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# Assessment of Elephant Dietary Biomass at the Adjoining Area of Kaeng Krachan Natural Park, Thailand

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## Abstract

This study investigated the dietary diversity and biomass of the elephants (*Elephas maximus*) ranging in the area adjoining Kaeng Krachan Natural Park, Pa Deng Sub-district, Kaeng Krachan District, Petchaburi Province, Thailand. The investigation was conducted by reconnaissance survey transect (Recce) combined with concentric sample plots with 3 different radii to observe vegetation and collect data on trees, saplings, seedlings, and undergrowth from 89 locations in the study area. Six transects along elephant feeding trails were surveyed at 200 m intervals within 15 m from the center of both sides of each line. The vegetation comprised in all 57 families and 140 plant species, of which 28 families and 51 species formed part of the elephant diets. The average biomass in the study area ranged from 8,314-65,863 tons $km^{-2}$, with an average of 25,000 tons $km^{-2}$. Huay Rae - Hub Pla Kang trail found the greatest amount of biomass which is 65,863 tons $km^{-2}$.

**Keywords:** Elephant (*Elephas maximus*); Biomass; Elephant dietary

## Introduction

Kaeng Krachan Natural Park, the adjacent area of Kui Buri Natural Park, has increasingly faced conflicts between local communities and elephants (*Elephas maximus*) trespassing on agricultural land in order to feed themselves. Kaeng Krachan Natural Park, a protected forest area, is Thailand's largest Natural Park, covering 2,914.7 $km^{-2}$. It originates in the upstream catchment of the Petchaburi and Pranburi Rivers.

The Kaeng Krachan forest area has a rich and complex ecological system. As one of the world's biodiversity hotspots, the area plays hosts to important genetic resources of flora and fauna in Asia, and plays an important international role in tiger conservation as a Tiger Conservation Landscape (TCL) and is also designated as an 'important bird area' (IBA) [2]. Its importance and significance for conservation of biodiversity in the Southeast Asia region led to its designation as an ASEAN Heritage Site in 2003 [1]. Many endangered species, including birds and butterflies, have been observed in this area.

Elephants living in Kaeng Krachan Natural Park can be classified into two groups: 1) elephants living near the upstream of Phetchaburi River along to Ban Krang and Huay Komkrit (about 130 individuals); and 2) elephants living in Pa Deng, Huay Sud Yai, Nong Plub, and Pa La-U Sub-district (about 130 individuals) [3]. In this research, elephants living in the area adjoining Kaeng Krachan Natural Park, Pa Deng Sub-district, Kaengkrachan District, Petchaburi Province, Thailand were selected for study as this is a location for an elephant feeding trial where severe conflicts have arisen between roaming elephants and local farmers. This research focuses on diets of elephants in the study area, in order to contribute to the sustainable management and prevention of conflicts between local communities and elephants in the agricultural areas adjoining Kaeng Krachan Natural Park.

This study was conducted to study types and number of dietary source of elephants in adjoining area of Kaeng Krachan Natural Park, Pa Deng Sub-district, Kaengkrachan District, Petchaburi Province, Thailand.

## Feeding and Habitat Behaviours

Elephants (*Elephas maximus*) are non-ruminants; nevertheless, the elephant's digestion and absorption rate is double that of ruminants [4]. With a diverse herbivorous diet, elephants feed mostly on grasses (*Gramineae* family) including bamboo and single stem grasses. They can also graze and browse on tree leaves during the rainy season, remaining within dense forests close to water [5].

Elephants need about 300 L of water per day [6], and so their habitats always include at least one river system. Due to this high daily water requirement, the locations of creeks and water resources are an important factor indicating the distribution and movement patterns of elephants in Huai Kha Khaeng Wildlife Sanctuary [7].

Naturally, both Asian elephants gather in herds, with herd size depending on factors such as forest condition, amount of food and water, and threats. Where the integrity of the forest is threatened or when food or water supplies are scarce, herd size is typically diminished [8].

