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Reproductive Patterns of *Cynopterus brachyotis* (Dog-Faced Fruit Bat) in Bintulu, Sarawak

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ABSTRACT

Reproductive period is a critical phase for most living organism. However, the influence of environmental condition on the reproductive pattern of Chiroptera in Malaysia is not well studied. A study on the reproductive patterns of dog-faced fruit bat, *Cynopterus brachyotis,* was conducted at Universiti Putra Malaysia, Bintulu Campus, Sarawak. Bats were captured in a planted forest and mixed dipterocarp forest using mist-nets for a period of 14 months from January 2009 to February 2010. The reproductive status was determined based on morphology of the bats. Five (I-Minor testes enlargement, no epididymal distention, II-Testes at or near maximal enlargement, no epididymal distention, III-Testes regressed, cauda epididymal distented, IV-Testes not regressed, cauda epididymal distented and V-No testiscular or epididymal enlargement) and four (I-Possibility pregnant, II-Lactating, III-Post-lactating and IV-Not reproductively active) categories of the reproductive status were categorized for the male and female *C. brachyotis*, respectively. Bats reproduce at all time of the year and the peak periods are associated with the rainy seasons. The first peak of reproduction (pregnancy and lactation) occurred in January to April 2009 and second peak in June to November 2009. The highest frequency of pregnancy and lactation female coincided with the fruit abundance. The results indicated that *C. brachyotis* performed a non-seasonal reproductive pattern. The findings are important in understanding the reproductive biology of bats and in protecting this ecologically important and diverse group of mammals.

Keywords: *Cynopterus brachyotis*, fruit bat, planted forest, reproduction

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INTRODUCTION

The environmental factors are known to affect the timing of reproduction in many species of mammals including bats. In bats, the reproductive cycles are affected by photoperiod, rainfall, food abundance, and temperature (Heideman, 2000). Most bat species that have been studied to date display strong seasonality and synchrony in their reproductive cycles such that pregnancies and lactation coincide with food abundance. This increases the chances of the young to survive.

The dog-faced fruit bat, *Cynopterus brachyotis* (family Pteropodidae), is a common frugivorous species in Southeast Asia, and widely distributed in Malaysia. Throughout its range, this bat species occupies a variety of habitats including primary forest, disturbed forest, mangrove, cultivated areas, orchards, gardens, and urban areas (Funakoshi *et al*., 1997). Feeding areas and the composition of their food are largely influenced by the seasonal flowering and fruiting of trees (Kofron, 1997). The species appears to be an important seed dispersal agent due to its wide distribution and it is also important in pollination as it feeds on nectar (Funakoshi *et al*., 1997). Considering its dependence on plants for food and the changing environment (Funakoshi *et al*., 1997; Phua *et al*. 1989), the response of *C. brachyotis* to these factors and the timing of its reproduction are of interest.

Rising development in industries, urbanization, animal husbandry and agriculture has been affecting bats' population. If these man-made disturbances prevail without any perturbation, it will lead to bats' population being threatened with extinction due to habitat loss, decreasing food resources, pollution, deliberate killing and loss of genetic diversity (Meffe *et al*., 1994). Therefore, a better knowledge on the reproductive biology is important in the management and conservation of this diverse group of mammals. This study was carried out to investigate the synchronization of the reproductive pattern between the male and female *C. brachyotis* and to correlate it with the climatic and food availability factors.

MATERIALS AND METHODS

Study Site

This study was carried out in planted forest (UPM~Mitsubishi Corporation Forest Rehabilitation Research Project) (113° 03.591' E, 03° 12.691' N) and mixed dipterocarp forest (113° 04.105' E, 03° 12.967' N) at Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB) from January 2009 to February 2010.

Bat Trapping

Cynopterus brachyotis were captured using mist-nets that were set along the trails at the vicinity of flowering and fruiting trees and in open areas within the forest. Mist-nets were set up from dusk to dawn and checked at 10 pm and 5 am for 16 days every month for 14 months. All adult bats were recorded and examined.

The bats' body mass (g), length of forearm (mm), sex, and their reproductive status were determined. The reproductive status was assessed based on the morphology. The reproductive status was determined following the characteristics outlined by Happold *et al*. (1990) and Kofron (1997). Male bats were categorized into five reproductive status (I-Minor testes enlargement, no epididymal distention, II-Testes at or near maximal enlargement, no epididymal distention, III-Testes regressed, cauda epididymal distented, IV-Testes not regressed, cauda epididymal distented and V-No testiscular or epididymal enlargement), while four reproductive status for female bats (I-Possibility pregnant, II-Lactating, III-Post-lactating and IV-Not reproductively active). Males with testes enlarged and females that were pregnant, lactating and post-lactating were classified as reproductively active individuals (Kofron, 1997). Meanwhile, post-lactating females possessed large, flaccid and dark nipples. Females lacking these characteristics were considered as non-reproductive (Duarte *et al*., 2010).

