Faculty of Resource Science and Technology

FEEDING BEHAVIOUR OF *Cynopterus brachyotis* AT KUBAH NATIONAL PARK, SARAWAK

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This project is submitted in fulfilment of the requirements for the degree of Bachelor of Science

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DECLARATION

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

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ABSTRACT

Information on the feeding habits of lesser dog-faced fruit bat, *Cynopterus brachyotis* was obtained using camera trap and by the collection of food remains directly beneath roost sites. The 99 photos were taken, in which 32 photos show the presence of bat while 67 photos did not show the presence of bat. The *C.brachyotis* photos were mostly taken between 11 pm to 12 midnight. The study indicates that *C.brachyotis* actively foraged at the before midnight with an average nine flights per hour compared to six flights per hour after midnight. A total of 802 seeds and fruit were collected during the study. Bat was found to feed on the fruit of 18 genera from 15 families of plant. The families were namely Moraceae, Arecaceae, Sapotaceae, Annonaceae, Mrytaceae, Gnetaceae, Clusiceae, Bursuraceae, Dipterocarpaceae, Ebenaceae, Actinidiaceae, Theaceae, Oxalidaceae, Lauraceae and Euphorbiaceae. The *Ficus* spp. (family Moraceae) is an important diet of *C.brachyotis*. Based on the wide range of food consumed, this study suggest that *C. brachyotis* is a very important seed dispersal agent at Kubah National Park.

Keyword: *Cynopterus brachyotis*, camera trap, *Ficus*, seed dispersal, Kubah National Park.

ABSTRAK

Maklumat berkaitan pemakanan kelawar buah, Cynopterus brachyotis di peroleh menggunakan camera trap dan dengan mengutip sisa-sisa makanan di bawah tempat tinggal nya. Jumlah 99 foto telah berjaya ditangkap, dimana 32 foto menunjukan kehadiran kelawar manakala baki 67 foto tidak menunjukkan kehadiran kelawar. Foto C. brachyotis kerap di ambil antara jam 11 pm hingga 12 tengah malam. Kajian juga mendapati C.brachyotis aktif mencari makan pada awal malam dengan purata sembilan penerbangan perjam berbanding enam pernerbangan perjam selepas tengah malam.. Sebanyak 802 individu biji dan buah telah dikutip sepanjang tempoh kajian dijalankan. C.brachyotis dipercayai bergantung pada buah daripada 18 genera dan 15 famili tumbuh-tumbuhan. Famili tumbuhan adalah seperti Moraceae, Arecaceae, Sapotaceae, Annonaceae, Mrytaceae, Gnetaceae, Clusiceae, Bursuraceae, Dipterocarpaceae, Ebenaceae, Actinidiaceae, Theaceae, Oxalidaceae, Lauraceae dan Euphorbiaceae. Ficus ssp. (famili Moraceae) di kenalpasti sebagai diet penting bagi C.brachyotis. Daripada kajian ini, dipercayai bahawa C.brachyotis adalah agen penyebar benih yang penting di Kubah National Park, dengan mempunyai tabiat makan yang luas.

Kata kunci: *Cynopterus brachyotis, camera trap, Ficus, penyebar benih, Taman Negara Kubah.*

1.0 Introduction

Megachiroptera includes a single family Pteropodidae (Findley, 1993). Megachiropteran are primarily plant-visiting bats and feeds on fruit and flower resources (nectar and pollen), while some have been observed practicing folivory by leaf fractionation (Marshall, 1985; Boon and Corlett, 1989). They chew the leaves, swallow the juices, and spit out the residue of fruit. Family Pteropodidae includes 166 frugivorous and nectarivorous species (Koopman, 1993).

Wild varieties of many of the world's most economically valuable crop plants also rely on bats for survival. Some of the commercial products include fruits such as bananas, avocados, dates, figs, peaches, and mangoes (Feldhamer *et al.*, 1999). According to Payne *et al.* (2005) 450 or more economic products are derived from plants pollinated or dispersed by fruit bats. Bats may provide several advantages to the plants on which they feed. Separation of pulp from seeds by frugivores may increase survival by reducing seed predation and microbial attack (Willson and Traveset, 2000).

