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Preliminary assessment of activity pattern and diet of the lesser dog faced fruit bat *Cynopterus brachyotis* in a Dipterocarp Forest, Sarawak, Borneo

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The short nosed fruit bat *Cynopterus brachyotis* (Müller 1838) is primarily a plant-visiting bat feeding on fruits, flowers and leaf fractions (Funakoshi *et al.* 1993). It typically roosts in small groups in trees, under banana leaves, palm fronds and man-made structures. It is locally abundant, has a wide distribution throughout South/South East Asia and occupies a variety of habitats including primary and disturbed forest, orchard, mangrove and cultivated areas (Corbet & Hill 1992). *C. brachyotis* is probably one of the best studied fruit bats in South East Asia. It's ecology and behavior, especially foraging ecology, has been well explored in Peninsular Malaysia. (Abdullah 2003; Campbell *et al.* 2006a,b; Campbell *et al.* 2007; Hodgkison & Balding 2004; Tan *et al.* 1998). No studies, however, have been carried out on the ecology of this species in Malaysian Borneo. The Peninsular Malaysia and Malaysian Borneo are different in terms of floristics, endemism and flowering phenology. This study deals with the activity pattern and diet of *C. brachyotis* in Borneo from where such information has not been collected so far.

There is scanty information on the natural history of bats occurring in the tropical rain-forests due to difficulty in making observations. In Peninsular Malaysia, *C. brachyotis* has been studied using radiotelemetry and faecal analysis (Campbell *et al.* 2006a,b; Hodgkison & Balding 2004). However, use of remote flash photography has never been explored in the field to observe bat behaviour. Radiotelemetry is labour intensive and inadequate to differentiate between feeding and other activities. This information is vital to understand dispersal and competition as some Pteropodidae including *C. sphinx* rarely remain on the fruit bearing trees to feed and frequently carry the fruits to a feeding roost (Elangovan *et al.* 1999; Thomas 1988). Therefore, we investigated the activity pattern and diet of *C. brachyotis* using infrared cameras.

The study was conducted at Kubah National Park (KNP; 01° 36.1704' N and 110° 11.159' E) which is located 22 km from Kuching city, in the state of Sarawak. The park covers an area of 2230 ha and surrounded by villages and small agricultural settings such as banana (*Musa* sp.), durian (*Durio zibethinus*) and rambutan (*Nephelium lappaceum*). Bird's nest fern (*Asplenium nidus*) is a common epiphyte. The study site received 3852 mm of rain during 2006 (Malaysian Meteorological Service 2007). A total of 93 rainy days were recorded

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during the study period (August to December 2006). Five main vegetation types found in KNP are: alluvial forest, mixed dipterocarp forest, kerangas (heath) forest, submontane forest and secondary forest.

Rapid assessment was conducted for 30 non-consecutive nights from August to December 2006 in order to obtain maximum probability of bats being recorded, especially during non-rainy nights (Fig.1). A total of five feeding locations were identified in the study area through visual searches. Two of the roosting sites were located in a lowland dipterocarp forest while the other two were located on sub-montane forest.

It has been observed that there is a close linkage between feeding roosts and foraging ecology (Campbell *et al.* 2006b). Day roosts are where bats roost alone or in groups during day time while feeding roosts are used for foraging purpose during night. We fixed mist nets (12 m x 2.5 m with mesh size 36 mm) near the feeding roosts to capture and identify the bat species. Mist netting was conducted in the month of June 2006 only at the understory level with inconsistent efforts at each roosting site that accumulated to 3252 net hours (7 - 9 days at 4 sites). Mist netting was conducted prior to the camera trapping sessions to minimize the effect of mistnetting on bat behaviour, e.g. abandoning their roost or changing their temporal pattern.