Monthly climatic data were obtained from Bintulu Meteorology Station, Sarawak. Opportunistic observations on flowering and fruiting trees (in campus and study area) were also recorded monthly. Statistical tests were done using analysis of variance (ANOVA) to determine the difference in body mass in different months. In addition, Pearson's correlation analysis was done to determine whether there is a correlation between the male and female bats' body mass with the climatic factors (rainfall, humidity and temperature).

RESULTS AND DISCUSSION

A total of 1,328 individual bats comprising of 679 females and 649 males were trapped during the study period. The relationships between body mass in male and female bats with rainfall, temperature and humidity over 14 months from January 2009 to February 2010 are shown in Fig.1. Fig.2 shows the male and female bats' reproductive percentages for the 14 month's period. Bats' body mass was also used as an indirect indicator of their reproductive status. The body mass of the male and female *C. brachyotis* fluctuated throughout the study period. The highest male bats' body mass was recorded in January 2009 (33.15 ± 6.68 g), whereby it coincided with the highest rainfall (1199.4 mm/month). Food resources are more abundant in the rainy season than in the dry season (Bumrungsri *et al.,* 2007). The highest percentage (24.24%) of status II (testes at or near maximal enlargement, no epididymal distention) was recorded within this wet season (see Fig.2).

In *Myotis myotis*, fluctuation of body mass can indicate times of food abundance and scarcity (Andreas *et al*., 2007). During spermatogenesis of *Pteropus poliocephalus*, the size of the testis increases to indicate the time of reproduction (McGuckin *et al*., 1991). The testis size of *C. brachyotis* was enlarged in January 2009, February 2009, July 2009, August 2009, November 2009 and December 2009. This was synchronized with the increase of the body mass of mature males, which might be influenced by the higher food availability (Table 1). According to Tan *et al*. (1998), *C. brachyotis* preferred

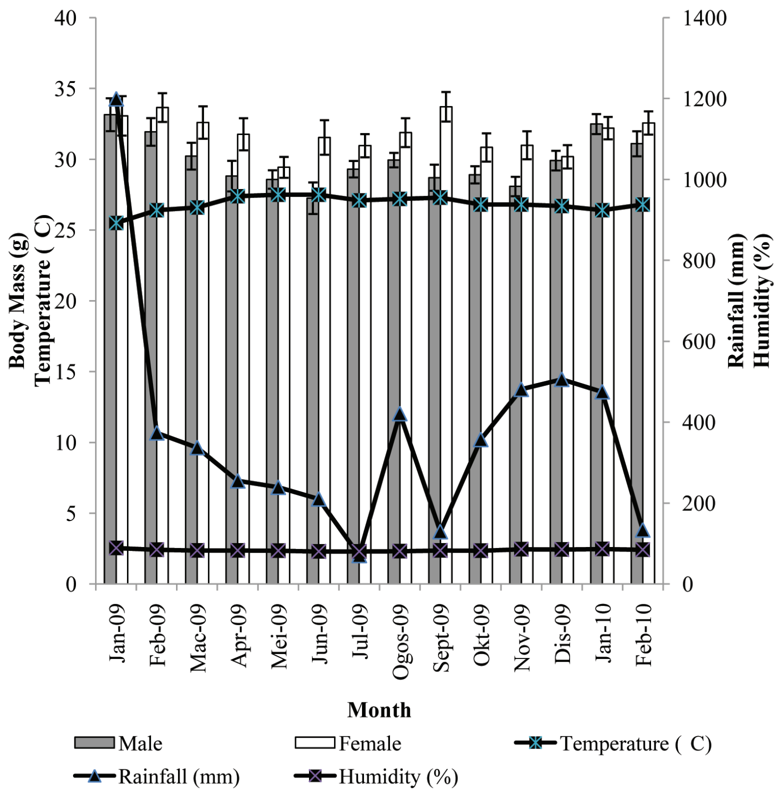

Fig.1: The relationship between the male and female bats' body mass (g) with rainfalls (mm), temperature (° C) and humidity (%) from January 2009 to February 2010 [this study is based on 1328 captures of adult *C. brachyotis* (male: 51 ± 21.09, female 52 ± 19.74 individuals caught each month)].

to feed on various kinds of non-seasonal fruit.

