Forest Habitat and Fruit Availability of Hornbills in Salakphra Wildlife Sanctuary, Kanchanaburi Province, Thailand

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Abstract

This study aimed to examine the quality of hornbill habitat in terms of tree and fruit availability in mixed deciduous forests, Kanchanaburi Province, Thailand. Salakphra Wildlife Sanctuary (SLP) has been known as a mixed deciduous forest, which has been disturbed by human activities. All canopy trees with a breast height diameter (DBH) ≥ 10 cm within the ten belt-transects of 2,000 m X 20 m (a total of 40 hectares) were monitored monthly. A total of 30 tree families including 81 species were observed on the belt-transects and the dominant species were non-hornbill fruit species. As hornbills needs emergent tree for nesting, trees with DBH size ≥ 40 cm were regarded as a potential nest tree and 37.78 % of trees were found in SLP. The abundance of preferred nest tree species (families Dipterocarpaceae, Myrtaceae and Datiscaceae) were 12.14%. The density of Ficus spp., which is regarded as the most important food source for hornbill, is 0.55 trees / ha in SLP. The Fruit Availability Index (*FAI*) of all fruit species during the breeding season is 23.49 % while the *FAI* of hornbill fruit species is 58.88 %. Furthermore, in addition to this study, a pair of Great hornbills was observed during the breeding season and the male abandoned the nest to feed the mate prior to the expected hatching period. A pair of great hornbills was observed during the breeding season in SLP and the male would only leave the nest to find and retrieve food for the female mate prior to the expected hatching period. The average estimated number of food items fed to the female mate was 220 food items during the period from March (n = 3) to 13 food items in April 2014 (n = 4). The reduction in the availability of food items may be considered as one of the factors that affect the success or failure of producing offspring.

Keywords: Forest Habitat / Fruit Availability / Hornbill / Salakphra Wildlife Sanctuary

1. Introduction

Habitat structure and fruit availability have been regarded as a factor that strongly influences the density and distribution of Asian hornbills (Poonswad and Kemp, 1993). These are adversely affected by both human and natural disturbances (Winarni and Jones, 2012; Cahill and Walker, 2000). The mixed deciduous forest of Salakphra Wildlife Sanctuary (SLP) is one of the badly disturbed protected habitats supporting two hornbill species, Great hornbill *Buceros bicornis* and Oriental pied hornbill *Anthracoceros albirostris* (Wiles, 1979). In Khao Yai National Park (KYNP), Thailand, it has been reported that a) fruit is the major source of food for hornbills and b) that the availability of ripe fruit, especially figs , is positively correlated with the density of hornbills (Poonswad and Jirawatkavi, 2004; Anggraini et al., 2000).

In addition, even though hornbills are known as a cavity nester, the availability of nest cavities in the forest is crucial since they cannot carve trees themselves. However, there has been little study on the environmental conditions for hornbill in mixed deciduous forests compared to major study sites for hornbills in Thailand such as Khao Yai National Park, Budo Su-ngai Padi National Park and Huai Kha Khaeng Wildlife Sanctuary. In this study, trees habitat and year-round fruit availability were examined for the quality of hornbill habitats at mixed deciduous forest of SLP. Moreover, in addition to this study, the breeding behavior of Great hornbill, which is regarded as one of the near threatened species by the International Union for Conservation of Nature (IUCN, 2013), was observed during the breeding season in order to understand hornbills traits in mixed deciduous forest, SLP.

2. Methodology

2.1 The Study Site

SLP was established in 1965 as the first wildlife sanctuary in Thailand, which covers 858.55 km^2. SLP is one of protected areas in Western Forest Complex (WEFCOM) as shown in Figure 1, which is the largest protected forest complex in Thailand located next to the border between Thailand and Burma. The main vegetation type in SLP is classified into mixed deciduous forest and bamboo forest, and the rest into evergreen, dry evergreen forest and grassland. The average temperature of 28 °C and the average annual precipitation is 1,170 mm which is relatively dry compared to other areas in Thailand. The dry season in this area is known for its extreme dry condition. Natural fires often occur in this area during the dry season. The highest temperature reaches 34 °C and the lowest is 23 °C.