We used four commercially made Cam Trakker brand camera traps using fully automatic 35 mm cameras with infrared heat-in-motion sensors and flash (manufactured by Camtrak South, 1050 Industrial Drive, Watkinville, GA 30677, USA) to monitor activity pattern in all the feeding roosts (n = 4). The lapse between each photograph was set to 90 seconds, thus it is possible the same individual was photographed more than one time in a single feeding activity. The sites where the bats clung were clearly visible on the roosts. The cameras were placed on a wooden platform targeting these sites and left operational 24 hours

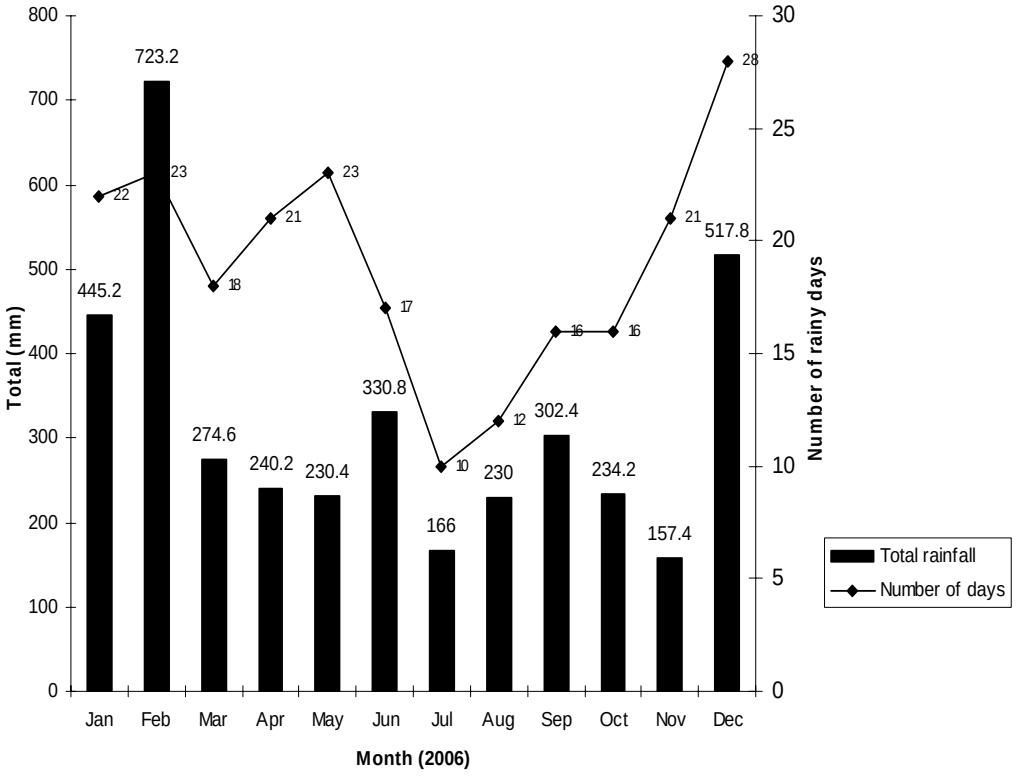

Fig. 1. Monthly rainfall and number of rainy days in each month of the year 2006 around Kubah National Park, Sarawak, Borneo.

a day. Twenty six camera days, resulting 552 hours of trapping effort in total were spent throughout the study period with unequal number of days at each location. The cameras recorded the date and time on each photograph. Photographs were sorted into one hour intervals, starting at 5 00 PM and ending at 7 00 AM, and activity level of *C. brachyotis* in each interval was calculated as a percentage of photographs taken in that interval out of the total photographs taken in one trap-night.

After the cameras were set, plastic sheets were placed under the target roosts to collect fruit and seed remnants. Fruit remains and seeds were collected daily to avoid seed depredation. They were preserved in 70 % alcohol and identified using morphological descriptions given by Saepodmo & Saw (2000), Saepodmo *et al.* (2002) and by comparing with the specimens kept at the Herbarium, Faculty of Resource Science and Technology (FRST), UNIMAS, Sarawak. Where possible, collected seeds were also matched with reference fruit and seed samples collected daily around the roost area.

We found that *C. brachyotis* mostly used areas close to human habitations and temporary huts for feeding roost. A total of 99 photographs were obtained at the camera traps. All the bat photos were of single individuals. Of theses, seven photos had bats carrying single fruit in their mouth. Two peak feeding activities were observed before midnight *viz*., between 19 00 - 20 00 hrs and the next between 22 00 - 23 00 hrs (Fig. 2). The second peak seems to be similar to that of sympatric species, *C. spinx* (Elangovan *et al.* 1999). No activity was recorded in the wooden structure during heavy rain, consistent with findings by Wilson (1971); Fenton (1970) that bat foraging activities could be depressed during rain. Two sites at the hill dipterocarp forest did not yield any photo, even though seeds were located beneath the feeding roost. This may be attributed to poor camera-trap setting. The effect of the camera flash on the bats' foraging behaviour was not tested but in a single night 13 shots were taken at a single roosting site suggesting that the effect could be minimal. In addition to this, bats returned to feed on the same roost on subsequent nights indicating that roosts were not being abandoned.