A study in the testes mass of *C. brachyotis* showed that the peak mass occurred twice in a year (from June to August and from December to January) (Marina *et al*., 2002). Meanwhile, a study by Wong *et al.* (2002) showed that spermatogenesis occurred throughout the year in the population but peaked in the fruiting seasons.

The highest females body mass was recorded in February 2009 (33.65 ± 5.85 g), which occurred a month after the highest rainfall and the highest male body mass. This could be due to the gestation periods which have caused the increase in body mass. Even though the highest female body mass was recorded in February 2009, the peak of pregnant females (status I) (66.67%) was found to be synchronized with the highest rainfall (see Fig.3). Therefore, rainfall is probably the most important factor in the seasonal reproduction of *C. brachyotis*. A study by Zortea (2003) indicated that pregnancy peak in *Anoura geoffroyi*, *A. caudifera* and *Glossophaga soricina* occurred in the rainy season.

Food resources are more abundant in the rainy season than in the dry season. Pregnancy, lactation and weaning are the

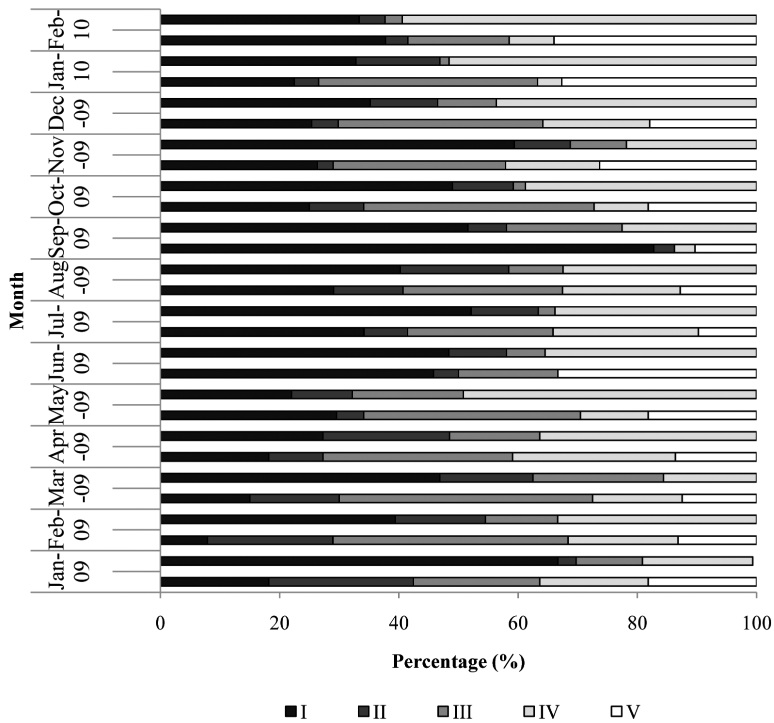

Fig.2: The male (♂) and female (♀) bats' reproductive status (%) for fourteen (14) months period. For male bats: I-Minor testes enlargement, no epididymal distention, II-Testes at or near maximal enlargement, no epididymal distention, III-Testes regressed, cauda epididymal distented, IV-Testes not regressed, cauda epididymal distented and V-No testiscular or epididymal enlargement. For female bats: I-Possibility pregnant, II-Lactating, III-Post-lactating and IV-Not reproductively active.

most energetically reproductive stages; therefore, they should coincide with the period of high food availability (Racey, 1982). Although the highest monthly captures of pregnant females occurred in certain months (e.g., January to March 2009 and June to November 2009), pregnant females were captured every month, suggesting that the breeding pattern is non-seasonal. Compared to pregnant females, the lactating females (status II) showed higher captures in April 2009 (21.21%) and August 2009 (18.18%), suggesting that parturition had occurred. Interestingly in Thailand, the birth periods of *C. brachyotis* was in March to April and August (Bumrungsri *et al*. 2006), which is similar to the present study.