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The average relative humidity of SLP ranges from 57 to 79 % (Youngpoy, 2012).

The mixed deciduous forest of SLP is one of the badly disturbed protected habitats in Thailand. While bamboo, is one of major the types of vegetation in SLP, it is often regarded as the result of forest degradation, due to over utilization of resources, human activity and political problems of a growing human population with difficulties in maintaining conservation (Bult, 2003; Youngpoy, 2012).

However, there are still two hornbill species inhabiting this area-Great hornbill *(Buceros bicornis*) and Oriental pied hornbill (*Anthracoceros albirostris*). The former is regarded as especially sensitive to forest disturbance compared to other hornbill species (Wiles, 1979; Datta, 1998).

Therefore, to examine the quality of hornbill habitat in mixed deciduous forest in disturbed condition, SLP was chosen as one of the study sites.

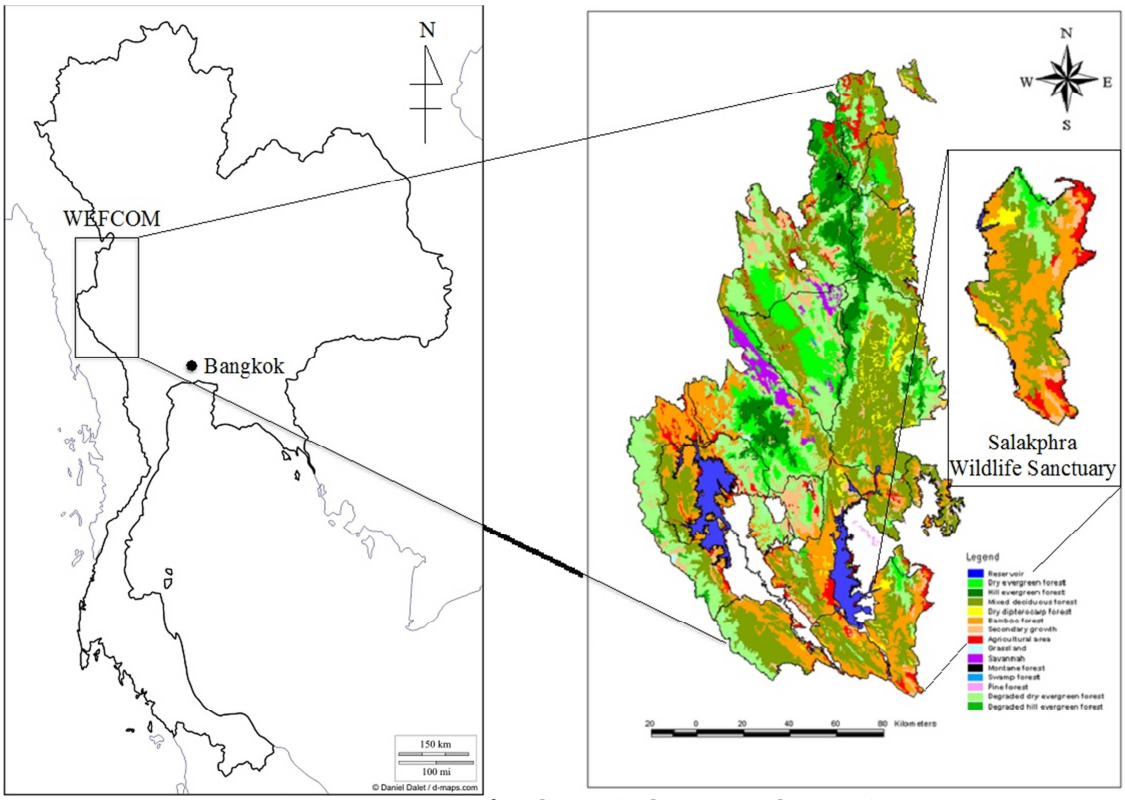

Figure 1: Location of study site (Bult, 2003; Dalet, 2007)

2.2 Data collection

Data collection was conducted in SLP to examine the quality of hornbill habitat from July 2013 to June 2014. Forest habitat was studied from July 2013 to June 2014 with the help of rangers and the members of Thailand Hornbill Project. The fruit availability throughout the year from July 2013 to June 2014 and the breeding behavior of a pair of Great hornbill during the breeding season in February to April 2014 were studied.