The short-nosed fruit bat, *Cynopterus brachyotis* is a common frugivorous species in Southeast Asia. This bat has a wide distribution and usually occupies a variety of habitats including primary forest, disturbed forest, orchard, mangrove and cultivated area (Boon and Corlett, 1989; Francis, 1990). *C. brachyotis* is a medium-sized bat which typically roosts in small groups in trees, particularly under the fronds of palms. It is not only consumed the fruit but also feed on the leaves, nectar and some insects (Boon and Corlett, 1989; Funakoshi *et al.*, 1993).

Foraging activity pattern of captive *C. brachyotis* has been studied by A.Wahab (2000) and Ramlee (2005). They found that the bats began to fly out to forage at 6.30 pm until 6.00 am. There was minimal activity after midnight compared to before the midnight.

The studies on the natural feeding behaviour of bat have been made for only a few bat species. The study on feeding ecology of fruit bats includes collecting (Tan *et al.*, 1998) and analysis of food items observed through food consumption and examination of fecal or stomach contents (Whitaker, 1988). Each of these methods has its limitation and none quantitatively defines the daily nutrient requirements of fruit bats.

1.1 Problem Statement

Despite many studies on the ecology of *C. brachyotis* that have been conducted throughout South East Asia (Abdullah, 2003; Campbell *et al.*, 2006; Tan *et al.*, 1998), not much is known on its foraging activity pattern in the wild. Thus this would be the first attempt to study the natural foraging activity pattern by using infrared sensored cameras.

1.2 Objectives

The objectives of the study are to:

1. Determine the foraging activity pattern of *C. brachyotis* at Kubah National Park through activity analysis.

2. Collect information on the fruits consumed by *C. brachyotis* at Kubah National Park

2.0 Literature Review

2.1 Foraging activity pattern

According to Tan *et al.* (1999) *C. brachyotis* eats several different types of fruit each night. Bats might eat the fruit on the tree or carry it to the feeding roost when foraging (Thomas, 1988; Boon and Corlett, 1989). Occasionally, bats transported to other nearby fruiting trees. After consuming one fruit, a bat would usually take away another fruits and transport it to a feeding or day roost (Tan *et al.*, 1999). The mass of the fruit that carried was significantly associated with body mass of the bat (Thomas, 1988). August (1981) found that the number of bats captured at *Ficus* spp. In the previous study done by Funakoshi and Zubaid (1997) *C. brachyotis* did not feed in the fruiting trees, but instead dispersed seed to feeding roost.

C. brachyotis first become active in a while after sunset, when individuals appeared in the area of the fruiting trees (Tan *et al.*, 1999). Most bats made one to several flight s around the fruiting trees before removing a single fruit (Tan *et al.*, 1999). Before the bats start to feed, they will elbow the feed a little bit as a "bite taste" (A. Wahab, 2000).

Studies on foraging pattern of *Cynopterus sphinx* bats was done by Marimuthu *et al.* (1998) and Elangovan *et al.*(1999). According Elangovan *et al.* (1999), *C. sphinx* began visiting fruit trees about 30 min after sunset. Individuals *C. sphinx* was seen circled the trees, then landed on the fruit or on nearby branches. These bats seldom remain in the fruit-bearing trees to feed, but instead carried fruits to feeding roosts. This behavior is repeating several times throughout the night. In addition, *C. sphinx* fed on steady state and big-bang fruits. The number of feeding bouts reached a peak during the pre-midnight hours when bats fed mostly on steady state fruits.

The peak of activity occurred during the post-midnight hours when they fed upon the big-bang fruits.

