BEHAVIOURAL ECOLOGY OF THE SUNDÁ COLUGO
Galeopterus variegatus (MAMMALIA: DERMOPTERA) IN BAKO
NATIONAL PARK, SARAWAK, MALAYSIA

Muhammad Dzulhelmi Bin Muhammad Nasir

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BEHAVIOURAL ECOLOGY OF THE SUNDA COLUGO *Galeopterus variegatus*  
(MAMMALIA: DERMOPTERA) IN BAKO NATIONAL PARK, SARAWAK, MALAYSIA

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A thesis submitted  
in fulfillment of the requirements for the degree of  
Master of Science  
(Zoology)

Faculty of Resource Science and Technology  
UNIVERSITI MALAYSIA SARAWAK  
2011
Declaration

I hereby declare that no portion of the work referred to this thesis has been submitted in support of an application for another degree or qualification to this or any other university or institution of higher learning.

(Muhammad Dzulhelmi Bin Muhammad Nasir)

Date:
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Abstract

A study on the behavioural ecology of the Sunda Colugo (*Galeopterus variegatus*) in Bako National Park headquarters was conducted between 16<sup>th</sup> August 2008 and 22<sup>nd</sup> July 2009. The objectives of this study were to determine the roosting selection, diet preferences and behaviour patterns of the Sunda Colugo in its free ranging habitat. Visual daytime search and focal samplings technique was applied for this study. A total of 56 sightings of the Sunda Colugo found roosting on 32 selected trees comprising 10 species and nine families within the main study area. The Sunda Colugo have preferences for *Illex cymosa* as its roosting tree species (Fisher's exact test: 0.705 > 0.05). A total of 12 species from 10 families were identified as the diets for the Sunda Colugo. Interestingly, the Sunda Colugo with young (GY) have higher preferences for *Buchanania arborescens*. Furthermore, a total of ten main behaviour categories comprising 39 behaviour patterns have been catalogued from this observation. Only the Maintenance Pattern (Kruskal-Wallis test: $H = 14.85, P = 0.001$) and grooming (Kruskal-Wallis test: $H = 11.84, P = 0.003$) differs significantly among the individual categories (GY, GN, ON). This database reveals potential studies which can be use to conserve this species especially in Bako National Park.

Key words: behaviour, diets, roosting selection, *Galeopterus variegatus*
EKOLOGI TINGKAHLAKU KUBONG (Galeopterus variegatus) DI TAMAN NEGARA BAKO, SARAWAK, MALAYSIA

Abstrak


Kata kunci: tingkahlaku, pemakanan, tempat tidur, Galeopterus variegatus
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Chapter 1

Introduction

1.1 Dermoptera

The Order Dermoptera contains a single living family, Cynocephalidae which are divided into two separate genus with a single species namely, Sunda Colugo (Galeopterus variegatus) and Philippine Colugo (Cynocephalus volans) (Stafford and Szalay, 2000; Stafford, 2005). Previously, some authors classified the species under Galeopithecidae instead of Cynocephalidae and also uses Galeopithecus Pallas, 1783 for species G. volans while placing C. variegatus in separate genus, Galeopterus Thomas, 1908 (Chasen and Kloss, 1929; Ellerman and Morrison-Scott, 1955). The classification of the Colugo was accepted as a single genus (Cynocephalus) with two species (Chasen and Kloss, 1929; Corbet and Hill, 1992; Wilson and Reeder, 2005).

The evolutionary relationships of the Dermoptera to Chiroptera, Primates and Scandentia are frequently debatable among biologists who are using classical methods, proteins, molecular DNA and vision pathways. Historically, the Colugo is taxonomically grouped in the superorder Archonta with Primates (ape, monkey and gibbon), Chiroptera (bats) and Scandentia (tree shrews) (Novacek, 1992). They are considered closely related to Primates based on analysis of fossil and morphological data (Nováček, 1992, 1993), visual pathways, particularly from eye to midbrain (Pettigrew, 1995) and molecular evidence (Janecka et al. 2007). However, molecular study challenged the association of the Colugo with Primates (Schmitz et al., 2003) and supports the Colugo to be related to
Scandentia (Schmitz et al., 2002; Nie et al., 2008; Martin, 2008). Based on evidence from craniodental and functional morphology, Stafford and Szalay (2000) concluded that the Dermopteran contains two distinct species, namely the Sunda Colugo (G. variegatus) and the Philippine Colugo (C. volans).