2.2.1 Forest habitat

Two sets of the 20 ha belt-transects including five belt-transects with 10 perpendicular plots per each were set at two sites: Khaosooa and Hoelow, in SLP. Each belt-transect was 2,000 m long, 20 m width, and the range between each belt-transect was 500 m. The choice and direction of data collection on the belt-transects were dependent on the weather conditions and safety from wildlife attack. Since hornbills are influenced by large trees when it comes to plucking fruit and nesting, the trees with its crown fully exposed when above neighbors around, or with crowns partially covered by neighbors with the same height as the tree, and with a diameter of breast height (DBH) $\geq$ 10 cm on the belt-transects were chosen to be tagged with aluminum number plates and nail (Poonswad, 1995; Kitamura et al., 2004). This was used to recognize each tree on the belt-transects. All of the canopy trees were chosen and tagged. On the belt-transects in study sites, canopy trees were chosen and tagged. The trunk circumference of each tree was measured and recorded. The trunk circumference was used for the calculation of DBH and basal area. The measurement of trunk circumference as DBH was conducted depending on six tree types including (1) trees without any special requirement (2) trees with fork below breast height (3) trees splitting into several stems close to the ground level (4) trees growing vertically on a slope (5) leaning trees, and (6) trees with buttress as shown in Table 1.

Table 1: Methods of DBH measurement

Type of tree	Methods
Trees without any special requirement	The DBH of trunk at a breast height was measured.
Trees with fork below breast height	Swollen part at breast height was avoided to measure the DBH if the fork level is below breast height and above 50 cm from the ground level. The DBH of main trunk below the fork was measured.
Trees splitting into several stems close to the ground level	If the tree is with fork below 50 cm, the DBH of each stem at breast height was measured and calculated as a stem of the sum of all stems' DBHs. (eg. $\sqrt{[(22\ cm)^2 + (34\ cm)^2 + (40\ cm)^2]} = \sqrt{3240} = 56.92$ cm)
Trees growing vertically on a slope	The DBH of the trunk was measured from the upper side of the slope.
Leaning trees	The DBH of the trunk on the side that the tree leans towards was measured.
Trees with buttress	If buttress along the trunk is up to the breast height, the DBH of the trunk right above the buttress was measured since buttress is swollen. Therefore, in this case, the trunk above breast height was measured.

Source: Agriculture, Fisheries and Conservation Department, 2006

Density (stems per ha), frequency (number of sample plots per total number of sample plots), and dominance (cm^2 per ha) per each species were also calculated using the DBH and basal area of each species. The density, frequency and dominance were used for calculating the Important Value Index (*IVI*), which indicates the dominant species in study sites. The bark, shape of tree, leaves, flowers, and specific scents were collected and recorded for identifying the tree. All of the data were examined and recorded by handwriting using observation form. After fieldwork in study sites, all of the data were coded, rechecked, and put into computer for data analysis and tree identification.

Tree identification was conducted with local Thai name with the help of local Thai park rangers. The local Thai name of trees were recorded and identified into scientific name with the help of local rangers in SLP and the members of Thailand Hornbill Project with expertized backgrounds: Mr. Plongmai Kamol (a taxonomist), Mr. Narong Jirawatkavi (a forest ecologist), Mr. Pithaya Chuailua (an ecologist), and Mr. Sangwan Togsungnuen (a research assistant). A Field Guide to Forest Trees of Northern Thailand by Gardner and colleagues (2000), previous research studied by Kitamura et al. (2002), the IUCN guidelines (2013) were included as reference.