In Krakatau, fruit bats (*Cynopterus* and possibly also *Rousettus* species) have been observed taking figs from all *Ficus* species except *F. ampelas* (Thornton *et al.*, 1996). In addition, bats have been observed removing *Timonius compressicaulis* fruits (like small figs). The fruit bat activity has been observed within the canopies of *Morinda citrifolia* and *Hernandia peltata*. Lesser fruit bats (unknown species) and flying-foxes (*Pteropus vampyrus*) have been observed in *Terminalia catappa* trees (also known as 'Indian almond'). Bat activity in *T. catappa* is fairly conspicuous as the *Pteropus* tend to clamber about the trees canopy, consuming fruits *in situ*, so that the large seeds of *T. catappa* can be heard raining down from the canopy.

Marimuthu *et al.* (1998), suggested moonlight is an environmental factor that inhibits the nocturnal activity pattern of a few species of bats especially *C. sphinx*. The study shows that when there is an increase in the intensity of moonlight, *C. sphinx* reduces the use of open space and restricts their foraging activity to the periods of darkness.

Similar study was done by Ramlee (2005), which compared the foraging activity of *C. brachyotis* in the dark and bright background. She found that the foraging activity of *C. brachyotis* was less in the bright background compared to the dark.

Recently, Singaravelan and Marimuthu (2002) studied the effect of the lunar eclipse on the foraging activity pattern of fruit bats in an orchard. The bats were observed forage on ripe black grapes (*Vitis vinifera*). The number of bat visits during the night of the lunar eclipse was significantly higher compared to both the pre-lunar and post-lunar eclipse days. There was no significant difference in the intensity of foraging between the pre-lunar and post-lunar eclipse days. The enhancement of foraging activity of fruit bats during the period of eclipse supports that bright moonlight apparently inhibited bat activity. The reduction of feeding activity of bats during bright moonlight is normally as an adaptation to avoid nocturnal predators such as barn owl (*Tyto alba*) and an Indian great horned owl (*Bubo bubo*) in an orchard.

2.2 Home range

Spacing and movement of Chiroptera are influenced by the availability and dispersion of food and day-roost resources (Humphrey, 1975; Winkelmann *et al.*, 2000), as well as by life history dynamics such as the timing and scope of migration or reproduction (Ceballos *et al.*, 1997).

Individuals of colonial species that roost in large group undertake long commuting flights to reach food resources not depleted or dominated by conspecifics. Highly colonial species such as Brazilian free-tailed bats (*Tadarida brasiliensis*) (Davis *et al.*, 1962) and gray-headed flying foxes (*Pteropus poliocephalus*) (Spencer *et al.*, 1991) can commute distances of 15 to 50 km to their foraging areas. In contrast, bat species that are solitary or live in small groups of approximately 15 individuals, particularly in tropical forests, often roost within 2 km of their foraging areas and acquire minimal time and energy costs for commuting.

Furthermore, in highly productive tropical rain forests, such bats meet nutritional requirements within comparatively small foraging areas, usually 12 hectares or less (Morrison, 1978, 1980; Kalko *et al.*, 1999; Winkelmann *et al.*, 2000). In Panama, solitary males of the Jamaican fruit bats (*Artibeus jamaicensis*) roosted in foliage and commuted less than half the distance to food resources observed for harem males or females living in small groups inside tree hollows

(Morrison, 1978). Thus, both commuting distances and the dispersion and abundance of food resources strongly influence the size of the home range.

In Krakatau, *Cynopterus* bats were observed dropping *Terminalia* fruits 100m from the nearest possible source tree in Pelabuhan Ratu, on the coast of south-west Java (Thornton *et al.*, 1996). This observation suggests *Cynopterus* bats do, at least on occasion, take *Terminalia* fruits to feeding roosts. That *Cynopterus* bats will remove *Terminalia* fruits and carry them some distance from the source tree is confirmed on Krakatau by the presence of *Terminalia* seeds on the floor of *C. tittaecheilus* roosts on Panjang Island (Tidemann *et al.*, 1990).

2.3 Diet of fruit bat

Megachiroptera are known to feed upon fruits of at least 145 genera of plants, from numerous families, but most notably Palmae (Arecaceae), Anacardiaceae and Sapotaceae (Marshall, 1985).