Based on opportunistic observation (Table 1), the fruiting seasons were recorded in January to February 2009 (*Mangifera indica, Fragrea fragrans*) and June to October 2009 (*Nephelium lappaceum*, *Durio zibethinus*, *Mangifera indica*, *Fragrea fragrans*, *Artocarpus integer*). The non-seasonal fruiting trees, such as *Ficus* sp., show continuous fruit availability throughout the year, as shown by other studies (e.g. Wong *et al*., 2003; Funakoshi *et al*., 1997; Lim (1970). Lim (1970) found peaks in pregnancies to occur

TABLE 1
The fruiting and flowering trees in Bintulu (through opportunistic observations)

Month	Flowering and fruiting trees in Bintulu
January 2009	Dipterocarp trees flowering *Mangifera indica* (mango), *Artocarpus integer* (cempedak), *Fragrea fragrans* (tembusu), *Durio zibetinus* (durian)
February 2009	*Mangifera indica* (mango), *Artocarpus integer* (cempedak), *Fragrea fragrans* (tembusu)
March 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
April 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
May 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
June 2009	*Mangifera indica* (mango) *Durio zibetinus* (durian), *Nephelium lappaceum* (rambutan), Artocarpus integer (cempedak), *Fragrae fragrans* (tembusu)
July 2009	*Mangifera indica* (mango) *Durio zibetinus* (durian), *Nephelium lappaceum* (rambutan), Artocarpus integer (cempedak), *Fragrae fragrans* (tembusu)
August 2009	*Mangifera indica* (mango) *Durio zibetinus* (durian), *Nephelium lappaceum* (rambutan), Artocarpus integer (cempedak), Fragrae fragrans (tembusu)
September 2009	*Durio zibetinus* (durian), *Nephelium maingayi* (rambutan), *Artocarpus integer* (cempedak)
October 2009	*Durio zibetinus* (durian), *Nephelium maingayi* (rambutan), *Artocarpus integer* (cempedak)
November 2009	Dipterocarp trees flowering (*Shorea* sp.) *Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
December 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
January 2010	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
February 2010	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)

Note: Non-seasonal fruits area available throughout the year

in January, May, and September and these coincided with the fruit abundance. This finding contradicts the results of Kofron (1997) in Brunei, Borneo and Bumrungsri *et al*. (2007) in Thailand, who found that the reproductive pattern of *C. brachyotis* was a continuous bimodal polyoestry with postpartum oestrus.

The differences in the *C. brachyotis'* reproductive pattern are generally associated with different latitudes, which have been found to cause seasonality of rainfall and

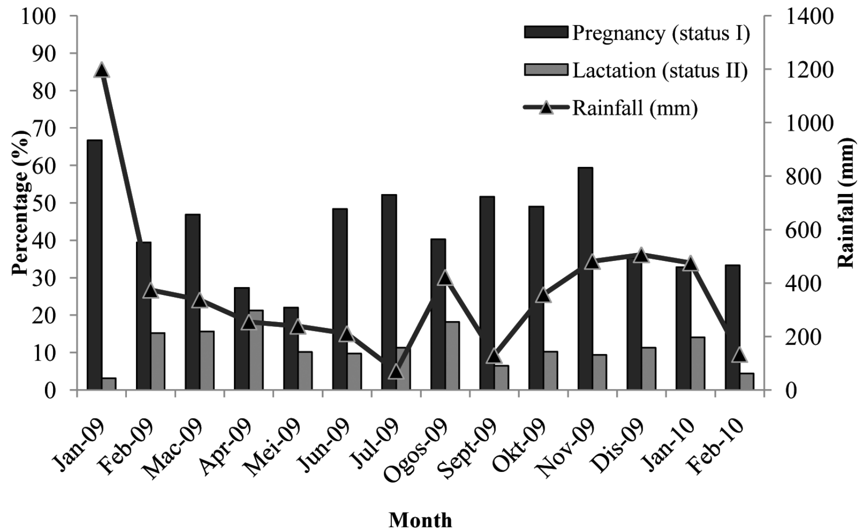

Fig.3: The reproductive status of female *Cynopterus brachyotis* in relation to rainfall pattern from January 2009 to February 2010.

food availability (Racey *et al*., 2000). Only the male bats' body mass showed significant correlation ($p<0.05$) with the climatic factors (rainfall, temperature and humidity). Kofron (1997) reported that the increase/decrease of adult males' body mass for *C. brachyotis* corresponded with the bimodal cycle of ripened mangoes in Brunei. However, the increase/decrease adult female *C. brachyotis'* body mass did not correspond to the bimodal cycle of ripened mangoes. The results suggest that male bats have to gain more energy for the mating repertoire (vocalizations, body movement, special flight patterns, roost defence, urinary tract markings), which is to pursuit the female partners. On the other hand, the body mass of female bats will increase due to pregnancy.

CONCLUSION

In conclusion, the reproductive pattern of the important seed disperser *C. brachyotis* is non-seasonal and significant correlation only occurs between male bats' body mass and climatic factor. In-depth information of the reproductive pattern of the species will help promote its protection in the forest.