2.2.2 Fruit availability

Observations and monitoring of the fruit availability were conducted monthly on two sets of the 20 ha belt-transects during 0800-1600 hours from July 2013 to June 2014 in SLP, using an observation form. Fruit abundance of all tagged trees was observed using binocular and recorded. The percentage of crown covered by ripe and unripe fruits was observed visually based on color changes using a binocular for each individual tree. The total amount of fruit in each tree was estimated and classified into five classes: 4 (100-76 %), 3 (75-51 %), 2 (50-26 %), 1 (25-1 %), 0 (no fruits) according to fruit coverage in canopy, ripeness of fruit, and proportion of fruit, unripe fruit and bud (Holbrook et al., 2002).

2.2.3 Breeding behavior

Great hornbills, as compared to other hornbill species are more common in undisturbed forest, were chosen for observation and monitoring during breeding activity, and foods delivered to nest trees by the male for the mate and nestlings (Datta, 1998). The observations and monitoring of a pair of Great hornbills were conducted using binocular and field scope between 0600-1800 hours during the breeding season in 2014 (March 2014 to April 2014). Dropped foods by Great hornbills were collected for fruit identification. The data of breeding activities were converted into incubation period, length of female incarceration and the number of days for fledging. Other activities of hornbills: the time of arrival, departure, and initiation and completion of the breeding process were also recorded. Furthermore, the presence of predator access routes and liana on the nest tree were observed and recorded. Root type was identified for examining nesting site characteristics.

2.3 Analysis

All of the data from observation form were checked, coded and put into computer for data analysis. Local Thai name of trees were converted into scientific names. The analyses of forest habitat and fruit availability were employed as follows.

2.3.1 Forest habitat

The quantitative data of a forest habitat on each belt-transect was described by density (*D*), relative density (*RD*), frequency (*F*), relative frequency (*RF*), dominance (*Do*), and Importance Value Index (*IVI*) (Whittaker, 1970). Collected data was calculated for:

Density (*D*) = number of individuals/number of sample plots (1)
Relative density (*RD*) = (*D*/sum all species density)*100 (2)
Frequency (%) (*F*) = (number of sample plots in which *k* species occurs/number of sample plots)*100 (3)
Relative frequency (*RF*) = (*F*/sum all species frequency valves)*100 (4)
Dominance (*Do*) = Total basal area of *k* species/number of sample plots (5)
Relative dominance (*RDo*) = (*Do*/sum of basal area for all species)*100 (6)
Important Value Index (*IVI*) = (*RD* + *RF* + *RDo*) (7)

2.3.2 Fruit availability

An index of overall fruit availability (Holbrook et al., 2002) was estimated on each set of the belt-transect every month by using Fruit Availability Index (*FAI*) as follows:

$$FAI = \sum_{k=1}^{n}(D_k \times B_k \times P_{km}) \quad (8)$$

On the belt-transects, where D_k is the density of species *k* (stems/hectare), B_k is the mean basal area of species *k* (cm^2/hectare), P_{km} is the percentage of observed trees of species *k* which produce ripe fruit in a given month *m* (eg. score 1 = 1-25 % = 12.5 %).

Table 2: Ten dominant species on two sets of 20 ha belt-transects in Study Sites

Family	Species	*IVI*	HFS
Lythraceae	*Lagerstroemia cochinchinensis* var. *ovalifolia*	34.67	-
Sapindaceae	*Sisyrolepis muricata*	16.22	-
Leguminosae	*Millettia brandisiana*	15.77	-
	Pterocarpus macrocarpus	13.89	-
Anacadiaceae	*Spondias pinnata*	12.83	-
Dipterocarpaceae	*Shorea siamensis*	11.70	-
Apocynaceae	*Alstonia* sp.	11.48	-
Dipterocarpaceae	*Shorea obtusa*	10.26	-
Sapindaceae	*Zollingeria dongnaiensis*	9.12	-
Leguminosae	*Dalbergia nigrescens*	9.04	-