Fruit vary widely in their nutritional properties. The proportions of protein, lipids, fibre and minerals can be differing by orders of magnitude (Herbst, 1986). However, some researchers believed that fruit contains low protein compared to other plant and animal food sources. According to Herbst (1986), fruit bats must enhance their fruit diets with higher protein items, including a more complementary array of amino acids, such as in pollen or leaf in order to meet protein needs.

Recent studies on the diet of fruit-eating bats have shown that leaf eating is a common phenomenon and that bats consume the leaves of a wide range of plant species (Funakoshi *et al.*, 1993; Kunz and Diaz, 1995). However, other researchers maintain that fruit bats can meet their protein requirements exclusively with fruits (Herbst, 1986; Stellar, 1986; Thomas, 1984). Fruit bats (*Carollia brevicauda* and *Sturnira ludovici*) in Costa Rica showed a strong preference for fruit (*Acristus arborescens*) that was not infested with insect larvae (Engriser, 1995). Furthermore, it has been proposed that most fig wasps will have depart figs by the time they become ripe and are consumed by bats, and residual remains are unlikely to contribute significantly to protein intake (Conklin and Wrangham, 1994).

Most fruit bats prefer to feed on figs (Dumont *et al.*, 2004). Ripe figs are primarily consumed by vertebrate frugivores especially fruit bat, which are the main dispersers of fig seeds (Shanahan *et al.*, 2001). Stier and Mildenstein (2005) noted that many pteropus species rely heavily on figs in their diet. Their may commute long distances each day to reach fruiting trees. *Dodsonia minor* in Papua New Guinea greatly feeds on figs and introduced piper (Bonaccorso *et al.*, 2002). Even the smaller pteropodids, Nyctimene also relied on figs. Commonly, figs contain quite large proportion of indigestible fibre but low in nitrogen and lipids. However, many fruits such *Solanum* sp and *Piper* sp have low fibre content but high in protein content.

The distribution and abundance of fruits are essential in determining the size and density of any given frugivore community (Fleming, 1988). The example of this relationship is found in the increase in frugivorous species in equatorial region where fruiting plants also increase their diversity and abundance. The differences in fruits diversity and abundance have been noticed as possible cause of high diversity species, dietary specialization feeding among phyllostomids and generalized feeding strategies among pteropodids.

Fruit bats are highly efficient in extracting the liquid portion of selected foods. They have fewer teeth than insectivores (Stoddart, 1979). Some studies on dietary strategy of fruit bats have involved collecting and analyzing food items for various nutrients (Morrison, 1978, 1980; Thomas, 1984). Thomas (1984) and Stellar (1986) conducted study on stomach content of bats in the wild. Fruit bats presumably have no difficulty meeting energy needs during periods of food abundance because they consume large amounts of high carbohydrate fruits, both in captivity and in the wild.

The fruit bats teeth are broad and quite flat for crushing fruits and allowing them to squeeze out and ingest the juice (Morrison, 1980). The survey on bats and their food plant was done by Marshall, (1985). He suggested that, 21 genera of bats feeds on 75 genera of flowers, 145 genera of fruit and 10 genera of leaves. Study by Tan *et al.* (1998), noted that *C. brachyotis* is an important seed disperser. These bats were found to feed on 54 species of fruit, 14 species of leaves and four plant species of flower part.

Boon and Corlett (1989) collected the fruit and seed remains under the roosting site. From the study, they argued that *C.brachyotis* primarily feeds on *Adinandra dumosa* which is the dominant pioneer plant in Singapore and southernmost part of the Malay Peninsular. *C. brachyotis* is reported to be a major seed dispersal agent for *A. dumosa* in Singapore. Defecating habits of this bat during flight provides high quality dispersal for small and light seeded such as *A. dumosa*.