Elephants have a broad dietary intake, foraging on various species according to season. The elephant diet may be broadly divided into five plant types as follows [8]:

- Grasses e.g. palm grass (*Setaria Palmifolia* (*Koen.*) *Stapf*),
- Bamboos e.g. *Dendrocalamus strictus* Nees, *Bambusa arundinacea* Willd, *Bambusa bambos* (L.) Voss, and *Bambusa blumeana*,
- Ivies e.g. *Euphorbia lacei Craib*, and *Capparis sepiaria L.* CAPPARIDACEAE,
- Trees and bushes e.g. *Spondias bipinnata Airy* Shaw & Forman, common fig (*Ficus carica*), *Macaranga sp.*, and *Acacia comosa*,
- Crop plants e.g. Turkey berry (*Solanum torvum*); pineapple (*Ananas comosus* spp.).

## Study Area

Pa Deng Sub-District covers an administrative area of 625 $km^{-2}$ located 90 km from the southwestern part of Kaeng Krachan District, and 125 km from Petchaburi Province in Thailand. It is located between 99° 20' E to 99° 37' E latitude and 12° 33' N to 12° 45' N with an elevation of 140 m above mean sea level.

Geologically, Pa Deng comprises a piedmont plateau with a slight slope from west to east. Some parts of Pa Deng fall within the national forest reserved forest and Kaeng Krachan Natural Park area. Pa Deng is situated on a plain surrounded by mountains. The western boundary of the site is defined by the Tanowsri Mountain Range which also serves as the Thailand-Myanmar border. The Pranburi River, the major river in the area [9] begins at the confluence of Huay Sat Lek, Huay Sat Yai, Huay Haeng, and Huay Sok rivers. The major creek in the area is Huay Pa Deng, flowing into Huay Pa Dang Reservoir.

## Methodology

### 1) Study on types and numbers of dietary source of elephants

The field survey was conducted within Pa Deng Sub-district which adjoins the Kaeng Krachan Natural Park, to study elephant feeding habits. The topography, forest type, water resources, land use, and community settlements were surveyed and recorded [10]. Data on the composition of elephant dietary plants were collected as described below.

The reconnaissance survey transect method (Recce) [11] together with concentric sample plots with 3 different radii was used to observe data of trees, saplings, seedlings, and undergrowth. In addition, 6 line transects along elephant feeding trails were surveyed. The survey areas were all within 15 m from the centre of both sides of each line transect which is the average distance from the centre of each feeding trail. For each line transect, concentric sample plots with 3 different radius; 17.85 m, 12.62 m, and 5.64 m, (Figure 1) were set up at intervals of 200 m [12] in order to collect types and numbers of elephant dietary plants.

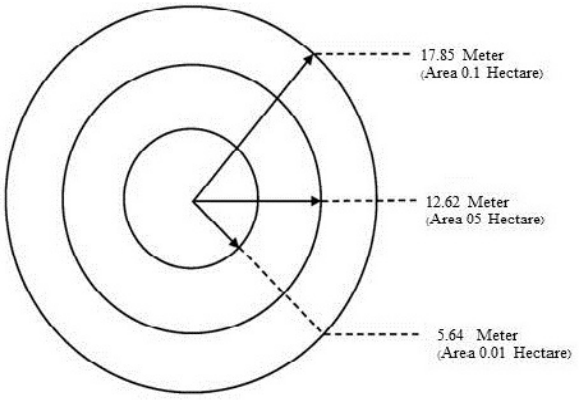


**Figure 1** Concentric sample plot applied in this study.

Size and height of trees with diameter at breast height; DBH (1.30 m), over 4.5 cm were measured from 38 locations. The concentric sample plot is appropriate for classifying vegetation since the space between each radius is uniform. [13] Data for three groups of flora were collected, corresponding to the different radius of the sample plots, as follows:

- Sample plot with 17.85 m radius (area is 1,000 $m^2$) was applied for collecting data of trees with DBH > 4.5 cm, and bamboos. Species, diameters, total height, number of logs which can be good (log = 5 m), and timber quality were recorded in tally sheets.
- Sample plot with 12.62 m radius (area is 500 $m^2$) was applied for collecting data for saplings; plants which have DBH < 4.5 cm but height above 1.30 m. Species, numbers, and height were recorded.
- Sample plot with 5.64 m radius (area is 100 $m^2$) was applied for collecting data of seedling; plants which have DBH and height lower than 4.5 cm and 1.30 m, respectively. Data of species and numbers of seedling and undergrowth were recorded.