HFS (✓) = Hornbill Fruit Species

3. Results and Discussion

3.1 Tree availability

The two sets of 20 ha belt-transects in SLP had a total of 1,821 canopy trees with 30 families and 81 species. The canopy layers did not have continuous crown of green leaves throughout the year because of the dry season. Even though bamboo species were often observed on the belt-transects, they were not recorded. According to *IVI* (number in the parentheses), the ten dominant species were *Lagerstroemia cochinchinensis* var. *ovalifolia* (34.67), *Sisyrolepis muricata* (16.22), *Millettia brandisiana* (15.77), *Pterocarpus macrocarpus* (13.89), *Spondias pinnata* (12.83), *Shorea siamensis* (11.70), *Alstonia* sp. (11.48), *Shorea obtusa* (10.26), *Zollingeria dongnaiensis* (9.12), and *Dalbergia nigrescens* (9.04) as shown in Table 2. None of them are hornbill fruit species.

The distribution of measured trees and the proportion of potential nest trees on the belt-transects in SLP is shown in Figure 2. Trees with DBH of 20-29 cm give the highest proportion of 566 out of 1,821 trees (31.08 %). Those with DBH of 80-89 cm had the lowest proportion of 24 out of 1,821 trees (1.32 %). Since trees with DBH ≥ 40 cm are regarded as potential nest trees for hornbills (Poonswad, 1995), they were distributed into two groups: DBH < 40 and DBH ≥40 cm. The proportion of trees with DBH ≥ 40 cm is 37.78 % and that with DBH < 40 is 62.22 %. Aside from the size of trees, hornbills select nest trees according to species. Aside from the size of trees, hornbills select nest trees according to species. According to Poonswad (1995) and Chimchome et al. (1998), the preferred tree families of hornbills are Myrtaceae and Dipterocarpaceae in the moist evergreen forest of KYNP and Myrtaceae and Datiscaceae in the hill evergreen forest of Huai Kha Khaeng Wildlife Sanctuary. The proportion of preferred tree as a nest tree of hornbill in SLP indicated that all 1,821 trees in SLP, 206 trees are Dipterocarpaceae (11.31 %), 15 trees are Myrtaceae (0.82 %), no tree is Datiscaceae (0 %) and other trees are 1,600 (87.9 %).

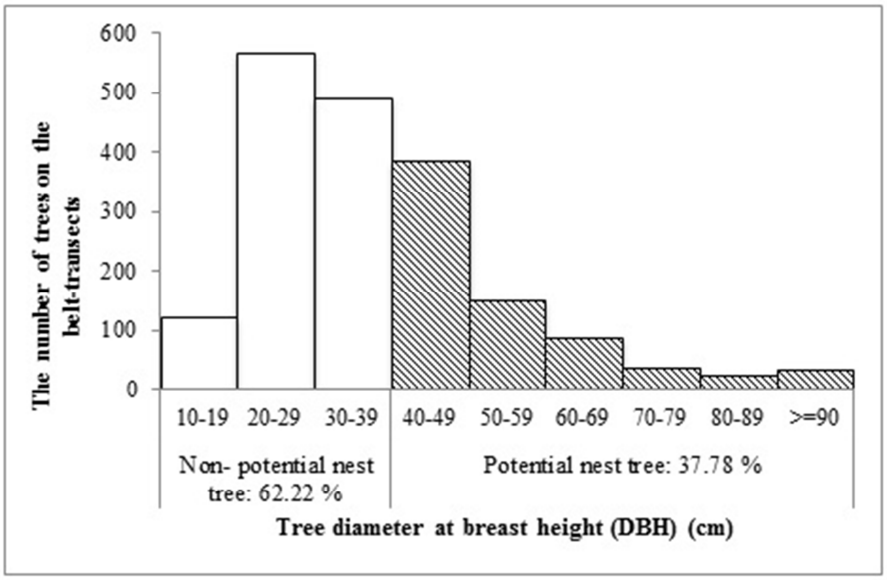

Figure 2: The distribution of measured trees and the proportion of potential nest trees