Bhat (1994) noted that, *C. sphinx* feeds on fruits from at least 23 plant species, leaves from eight species, and flowers from two species. In addition, *C. sphinx* visits fruit-bearing plants which have both `steady state' (*Polyalthia longifolia*) and `big-bang'(*Ficus religiosa*) (Gentry, 1974). Harem males forage range relatively within less than 1 km to day roosts, whereas non-harem males and females forage at greater distances from day roosts (Marimuthu *et al.*, 1998).

According to Kunz and Diaz (1995), *A. jamaicensis* is diversified in dietary which feed on fruits from over 70 genera. The study on dietary of two species of Philippines Flying Foxes which is *Acerodon jubatus* and *Pteropus vampyrus lanensis* was done by Stier and Mildenstein (2005), suggests that *A. jubatus* is a forest obligate which feeds on fruits and leaves from plant species limited to lowland. However *P. v. lanensis* has a broader diet, including fruits, leaves, and flowers and uses a wide variety of fruit than *A. jubatus* in natural forest habitats.

Agoramoorthy and Hsu (2005) studied Indian fruit bat, *Latidens salimalii*, noted that the analysis of fruit remains found under the roost sites revealed the presence of at least three species of figs such as *Ficus daldotii*, *F. macrocarpa*, and *F. racemosa*, plus other plants such as *Eleocarpus oblongus*, *Diospyros ovaliflora* and *Prunus ceylanicus* in their diet. They also noted seeds of an unidentified plant scattered underneath the roost sites, with deep canine holes on both sides of the large seeds it seems that to dig out its soft inside parts. The seeds probably crushed by *L. salimalii* measured 22.4–32.2 mm in length, 17.4– 24.9 mm in width and had a coat thickness up to 4.1 mm, the seeds were extremely hard and difficult to penetrate, even with a knife. In addition, this bat was observed plucking forest fruits and bringing them into the caves for consumption.

Nyhagen *et al.* (2004), studied the diet of *Pteropus niger* noted that fruit was the main composition. They documented 22 species of food plants, but 36% of food plants are vulnerable or rare and their availability to the bats may decrease even further in the future. The truth that half of the food plant species were introduced suggests that *P. niger* is an opportunistic feeder, strongly influenced by habitat alteration resulting from human activity.