### 2) Assessment of elephant dietary biomass

An allometric equation for dry evergreen forest and hill evergreen forest [14] was applied for estimating tree biomass. The equations are;

$Ws = 0.0509 (D^2H)^{0.919}$
$Wb = 0.00893 (D^2H)^{0.977}$
$Wl = 0.0140 (D^2H)^{0.669}$
$Wr = 0.0313 (D^2H)^{0.805}$
$Wt = Ws + Wb + Wl + Wr$

An allometric equation according to the study of Kowanich [16] was applied for estimating bamboo biomass. The equations is;

$Ws = (89.3059 (D^2H)^{0.66513})/1000$
$Wb = (15.3063 (D^2H)^{0.58255})/1000$
$Wl = (0.0140 (D^2H)^{0.44363})/1000$

An allometric equation according to the study of Kowanich [16] was applied for estimating bamboo biomass. The equations is;

$Wt = 0.2425 (D^2)^{1.0751}$

where; Ws = biomass of stalk (kg)
Wb = biomass of branches (kg)
Wl = biomass of leaves (kg)
Wr = biomass of roots (kg)
Wt = total biomass (kg)
D = diameter at breast height (cm)
H = canopy height (m)

The 6 line transects surveyed within Pa Deng Sub-district adjoining Kaeng Krachan Natural Park and Huay Sat Yai Sub-district (shown in Figure 2) are as follows:

1) Saroj Plantation-Hub Pla Kang trail: 2.86 km
2) Pa Deang Reservoir-Huay Sat Lek trail: 5.02 km
3) Kho Lam-Karang 3 Reservoir trail: 6.39 km
4) Huay Rae-Hub Pla Kang trail: 3.48 km
5) Pala-u Reservoir-Huay haeng trail: 2.19 km
6) Pala-u-Huai Sator trail: 7.82 km.