Table 3: Ten hornbill fruit species in Study Sites

Family	Species	Relative Density (%)	Relative Frequency (%)	Relaive Dominance (%)	*IVI*
Alangiaceae	*Alangium salvifolium* spp. *hexapetalum*	0.27	0.17	0.08	0.53
Anacadiaceae	*Buchanania lanzan*	0.16	0.29	0.01	0.47
Lauraceae	*Litsea glutinosa* var. *glutinosa*	0.16	0.29	0.02	0.47
Meliaceae	*Aphanamixis polystachya*	0.49	0.87	1.09	2.46
	Artocarpus lakoocha	0.22	0.58	0.16	0.96
	Ficus sp.	0.77	2.61	4.13	7.51
	Streblus asper var. *asper*	0.33	0.87	0.23	1.43
Myrtaceae	*Syzygium claviflorum*	0.55	0.87	0.65	2.07
Sterculiaceae	*Sterculia villosa*	0.93	0.58	0.49	2.00
Sterculiaceae	*Sterculia* sp.	1.76	2.61	2.29	6.66

Ten out of 81 species (113 out of 1,821 trees; 5.96 %) are hornbill fruit species in SLP: *Alangium salvifolium* spp. *hexapetalum, Buchanania lanzan, Litsea glutinousa* var. *glutinousa, Aphanamixix polystachya, Artocarpus lakoocha, Ficus* sp. *Strebluc asper* var. *asper, Syzygium clabiflorum, Sterculia villosa and Sterculia* sp. As shown in Table 3. Since *Ficus* (Moraceae) is an of the important food source among all fruit species for hornbills (Kannan and James, 1999) and that there is a positive correlation between fig and hornbill density (Kinnaird and O'Brien 2007), the abundance of *Ficus* in forest habitat may be considered as one of the factors for the quality of hornbill habitat. There are 22 *Ficus* species on two sets of 20 ha belt-transects in SLP (0.55 trees per ha). Based on the DBH size of the *Ficus* trees, the most prevalent DBH measure is greater than 90 cm (Figure 2). Since large trees are supposed to bear more crops than small trees, the high density of large trees may be considered as a factor for good quality hornbill habitat.

3.2 Fruit availability

The observations and monitoring of fruit availability were conducted monthly on two sets of 20 ha belt-transects (a total of 40 ha) in SLP from July 2013 to June 2014. The amount of precipitation in Kanchanaburi Province during September 2013 to June 2014 and the Fruit Availability Index (*FAI*) were put combined as shown in Figure 3.

The *FAI* of available fruit species was 23.49% during breeding season (January to June)

and was 59.09% during non-breeding season (July to December). Hornbill fruit species in SLP had less seasonality compared to all fruit species that had strong seasonality depending on the amount of precipitation.

Hornbill fruit species support hornbills as food sources throughout year. Hornbills in SLP select their breeding period depending on the abundance of the hornbill fruit. The *FAI* of all fruit species is significantly correlated (r = 0.797, $p < 0.01$) to monthly rainfall; whereas, the *FAI* of hornbill fruit species is not significantly correlated to monthly rainfall. The highest *FAI* of all fruit species was noted in August 2013 and the lowest in March 2014, while the highest *FAI* of hornbill fruit species was in April 2014 and the lowest in September 2013.