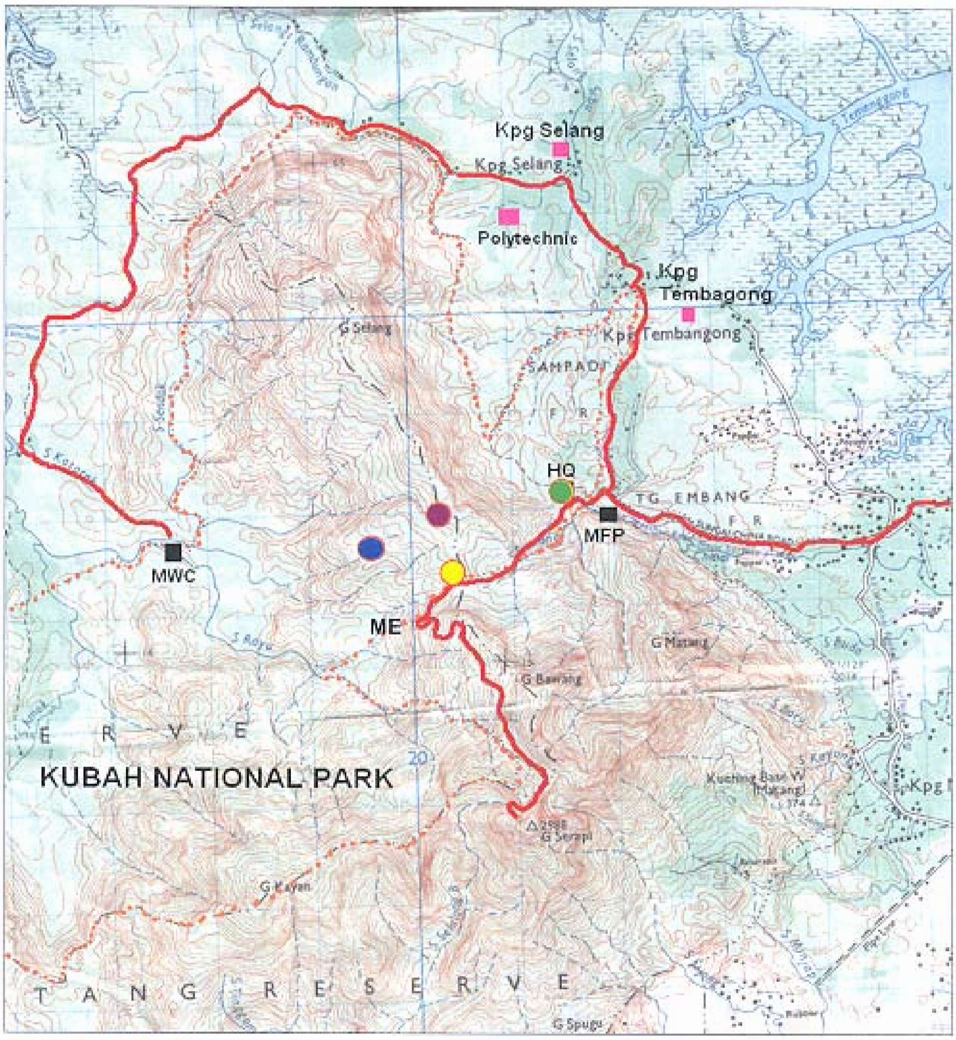
3.0 Materials and Methods

Three sampling sessions were conducted at Kubah National Park (KNP); between 26th August to 2nd September; 2nd December to 7th December, and 16th December until 22nd December 2006.

3.1 Study site

Kubah National Park (N 01° 36.1704, E 110° 11.159) covers an area of 2230 hectares is relatively small in size and consists of a sandstone plateau which includes three mountains; Gunung Serapi, Gunung Selang and Gunung Senduk (Hazebroek and Abang Morsidi, 2000). Kubah National Park occupies the northwest flank and ridge of the Gunung Serapi massif. Kubah National Park was one of Sarawak's accessible national parks that located about 22 kilometers west of Kuching city (Hazebroek and Abang Morsidi, 2000).

Much of the park consists of fairly steep terrain. Altitude ranged between 20 and 777 meter above sea level. The park does not include Gunung Serapi's summit, which is 911 meters above sea level (Hazebroek and Abang Morsidi, 2000). Kubah National Park is largely covered by mixed dipterocarp forest. On the ridge tops grows a distinct type of forest, referred to as "ridge top forest". There are five main vegetation types that can be found in this national park; alluvial forest, lowland mixed dipterocarp forest, kerangas (heath) forest, submontane forest and secondary forest.



Park boundary
Road
Camera site
= Gazebo near Waterfall trail
= Gazebo at an entrance of Rayu trail
= Gazebo along Rayu trail
= Headquarter Office of KNP
ME = Middle elevation of Mount Serapi
HQ = National Park Headquarters
MWC = Matang Wildlife Centre
MFP = Matang Family Park

Figure 1: Study site and location of the cameras at Kubah National Park.

Study sites were selected based upon the ground surveys for evidence of roosting sites food remains under these roosts. These roost are further determined their current utilization by *C. brachyotis* by checking for fresh fruit remains. Once such information has been collated, plastic sheets was laid under the selected feeding roost area. These sheets were pinned to the ground to avoid being blown away.

3.2 Site selection

Described below is the site selected based on ground survey.

a) Headquarter Office of KNP (1° 35.280 'N, 110° 11. 540 'E).

The roosting site for *C. brachyotis* bat was detected at this point. There are presence of food remaining and seeds under this roosting site. Single camera trap was deployed at the top near the roof to observe the feeding behaviour. Plastic sheet was set below the roosting area to collect the foods dropped and seed.

b) Gazebo at an entrance of Rayu trail (1° 36.421'N, 110° 11.106'E).