Previously, Colugo are known as “flying lemur” (Yasuma and Andau, 2000; Feldhamer et al., 2003), the Malayan flying lemur referred to the Sunda Colugo (G. variegatus) and Philippine flying lemur referring to the Philippine Colugo (C. volans). But the term was misleading as they do not fly but rather glide, nor they are lemur because lemurs are categorised in the Order Primates (Yasuma and Andau, 2000). Thus, the term ‘Colugo’ was adopted and accepted among researchers. The species name G. variegatus was adopted from the Greek words variegatus – ‘variegated’ (Yasuma and Andau, 2000). The species name for C. volans were obtained from the Greek words, Cyno – ‘dog’, and cephalus – ‘head’ which means “dog-head”, while volans – “to fly” (Lim, 2007).
1.2 Study Species

*Galeopterus variegatus* (Audebert 1799)

The Sunda Colugo or *G. variegatus* have two forms but are not morphologically distinct from one another, the large form occurring on the mainland of the Sunda shelf area and the mainland of Southeast Asia while the dwarf form occurring in Central Laos and some other adjacent islands (Stafford and Szalay, 2000). According to Ruggeri and Etterson (1998), the Sunda Colugo from Laos specimen is smaller (about 20%) than the other known mainland population. Despite the large and dwarf form, there are four known subspecies of *G. variegatus*: *G. v. variegatus* (Java), *G. v. temminckii* (Sumatra), *G. v. borneanus* (Borneo), and *G. v. peninsulæ* (Peninsular Malaysia and mainland of Southeast Asia) (Stafford and Szalay, 2000) incorporating on the genetic species concept due to geographic isolation and genetic divergence. Recent molecular and morphological data provide the evidence that the mainland, Javan and Borneo Sunda Colugo subspecies may be recognised as three separate species in the genus *Galeopterus* (Janecka *et al.*, 2008).

1.2.1 Internal and external characteristics

There are three groups of mammals that possess skin membrane as one of the special features for their locomotion – Dermoptera (colugo),Rodentia (e.g. flying squirrel) and Chiroptera (bat). However, the function of the extended membrane differs as Dermoptera and flying squirrel are modified for gliding while the Chiroptera are highly adapted for
powered flight. This gliding mammal is about the size of a domestic cat. It has large eyes, a blunt muzzle, mottled fur (for camouflage) and strong claws for climbing (Burnie, 2001). Morphologically, male and female shares the same basic features.

Sunda Colugo is grayish white and heavy black with markings (Payne and Francis, 1985). Some are mixed with white spots on limbs and bright orange on under part of body. There are few white or yellowish spots (some have no spots) which may or may not be seen very obviously on the head. The colour on the neck can be yellowish or grayish colour - can be pale. There are also fur of totally reddish-brown or orange colour covering the body with white spots (or without any spots) on parts of the body except yellowish and whitish spots on the limbs and heads. In addition, Sunda Colugo can also be brown and black stripes (some may not be clearly seen) on the patagium, with few white spots concentrated on tails, limbs and head. To explain this variation, Khan (1992) mentioned that the colours may vary according to their surroundings.

Both male and female can have identical fur colouration although of different gender. Gender determination based on fur colouration was examined by Lim (2004) and he concluded that fur colouration may not be a reliable method for gender determination. Fur colourations of the Sunda Colugo populations depend on the geography, localities and their habitats.
1.2.2 Morphological measurements

1.2.2.1 Body measurements

Other than molecular analysis, the measurements on body, skull and dental on large form Sunda colugos can be an informative data to differentiate between the small and large form Sunda colugos. Previous measurements of the Sunda Colugo are obtained from Chasen and Kloss (1929), Lekagul and McNeely (1977), Medway (1978), Payne et al. (1985), Khan (1992), Hill (1993), Burnie (2001), Yasuma and Andau (2000), Feldhamer et al. (2003), Parr (2003), Ketol et al. (2006), Francis (2008) and Maryanto et al. (2008) (Table 1.1). Unfortunately, some authors did not mention the number of individual(s), locations and important morphological measurements (e.g. ear length).
Table 1.1: Body measurements of the Sunda Colugo from previous studies.

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<td>Lekagul and McNeely (1977)</td>
<td>340-420</td>
<td>175-270</td>
<td>65-73</td>
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<td>na</td>
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<tr>
<td>Medway (1978)</td>
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<td>Hill (1993)</td>
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<td>na</td>
<td>na</td>
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<td>Burnie (2001)</td>
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<td>900-2,000</td>
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<td>na</td>
<td>850-1,300</td>
<td>na</td>
</tr>
<tr>
<td>Feldhamer et al. (2003)</td>
<td>340-400</td>
<td>170-270</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>1,000-2,000</td>
<td>na</td>
</tr>
<tr>
<td>Parr (2003)</td>
<td>340-420</td>
<td>175-270</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Ketol et al. (2006)</td>
<td>310</td>
<td>250</td>
<td>56</td>
<td>21</td>
<td>560</td>
<td>1,200</td>
<td>1</td>
</tr>
</tbody>
</table>

Head and body length (HB); Tail length (T); Hind foot length (HF); Ear length (E); Total length (TL); Weight (Wt). Length in millimeters (mm); Weight in grams (g); n: Number of specimen(s); na: Data is not available.