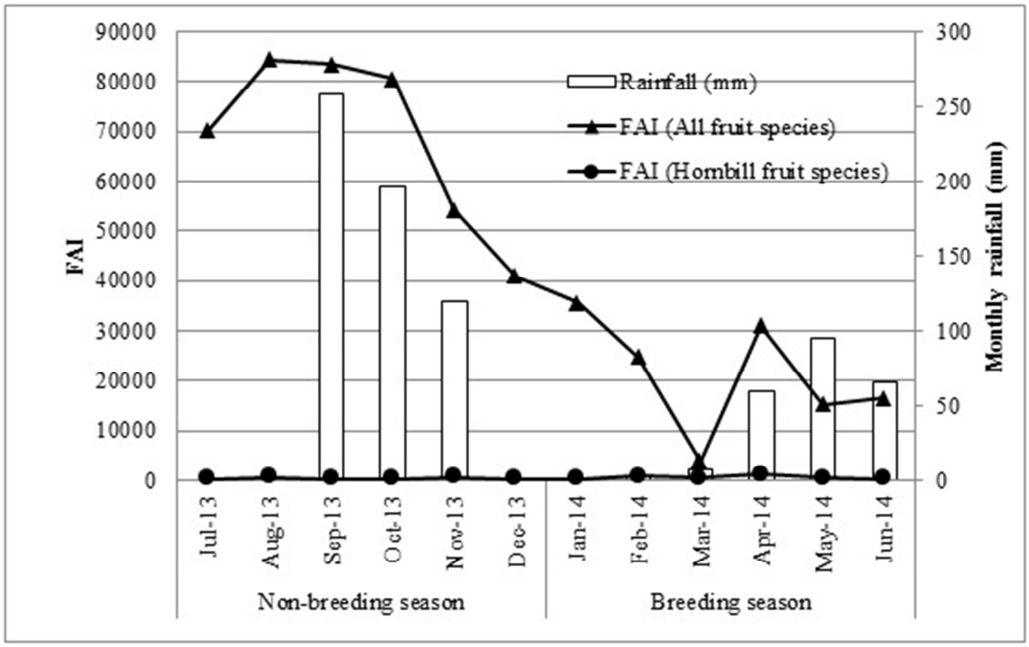

Figure 3: Location of study site (Bult, 2003; Dalet, 2007)

Table 4: Feeding behavior of a pair of Great hornbill in SLP

Date	Feeding Behavior		
	Feeding cycle (return / feeding / departure)	Duration (minutes)	Estimated number of food items fed
14 Mar 2014	1	6	120
15 Mar 2014	4	20	400
16 Mar 2014	1	7	140
8 Apr 2014	1	1	4
9 Apr 2014	1	3	12
11 Apr 2014	1	3	36

3.3 Breeding behavior

The breeding behavior of Great hornbills in SLP was observed from 0600-1800 hours in March 2014 and April 2014 at a nest tree close to Hoelow Ranger Station. The nest tree was located behind a ranger house in the station, so their breeding behavior was observed by using field scope and binoculars from the ranger's house. A pair of Great hornbill first visited the nest tree late January 2014 to early February 2014 and their mating was last observed on February 14, 2014.

Probable nest sealing was made on late February 2014 to early March, 2014 and first observation of the male feeding the mate was on March 15, 2014. The male Great hornbill abandoned the nest to feed the mate on April 12, 2014 to April 22, 2014 as shown in Table 4. Foods brought by male were made out of at least six fruit species including *Ficus benjamina*, *Ficus auriculata*, and other four unknown fruit species. Nine feeding cycles (return/feeding/departure) of the male Great hornbill were observed.

On most days of the observation, the feeding cycles were made once a day (total 5 days), and the rest for three times a day. The average estimated number of items fed by the male Great hornbill was 220 in March and 13 in April 2014. The reduction of the number of food items may be considered as a breeding failure for the pair of Great hornbill.

4. Conclusion

Based on forest habitat, the mixed deciduous forest in SLP is dominated by deciduous tree species and non-hornbill fruit species. The average size of the trees in SLP is small and they cannot be even considered as potential nest sites for hornbills. Examining the quality of hornbill habitat in SLP in terms of forest habitat, the quality is poor.

FAI of hornbill fruit species in SLP is stable throughout the year instead of *FAI* of all fruit species being influenced by the amount of rainfall. The amount of *FAI* of hornbill fruit species is small, when compared to *FAI* of all fruit species. Examining the quality of hornbill habitat in SLP in terms of fruit availability, the quality is poor. The number of recognized cavities in SLP is regarded as a limiting factor since only two nest cavities of Great hornbills have been found in 40 ha belt-transects in SLP. Further study on hornbills in SLP is needed to fully understand hornbill habitat.

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