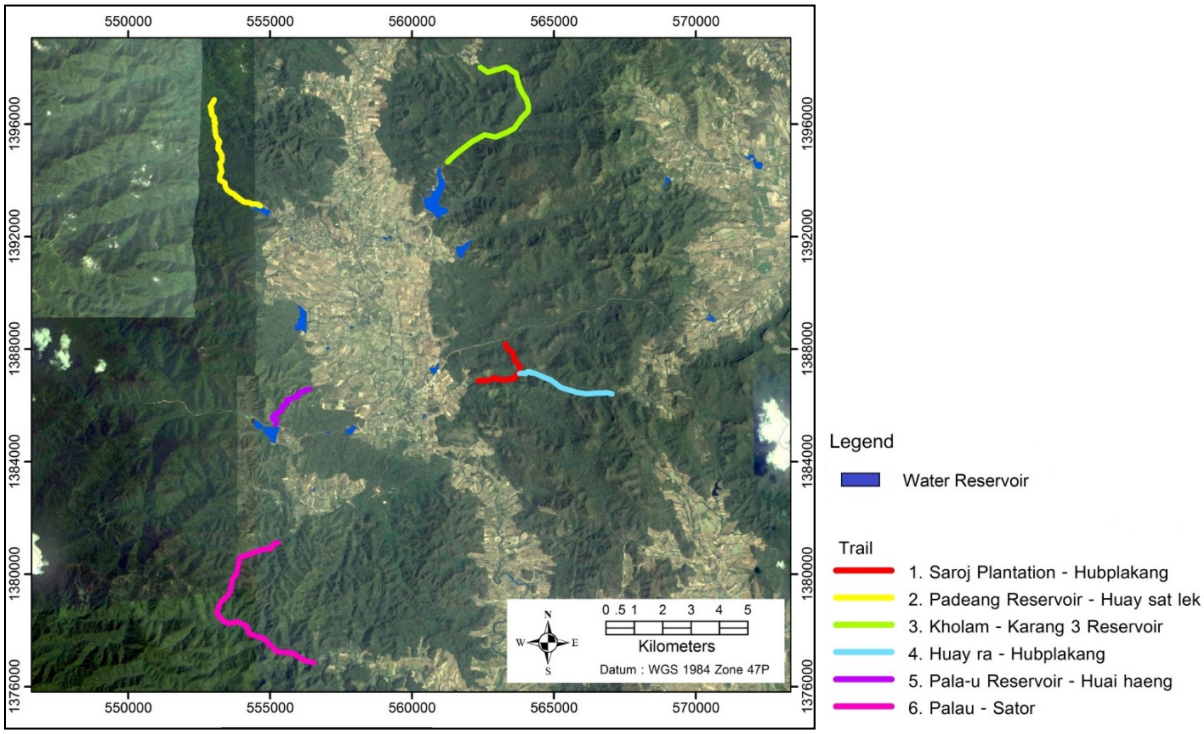


**Figure 2** Six reconnaissance survey lines transect covering the area adjoining Kaeng Krachan Natural Park, Pa Deng Sub-district, Thailand.

## Results and discussion

### 1) Field survey of plant and elephant diet in study area

A total of 140 plant species were identified in six trails within Zone 5 of Kaeng Krachan Natural Park. Of these, 51 species formed part of the elephant diet. The highest number of plant species was observed along Kho Lam – Karang 3 Reservoir trail (6.39 km) where 60 plant species were found, of which 26 species formed part of the elephant diet (Table 1).

The flora identified in the study area were those expected in an evergreen forest. The most important contributors to the elephant diet were members of the Gramineae family (7 species), Euphorbiaceae (5 species), Sterculiaceae (4 species) and Caesalpiniaceae (4 species). Details are summarized as follows;

- Gramineae: *Bambusa arundinacea Willd*., *Thyrsostachys siamensis Gamble, D. strictus Nees*, *Bambusa arundinacea Willd*., *Acroceras munroanum Henr*., *Vitex pinnata Linn*., and *Setaria palmifolia Stapf* (leaves, shoots, and stalks);
- Euphorbiaceae: *Homonoia riparia Lou*, *Blachia siamensis Gagnep*., *Vitex pinnata Linn*. (leaves), *Euphorbia lacei Craib* (shell), and *Bridelia ovata Decne*. (leaves and fruits);
- Sterculiaceae: *Leucaena leucocephala de Wit*, *Sterculia spp*., *Pterocymbium javanicum R. Br*., and *Albizia chinensis Merr*. (leaves);
- Caesalpiniaceae: *Sindora spp*. (fruits), *Maesa ramentacea A. DC*., *Caesalpinia sappan Linn*. (leaves), *Bauhinia scandens Linn*. (shell).

### 2) Biomass of elephant dietary plant in study area

The average biomass in the study area ranges from 8,314 to 65,863 tons $km^{-2}$, with an average of 25,000 tons $km^{-2}$. The greatest proportion of biomass (approximately 64.99 %) was found in the stalks, followed by branches (20.08 %), roots (13.29 %), and leaves (1.64 %), respectively. The highest amount of biomass was found along Huay Rae - Hub Pla Kang trail, with 65,863 tons $km^{-2}$, followed by Kho Lam - Karang 3 Reservoir trail (32,172 tons $km^{-2}$). The lowest amount of biomass was found along Saroj Plantation - Hub Pla Kang trail, with only 8,314 tons $km^{-2}$, as shown in Table 2.

A total of 20,190.45 tons of biomass was found within 15 m from the centre of both sides of all 6 lines transect, with a range from 718.5 0 to 6,924.56 tons. In addition, Huay Rae - Hub Pla Kang trail found the greatest amount of biomass (6,924.56 tons) followed by Kho Lam - Karang 3 Reservoir trail (6,191.20 tons) as shown in Table 2.

**Table 1** Results of flora survey along elephant feeding trials in Kaeng Krachan Natural Park

| Trails | Number of all plant species found | Number of elephant dietary plant species found |
|---|---|---|
| 1. Saroj Plantation - Hub Pla Kang | 45 | 20 |
| 2. Pa Dang Reservoir -Huay Sat Lek | 46 | 16 |
| 3. Kho Lam - Karang 3 Reservoir | 60 | 26 |
| 4. Huay Rae - Hub Pla Kang | 52 | 19 |
| 5. Pala-u Reservoir - Huay Haeng | 34 | 17 |
| 6. Pala-u - Huai Sator | 45 | 27 |
| Total | 140 | 51 |

