis, 2008; Mohd Ridwan & Abdullah, 2012). In this study, they were found in orchards and also at Pandanus beach where the *Ficus* sp. was fruiting. The largest individual had FA=68.00mm measurement while the smallest individual had FA= 56.51mm measurement. Their morphological variation is suggested to be caused by the possible factors of breeding, crowding effect, foraging behaviour, resource availability, sexual dimorphism and selective pressure (Abd Rahman & Abdullah, 2010). They were usually caught alongside *C. brachyotis* and can be distinguished by observing the number of incisors present. *P. lucasi* has one pair of lower incisor whereas *C. brachyotis* has two pairs (Payne et al., 1985). It is listed as a 'Least Concern' species in the IUCN Red List with a decreasing population trend (Bates et al., 2008b).

Pteropus vampyrus (Linnaeus, 1758)

Large Flying Fox (Keluang Besar)

This species was netted near a rambutan tree (*Nephelium lappaceum*) in Orchard 2. Most of the rambutans were ripe and the canopy level of the rambutan tree was quite low (three to four metres) thus, forcing the *P. vampyrus* to fly closer to ground and was netted using an understorey mist net. Although recorded in orchard areas, it is commonly seen in mangrove or nipah palm areas, typically roosting in large colonies on trees with open branches (Payne et al., 1985). This species is able to fly up to 50 km overnight for foraging (Lim, 1966). Unfortunately, the population is declining due to extensive hunting for its meat, which is believed to have medicinal properties (Fujita & Tuttle, 1991; Mohd-Azlan et al., 2001). It is listed as a 'Near Threatened' species in the IUCN Red List with a decreasing population trend (Bates et al., 2008c).

Rousettus amplexicaudatus (É. Geoffroy, 1810)

Geoffroy's Rousette (Cecadu Besar)

Rousettus amplexicaudatus was also netted mainly in orchard compounds. The highest number of capture for this species was on 31st July 2015 during the morning inspection, for the seventh survey. Eleven individuals of *R. amplexicaudatus* were captured in the mist nets deployed five to six metres from the ground without the occurrence of other bat species. Previously, echolocation in family Pteropodidae has been exclusively described in a few

species of genus *Rousettus* bats by their production of audible clicking sounds (Payne et al., 1985). However, recent studies managed to show echolocating calls demonstrated by other pteropodids such as *E. spelaea*, *C. brachyotis* and *M. minimus* through wing clapping motion (Boonman et al., 2014). Records from Fukuda et al. (2009) showed the presence of this species in primary and secondary forests at Lambir Hills National Park. *R. amplexicaudatus* is listed as a 'Least Concern' species in the IUCN Red List with an unknown population trend (Csorba et al., 2008b).

FAMILY RHINOLOPHIDAE

Rhinolophus borneensis Peters, 1861

Bornean Horseshoe Bat (Kelawar Ladam Borneo)

Rhinolophus borneensis was caught using an aerial net while roosting in one of the public toilets at Pandanus beach. The individual captured in this study has brown to reddish body fur. Regardless of the distribution across Malaysia, this species is more likely to be found in Borneo compared to Peninsular Malaysia (Biotani et al., 2006). It is reported to roost in large colonies in caves (Payne et al., 1985) and also in bamboos, tree cavities, rock crevices and young foliage of banana plants (Mohd Ridwan et al., 2011). *R. borneensis* also lacks extra lappets or flaps on its noseleaf, and its connecting process varies from slightly rounded to bluntly pointed (Payne et al., 1985). It is listed as a 'Least Concern' species in the IUCN Red List with an unknown population trend (Hutson et al., 2008).

Rhinolophus sedulus K. Andersen, 1905

Lesser Woolly Horseshoe Bat (Kelawar Ladam Bulu Halus)

Rhinolophus sedulus was caught using an aerial net while roosting in a changing room at Pandanus Beach. It has been observed that this particular individual still roosts at the same spot in the changing room even after several unsuccessful attempts to capture it. This species has body fur that is greyish, dark grey ears and noseleaf with lateral lappets at the base of its sella (Payne et al., 1985). It is listed as a 'Near Threatened' species in the IUCN Red List with a decreasing population trend (Hutson & Kingston, 2008).

Discussion

This study recorded nine species, of which six are additional records for SCCA. The survey from this study recorded the highest number of species compared to previous studies by Ketol et al. (2009) and Azniza et al. (2015). Among the potential factors that might affect the abundance of bats are food availability, temporal disparity, sampling efforts, sampling methods, duration of study,

forest types and the intensity of area disturbance which then may influence the difference in data between these studies (Abdullah et al., 1997; Hodgkison et al., 2004; Mohd-Azlan et al., 2005, 2008; Jayaraj et al., 2011).

Consistent with results of most previous studies, *C. brachyotis* is a common species, usually recorded in high number in most bat surveys (Francis, 1994; Abdullah & Hall, 1997; Fukuda et al., 2009; Jayaraj et al., 2011; Nur Juliani et al., 2011; Noor Haliza et al., 2012). This is due to their ability to adapt and tolerate to a broader range of environments (Nur Juliani et al., 2011). Moreover, the stability of *C. brachyotis* populations is also aided by tree species that have extended fruiting periods or that fruit constantly throughout the year (Tan et al., 2000). It is speculated that the high number of pteropodids species were influenced by the fruiting season during the survey due to higher availability of food source as fruits and floral resources are part of their main diet. Thus, temporal disparity affects the gap of data between this survey and previous studies despite the brief sampling period. Furthermore, pteropodid bats often travel to areas where food is available (Nelson, 1965; Thomas, 1982, 1983; Hodgkison et al., 2004) in response to temporal variation. The presence of individual fig trees (*Ficus* sp.) in SCCA is another factor that contributes to the stable pteropodids population as *Ficus* sp. is also an essential food source for bats in Southeast Asia (Lambert & Marshall, 1991; Bhat, 1994; Funakoshi & Zubaid, 1997; Marshall, 1985; Boon & Corlett, 1989; Tan et al., 1998, 2000; Mohd Ridwan et al., 2011).