The camera traps are difficult to set in the wild and sometimes produce poor image quality. They might be useful, however, to address specific objectives such as in this case, understanding the feeding roost behaviour.

We analysed 802 samples (591 seeds and 211 fruits) dropped below the roosting sites of *C. brachyotis* (Table 1). The bats fed on at least 24 species (18 species of seeds and 6 species of fruits) representing 16 genera and 15 families. Of all the seeds collected, *Eugenia* sp. (Myrtaceae) had the highest count, i.e. 158 (26.7 %) followed by *Palaqu-*

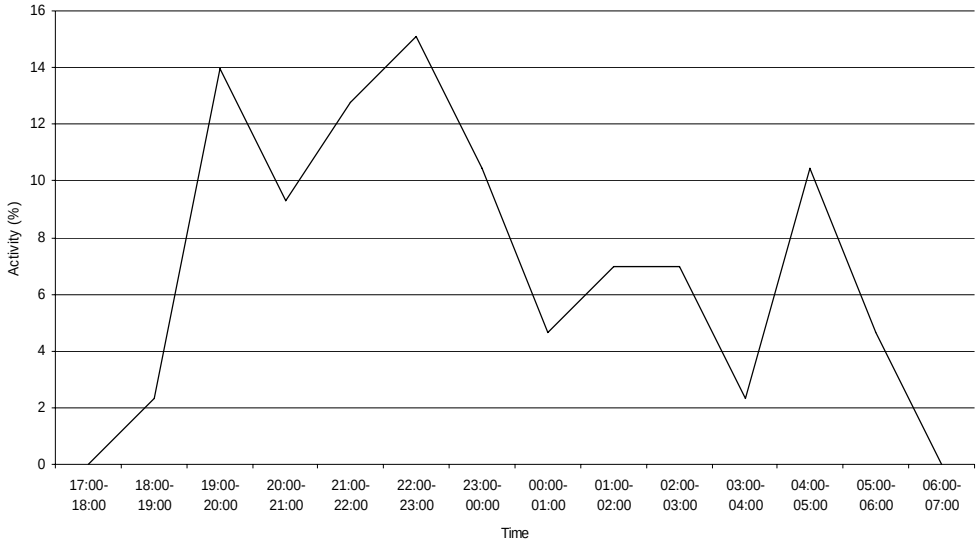

Fig. 2. Activity pattern of *C. brachyotis*, expressed as a percentage of photographs in each hour interval of the total number of photographs in one trap-night, at two feeding roosts at KNP from August to December 2006 (n = 99).

Table 1. Species, location, weight and length measurements of remnant fruits and seeds collected beneath feeding roosts of *C. brachyotis*.