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REFERENCES

Andreas, Z., Luisa, R., Ana, R., & Palmeirim, J. M. (2007). Critical times of the year for *Myotis myotis*, a temperate zone bat: roles of climate and food resources. *Acta Chiropterologica, 9*(1), 115–125.

Anu, A., Sabu, T. K., & Vineesh, P. J. (2009). Seasonality of litter insects and relationship with rainfall in a wet evergreen forest in south Western Ghats. *Journal of Insect Science*, *72*(2), 10-11.

Bumrungsri, S., Bumrungsri, W., & Racey, P. A. (2007). Reproduction in the short-nosed fruit bat in relation to environmental factors. *Journal of Zoology, 272,* 73-81.

Duarte, A. P. G., & Talamoni, S. A. (2010). Reproduction of the large fruit-eating bat *Artibeus lituratus* (Chiroptera: Phyllostomidae) in a Brazilian Atlantic forest area. *Mammalian Biology, 75*(4), 320-325.

Funakoshi, K., & Zubaid, A. (1997). Behavioral and reproductive ecology of the dog-faced fruit bats, *Cynopterus brachyotis* and *C. horsfieldi*, in a Malaysian rainforest. *Mammal Study, 22*, 95-108.

Happold, D. C. D., & Happold, M. (1990). Reproductive strategies of bats in Africa. *Journal of Zoology (London)*, *222*, 557-583.

Heideman, P. D. (2000). Environmental regulation of reproduction. In E. G. Crichton, & P. H. Krutzsch (Eds.), *The reproductive biology of bats* (pp. 469-499). London: Academic Press.

Kofron, C. P. (1997). Reproductive of two spesies of congeneric fruit bats (*Cynopterus*) in Brunei. *Journal of Zoology (London)*, *243*, 485-506.

Lim, B. L. (1970). Food habits and breeding cycle of the Malaysian fruit-eating bat, *Cynopterus brachyotis*. *Journal of Mammalogy, 51*, 174-177.

Marina, M. T., Wong, C. H., Tay, T. W., Zubaid, A., & Kamis, A. B. (2002). Annual changes in testes mass in *Hipposideros larvatus*, *Cynopterus brachyotis* and *C. horsfieldi* (Chiroptera) from Peninsular Malaysia. *Malaysian Applied Biology, 31*(2), 85-86.

McGuckin, M. A., & Blackshaw, A. W. (1991). Seasonal changes in testicular size, plasma testosterone concentration and body weight in captive flying foxes (*Pteropus poliocephalus* and *P. scapulatus*). *Journal of Reproduction and Fertility*, *92*, 339-346.

Meffe, G. K., & Carroll, C. R. (1994). *Principles of conservations biology*. Sunderland: Sinauer Associates Inc., London.

Phua, P. B., & Corlett, R. (1989). Seed dispersal by the lesser short-nosed fruit bat (*Cynopterus brachyotis*, Pteropodidae, Megachiroptera). *Malayan Nature Journal, 42*, 251-256.

Racey, P. A. (1982). Ecology of bat reproduction. In T. H. Kunz (Ed.), *Ecology of bats* (p. 425). New York: Plenum Press.

Racey, P. A. (1988). Reproductive assessment in bats. In T. H. Kunz (Ed.), *Ecological and Behavioral Methods in the Study of Bats* (pp. 31–45). Washington, D.C.: Smithsonian Institution Press.

Racey, P. A., & Entwistle, A. C. (2000). Life history and reproductive strategies of bat. In E.G. Crichton, & P. H. Krutzsch (Eds.), *The reproductive biology of bats* (pp. 469-499). London: Academic Press.

Wong, C. H., Tay, T. W., Marina, M. T., Zubaid, A., & Kamis, A. B. (2001). Reproduction Status of Male *Cynopterus Brachyotis* in an Agricultural Area and a Fragmented Forest. In 12th International Bat Research Conference. 5-9th August 2001, Bangi, Selangor, Malaysia.

Wong, C. H., Tay, T. W., Marina, M. T., Zubaid, A., & Kamis, A. B. (2003). Male reproductive status and testosterone concentration of *Cynopterus brachyotis* in a fragmented forest. *Natural Resources Journal 31*(2), 215-218.

Zortea, M. (2003). Reproductive patterns and feeding habits of three nectarivorous bats (Phyllostomidae: Glossophaginae) from the Brazilian Cerrado. *Brazilian Journal of Biology, 63*(1), 159-168.