There are presence of remain food and seed under roosting site. Single camera trap was deployed to observe the feeding behaviour of this bat. Plastic sheet was set under the roosting area to collect the foods remain fall and seeds.

c) On banana leaf (*Musa* sp.)tree at middle elevation(1040 ft) of Mount Serapi(1° 36. 161'N, 110° 11.110'E)

The mist net was setup at this point. Two individual of *C. brachyotis* were seen during the day and was mist netted. Plastic sheet was spread under this feeding roost.

d) Gazebo along Rayu trail

Two mist nets were setup at this point. Four individual of *C. brachyotis* was mist netted. Plastic sheet was set under the gazebo.

e) Gazebo near Waterfall trail

At this site, camera trap was deployed at the top near the roof to observe the feeding behaviour of this bat. A number of bats were seen flying away from the roost each I approach the roost site. Plastic sheet was set below the roosting area to collect the foods dropped and seed.

3.3 Camera traps

Camera traps that were used are the commercially made Cam Trakker brand (see figure 2). These camera traps manufactured by Camtrak South, 1050 Industrial Drive, Watkinville, GA 30677, USA. Cam Trakker combines a fully automatic 35mm, camera with an inactive infrared heat-in-motion detector. The heat-in-motion sensors operates on a horizontal plane, thus it is important that it is aim parallel to target area where the bat is suspected to roost. When something that moves and gives off heat, a silent electronic switch engaged the camera, which takes a photograph. The cameras were operational 24 hours a day with no break in monitoring.

All the cameras were programmed automatically to have the date and time printed on each photograph. Setting of date and time is important for analysis of activity pattern for each species of an animal. To obtained clear photographs of the animals, 400 ASA films were used. The edge of camera casing was sealed with dark tape to avoid moisture from getting inside the camera case. To absorb moisture inside the camera case, silica gels were placed inside the casing.

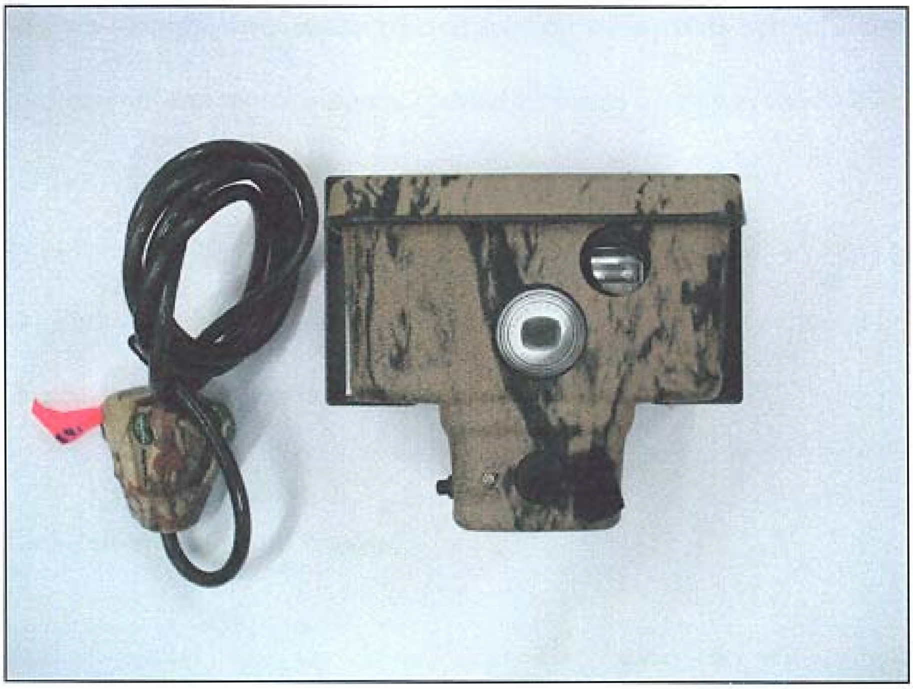


Figure 2: Camera trap with cable lock.