Family	Species	Location					n	% of seed	Weight (mean) of seed (min-max)(g)	Length (mean) of seed (min-max) (mm)
		LDF1	LDF2	LDF3	HDF1	HDF2				
Actinidiaceae	*Saurauia* sp. *,***	9	10	42	-	-	61	7.60	1.34(0.86-1.52)	23.67(19.64-26.86)
Annonaceae	*Mezettia* sp. **	35	-	-	-	-	35	4.36	1.76(1.25-2.21)	17.32(15.37-19.53)
Arecaceae	*Pinanga* sp.**	10	-	-	-	-	10	1.25	1.27(1.19-1.46)	28.45(25.44-30.71)
Arecaceae	*Licuala* sp. **	14	-	-	-	-	14	1.75	0.72(0.58-0.96)	12.32(10.12-15.85)
Arecaceae	*Calamus* sp. **	14	-	-	-	-	14	1.75	0.89(0.62-1.17)	24.73(22.86-26.92)
Burseraceae	*Canarium* sp. **	3	-	-	-	-	3	0.37	3.53(2.86-3.99)	34.13(32.74-36.76)
Clusiaceae	*Calophyllum* sp. **	3	3	6	-	-	12	1.50	1.25(1.09-1.46)	14.39(10.4-16.97)
Dipterocarpaceae	*Shorea* sp. *,**	-	3	1	-	-	4	0.50	1.46(1.39-1.63)	13.2(12.47-14.36)
Ebenaceae	*Diospyros* sp. **	29	15	11	-	-	55	6.86	0.58(0.45-0.81)	14.56(10.46-17.8)
Euphorbiaceae	*Macaranga gigantea* *	9	21	35	-	-	65	8.10	0.67(0.51-0.96)	11.3(8.3-14.64)
Gnetaceae	*Gnetum* sp. **	15	8	-	18	23	64	7.98	0.84(0.72-1.09)	35.19(33.73-36.59)
Lauraceae	UnId 5 **	8	-	-	-	-	8	1.00	1.2(0.98-1.46)	14.64(12.35-17.21)
Moraceae	*Ficus aurata* *	-	-	24	-	-	24	2.99	2.17(2.04-2. 52)	26.54(21.67-29.44)
Moraceae	*Ficus* sp.*1* *	-	-	16	-	-	16	2.00	5.75(5.23-6.17)	17.32(16.18-20.46)
Moraceae	*Ficus* sp.*2* *	-	12	33	-	-	45	5.61	0.56(0.37-0.88)	11.22(8.18-14.53)
Myrtaceae	*Eugenia* sp.**	58	-	36	20	44	158	19.70	2.78(1.25-4.16)	18.93(15.61-22.5)
Oxalidaceae	UnId 6**	6	-	-	-	-	6	0.74	0.92(0.76-0.97)	18.77(17.19-19.81)
Sapotaceae	*Palaquium* sp. **	38	-	-	31	-	69	8.60	1.46(0.34-2.28)	28.8(25.5-33.33)
Sapotaceae	*Maducha* sp.**	52	-	-	-	-	52	6.48	1.67(0.89-2.17)	16.49(16.08-16.87)
Theaceae	*Adinandera* sp. **	2	-	1	-	-	3	37.00	1.53(1.48-1.55)	21.46(19.08-22.84)
UnId 1	- **	3	7	27	-	-	37	4.61	0.35(0.23-0.56)	13.67(9.04-15.62)
UnId 2	- **	6	-	-	-	-	6	0.74	0.67(0.42-0.73)	12.28(10.12-15.37)
UnId 3	- **	2	-	-	-	-	2	0.25	0.84(0.75-0.93)	15.77(15.12-16.42)
UnId 4	- **	7	-	21	-	11	39	4.86	1.17(0.83-1.58)	24.4(20.64-27.8)
Total fruit species m	24	20	8	12	3	3	802	100	-	-
Net Hours	-	2880	48	180	72	72	-	-	-	-
Camera Trap Hours	-	96	N/A	288	96	72	-	-	-	-
Total photos	-	6	N/A	93	0	0	-	-	-	-
Roost height (m)	-	10	3.5	3	3	3	-	-	-	-

LDF: Lowland Dipterocarp forest, HDF: Hill Dipterocarp forest, UnId: unidentified,* Fruit remains,** Seeds,*** Pulps, n-number.

ium sp. (11.6 %) and *Macaranga gigantea* (10.9 %). Four species of seeds could not be identified. The bats consumed the fruit pulps from four species namely *Saurauia* sp. and three species of *Ficus* from the remaining left-over, in which the flesh of the fruits were squeezed in order to obtain the juices and later discarded. All seeds measured more than one centimeter in length. Bat dispersed seeds are usually large in size which is attributed to greater energy requirements for establishment under low light conditions of dense canopy forests in tropical rainforests (Pijl 1957).

In comparison to our five-month long study, Hodgkison & Balding (2004) recorded 31 fruit species consumed by eight fruit bat species collectively (including *C. brachyotis*) for a period of 33 months in a lowland dipterocarp forest of Peninsular Malaysia, while Tan *et al.* (1998) recorded 54 fruit species over a period of 12 months in an urbanized and secondary forest in Peninsular Malaysia suggesting that urbanised and secondary forests can provide high diversity of food resources to *C. brachyotis*. This study provides a preliminary diet profile of *C. brachyotis* for five months in Borneo. The list of food species remains incomplete as some fruits may have been ejected in flight or consumed *in-situ*. The results indicate that *C. brachyotis* may have higher fruit species diversity in its diet in the primary forests of Borneo compared to that of Peninsular Malaysia.

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