Gunung Madai is the nearest cave and is 44.8km away from SCCA. This might explain the capture of a few cave-dwelling species such as *R. amplexicaudatus, P. lucasi, E. spelaea,* and also *R. borneensis* that were previously recorded by Payne et al. (1985) in Gunung Madai. In this study, only the mist-netting method was applied to capture chiropterans because of equipment shortage, which affects the results of this survey. This method is more effective for pteropodids sampling. Insectivorous bats tend to chew and damage the mist nets, enabling them to escape in an instant if they are not removed upon capture (Abdullah et al., 1997). Apart from that, insectivorous bats echolocation call has empowered their flight capacity to avoid mist nets where it reflects stronger resonance due to higher material density (Abdullah et al., 1997; Berry et al., 2004; Schnitzler et al., 2003; Ramli & Hashim, 2009). Hence, the usage of four-bank harp traps will increase sampling competency and the likelihood of capturing insectivorous bats (Laval & Fitch, 1977; Francis, 1989; Tidemenn & Woodside, 1989; Mohd-Azlan et al., 2000, 2005; Ramli & Hashim, 2009; Mohd Ridwan et al., 2011). Likewise, extended duration added

with extra frequency of sampling may possibly lead to a higher number of recorded species. There are still areas in SCCA that are not explored for bats surveys.

Insectivorous bats in this study were captured opportunistically using aerial nets while they were roosting in old public toilets and a changing room at Pandanus Beach. Hence, testing different approaches to sample faunal diversity was positive, not only in generating extensive data but also in leading to unanticipated discoveries. The presence of a forest interior bat such as *R. sedulus* leads to the speculation that the forest could sustain the survivability of fragile species, which are very susceptible towards habitat conversion (Kingston et al., 2003). Therefore, trappings with proper equipment such as harp traps and ultrasonic bat detectors coupled with increased sampling efforts might yield additional species of insectivorous bats and reveal more information regarding the species composition in a sampling site.

Habitats in SCCA include mangrove forest, beach vegetation, orchards, secondary forest and oil palm. Each of these habitats has a unique ecosystem that can accommodate a variety of bat species. It was observed that there are patches of forests logged in some parts of the forest and also remnant of cleared rattan trees and bamboo which are abundant in SCCA. There are also some housing settlements at the edge of this area near the main road. Regardless of the environmental disturbance, SCCA is able to support a few vulnerable species such as *P. vampyrus* and *R. sedulus*. However, bat populations in SCCA might be affected and decline if the intensity of disturbance increases (Mohd Ridwan et al., 2011). Excessive clearing of bamboo and rattan may result in habitat loss for a few species of bats in genus *Tylonycteris, genus Kerivoula* and genus *Rhinolophus* that are known to roost in these vicinities (Payne et al., 1985; Francis, 2008).

Conclusion

Nine species of chiroptera from two families were documented within Silam Coast Conservation Area (SCCA). Though the newly recorded species are higher than previous studies, data suggests that the species diversity of chiropteran in SCCA has not been fully reflected and greater efforts and coverage are essential to obtain complete chiropteran data in this conservation area. For future surveys, advanced trapping equipment such as ultrasonic bat detectors and harp traps could be used to improve sampling efficiency. The sampling

period could also be prolonged by taking into account spatial and temporal factors including forest phenological changes.

Being the only conservation area that is involved in the management of coastal and marine ecosystems, SCCA harbours a bountiful combination of unique terrestrial and marine biota. Thus, they need to be properly assessed and conserved for future generations.

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Appendix 1

Table 4. Morphological measurements of chiroptera (maximum and minimum ranges). **N**= total individuals, **FA**= forearm, **E**= ear, **TB**= tibia, **HF**= hind foot, **T**= tail, **HB**= head-body and **WT**= weight.

Family	Morphological measurements							
Species	N	FA (mm)	E (mm)	TB (mm)	HF (mm)	T (mm)	HB (mm)	WT (g)
PTEROPODIDAE								
Cynopterus brachyotis	56	59.00 - 67.87	11.61-16.21	20.73-25.63	6.53-12.28	6.51-14.27	64.48-92.95	25.00-46.00
Eonycteris spelaea	9	61.00 -73.00	15.37-25.00	26.81-30.39	10.27-21.00	11.50-22.00	87.00-116.00	32.00-49.00
Eonycteris major	1	81.06	21.06	38.02	16.34	20.65	95.01	80.00
Macroglossus minimus	2	43.00- 47.00	17.00 - 22.00	29.00	12.00-15.00	-	67.00-69.00	10.00-14.00
Penthetor lucasi	8	56.51-68.00	15.00-25.00	20.73-34.00	8.92-20.00	10.33-17.00	67.00-82.00	14.00-29.00
Pteropus vampyrus	1	190.81	43.38	92.76	40.32	-	235.41	567.00
Rousettus amplexicaudatus	12	83.87 - 96.00	17.24 - 27.00	40.00 - 49.00	11.09 - 23.00	16.12-29.00	104.37 - 119.00	49.00-91.00
RHINOLOPHIDAE								
Rhinolophus borneensis	1	45.79	17.94	19.57	4.55	21.68	45.60	7.00
Rhinolophus sedulus	1	45.26	18.49	22.96	5.36	20.04	48.34	12.00