**Table 2** Amount of elephant dietary plant biomass found along line transect in Kaeng Krachan Natural Park

| Trials | Distance (km) | Area (ha) | Biomass | |
|---|---|---|---|---|
| | | | tons km$^{-2}$ | tons |
| 1. Saroj Plantation - Hub Pla Kang | 2.86 | 8.64 | 8,314 | 718.56 |
| 2. Pa Dang Reservoir -Huay Sat Lek | 5.02 | 15.10 | 19,605 | 2,960.50 |
| 3. Kho Lam - Karang 3 Reservoir | 6.39 | 19.24 | 32,171 | 6,191.20 |
| 4. Huay Rae - Hub Pla Kang | 3.48 | 10.51 | 65,863 | 6,924.56 |
| 5. Pala-u Reservoir - Huay Haeng | 2.19 | 6.61 | 13,360 | 883.69 |
| 6. Pala-u - Huai Sator | 7.82 | 23.50 | 10,687 | 2,511.93 |
| Average | 4.63 | 13.94 | 250.00 | 3,365.07 |
| Total | 27.76 | 83.62 | 1,500.00 | 20,190.45 |

## Conclusion

Kaeng Krachan Natural Park enjoys global recognition as a biodiversity hotspot and habitat for endangered species; it is the origin of two important rivers (Petchaburi and Pranburi Rivers), provides food for both humans and animals, and is an important destination for recreation. The area comprises a vast area of evergreen, dry evergreen, mixed deciduous and dry dipterocarp forests. The area is however beset by threats such as illegal logging, trespassing and encroachment for housing and cultivation, and illegal hunting. These threats have driven elephants to search for food in adjacent agricultural areas, causing conflict with local communities due to ruination of their crops on land adjacent to Kaeng Krachan Natural Park, particularly in Zone 5. For these reasons, the flora and elephant dietary plants in this area have been surveyed in order to develop a forest resource management plan.

Totally 27.76 km of 6 trails in Zone 5 of Kaeng Krachan Natural Park and the adjoining area were surveyed. Totally 140 plant species were identified, of which 51 species formed part of the elephant diet. The highest numbers of plant species were found along the Kho Lam - Karang 3 Reservoir trail found.

A total of 20,190.45 tons of biomass were found within 15 m from the center of both sides of all six line transects, with a ranges from 718.50 to 6,924.56 tons. The greatest amount of biomass (6,924.56 tons) was found in Huay Rae - Hub Pla Kang trail, followed by Kho Lam - Karang 3 Reservoir trail (6,191.20 tons).

According to the study, 7 species of Gramineae (bamboo and grasses) comprised the major diet of elephants in the park, although dietary intake is habitat-dependent. The study results are consistent with prior findings from Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani Province [17], Phu Luang Wildlife Sanctuary, Loei Province [18], and Shangyong National Natural Reserve located at Xishuangbanna, China [19]. In addition, analysis of elephant excrement has confirmed found that elephant's excrement is mainly composed of grass.

However, feeding habits have been impacted by deforestation, with a reduction in canopy density causing changes in ground vegetation [21]. Moreover, many elephant habitats have been impacted by land use changes due to expansion of communities and agricultural production in land adjacent to the park, leading to elephants roaming beyond the park into adjacent areas in search of food, and frequently

causing extensive damage to agricultural crops. The resulting conflicts sometimes result in the death of trespassing elephants.

An effective resource management plan offers an effective approach to mitigating the impacts of land use changes on elephant habitats, as evidenced at Salakpra Wildlife Sanctuary [22]. If community expansion at Pa Deng Sub-District is well controlled, the feeding area of elephants at Pa Deng Sub-District can be preserved and conflicts with surrounding communities avoided.

## Recommendations

The study results showed that Kaeng Krachan Natural Park Zone 5 is still abundant in elephant food plant species and remains an important habitat for Kaeng Krachan elephants. Forest area utilization should be appropriately managed considering the potential of the area. A safe zone with adequate food and water sources for elephants should be provided to support their movements within their regular habitat within the park. Amount of adequate food sources in each area should be estimated. The equations for calculating above ground biomass of forest ecosystem can be applied for the various type of forest for further research.

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