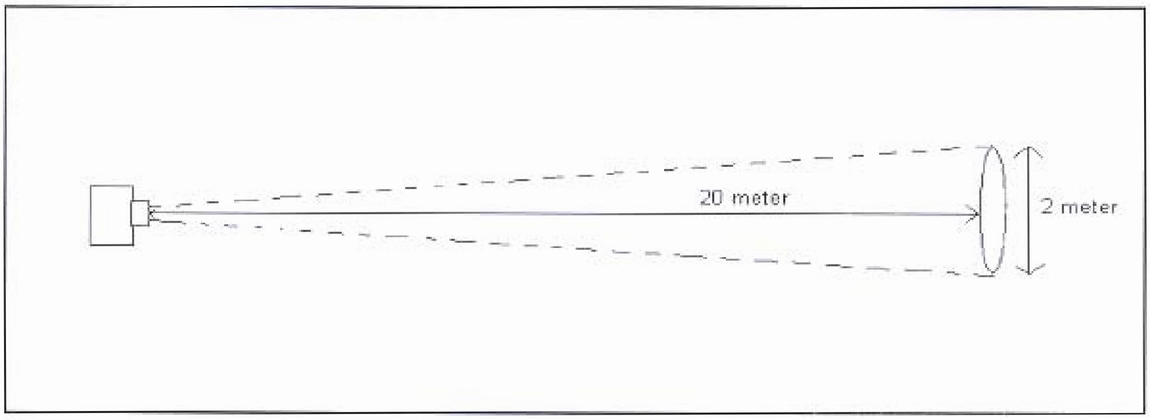


Figure 3: Top view of passive infrared camera system for Cam Trakker and distance of sensor detection. Cam Trakker has narrow beam of sensor that sensed heat-in-motion within the conical area.

3.4 Identification of *C. brachyotis* species.

a) Netting – The bats were netted using mist nets 12m x 2.5m with mesh size 36 mm. Four mist nets was setup across each targeted feeding roost. Bats netted identification based on measurements and morphological characters based on Payne *et al.* (2005).

b) Observation – By the direct observation made using torchlight at each gazebo. Kubah National Park headquarters office was observed during the day time. The identification of bat based on external feature described by Payne *et al.* (2005).

3.5 Identification of seeds and fruits.

Fruits remains and seeds were collected daily by placing them into separate sheets and labelled. These samples were later places in alcohol 70% for further identification in the laboratory. The collections were separated according to the morphology features (size, shape, and color) and types of the seed species. All the plant species were identified using Corner (1988), Ng (1978, 1989), Whitmore (1972a, 1972b), Saepadmo and Saw (2000) and Saepadmo *et al.* (2002) and for further verified by using specimens from herbarium Faculty Resource Science and Technology (FRST), UNIMAS.

4.0 Result

4.1 Foraging Activity

Throughout the sampling periods, a total of 99 photographs had been taken by camera traps. There are 93 photographs were taken at rest area near entrance of Rayu trail (Table1). The six photographs taken at the National Park Headquarter office during the third sampling session did not show any bats. No photographs were recorded near waterfall and in Rayu trail area.

Table1: The camera effort for each feeding roost.

Camera location	Effort	No of Photos	Remarks
Headquarter office	5 camera nights	6	Seeds collected
Gazebo at Rayu entrance	16 camera nights	93	Fruits and seeds collected
Waterfall	3 camera nights	0	Seeds collected
Gazebo along Rayu	2 camera nights	0	Seeds collected

Thirty two photographs showed the presence of the *C. brachyotis* bat (see Appendix A). The remaining 67 of photographs did not show clearly the presence of this bat. Based on the photograph taken, two peaks of activity was recorded in the first trip, that is at 8 to 9 pm and 11 to 12 midnight (figure 4). There were no photographs taken at the second trip since the heavy rain occurred during the study. During the third trip the peak activity occurred at 8 to 9 pm, 11 to 12 midnight and 5 to 6 am (figure 4).