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Communication

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COMMUNICATION

Dietary analysis of the Indian Flying Fox *Pteropus giganteus* (Brunnich, 1782) (Chiroptera: Pteropodidae) in Myanmar through the analysis of faecal and chewed remnants

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Abstract: The diet of Indian Flying Fox *Pteropus giganteus* in southern Myanmar was analyzed from June 2017 to April 2018. Food resources were identified by collecting faeces, food remnants, and rejecta pellets beneath day roosts. *Pteropus giganteus* consumed fruits, flowers, and leaves of 14 species of plants. Six species of fruits were found in the faeces below the day roosts, 13 species of fruits and two species of leaves in the rejecta, and seven species of fruits and one species of leaf at the day roost. These observations indicate that *P. giganteus* is a phytophagous bat with rapid intestinal passage.

Keywords: Flying fox, food resources, pollination, seed dispersal.

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Author contribution: MMA - developed research design and hypothesis. She made the collection of some data, most of the manuscript writing and reviewing. TTH - collected most of the sample, took sample photos, made data arrangement and wrote a few part of manuscript.

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INTRODUCTION

The Old World bat family Pteropodidae is distributed throughout the tropics and subtropics of Australasia, Africa, and Oceania (Marshall 1983; Mickleburgh et al. 1992). It comprises 196 species (Simmons 2005) that feed primarily on fruits, flowers (nectar, pollen, petals, and bracts), and leaves of at least 188 plant genera from 64 families (Lobova et al. 2009; Fleming & Kress 2011; Aziz et al. 2015). Some species were also recorded eating insects (Clulow & Blundell 2011; Scanlon et al. 2013).

Seed dispersal plays a significant role in forest regeneration and maintenance. Flying foxes are often posited as effective long-distance seed dispersers due to their large home ranges and ability to disperse seeds while flying (Oleksy et al. 2017). Long-distance seed dispersal can be important for the regeneration of forested habitats, especially in regions where deforestation has been severe. Old World fruit bats (Pteropodidae) have considerable potential for long-distance seed dispersal (Oleksy et al. 2015). Pteropodid bats, however, also damage a wide range of fruit crops in some countries, leading to persecution. In some of these countries, bats are not legally protected. In others, legal protection is either not implemented or over-ridden by legislation specifically allowing the killing of bats (Aziz et al. 2015).

Pteropodids primarily eat ripe fruits; the seeds are often swallowed and defecated unharmed or dropped during food processing (Banack 1998; Dumont & Irvine 1998). Moreover, bat-dispersed fruits in the Palaeotropics are morphologically variable and have a variety of colours, and some are strongly scented (Thomas 1984; Tan et al. 1998). Many fruit-eating bats depend heavily on plant resources throughout the year (Banack 1998; Fleming 1998; Tan et al. 1998). Figs, in particular, are thought to be staples in fruit bat diets because of their nutritional value and year-round asynchronous fruiting cycle (Shanahan et al. 2001; Stier & Mildenstein 2005). These ecosystem services are dependent on large populations of flying foxes and are necessary to maintain the Old World tropical forests (Fujita & Tuttle 1991; Nyhagen et al. 2005; McConkey & Drake 2006). The aim of this study was to provide information on food resources of *P. giganteus* and to confirm whether this species is a seed disperser in Myanmar, where the fruit bats remain the limited number of publication. *Pteropus giganteus*, therefore, plays an essential role in seed dispersal and pollination (Whitaker & Jones 1994) and thereby in structuring forest communities.

MATERIALS AND METHODS

Study site and study colony

This study was conducted within the Municipal Office Compound in Pyay Township (18°49'19.662''N & 95°12'47.368''E) in the Bago region on the eastern bank of the Ayeyarwady River in Myanmar (Fig. 1; Images 1 & 2). Some bat roosting trees are on the eastern bank of the river. The northern and northeastern parts of the district are forest-covered and contain numerous valleys and ravines. The Bago and Yakhine range forests are found on the western bank of the Ayeyarwady River opposite Pyay. Pyay has a tropical savanna climate. Temperatures are high throughout the year, especially before the monsoon from March to May when the average maximum temperature exceeds 36^0C.

The colony size was estimated by counting the bats emerging after sunset with the help of two observers following Moe Moe Aung (2013).

Dietary analysis

Two main methods were used to investigate the diet of *P. giganteus* in the study area. These are:

(i) regular faecal and rejecta collections at day roosts and nocturnal perches and

(ii) chance discovery of food items carried into day roosts by the bats.

Regular faecal and rejecta collections at day roosts

The diet of *P. giganteus* was investigated throughout the year using plastic sheets which were placed directly below the day roosts to catch faeces and discarded fruit parts.

Chance collections of seeds and fruits

Dietary information was occasionally collected by chance, either when a bat carried fruit and/or other feed remnants directly into day roosts. These were also collected from the plastic sheets.

Identification of food plants

Seeds, fruits, flowers, and leaves from dropped, defecated, and rejecta plant parts were identified following Kress et al. (2003) to determine the different food items consumed seasonally.

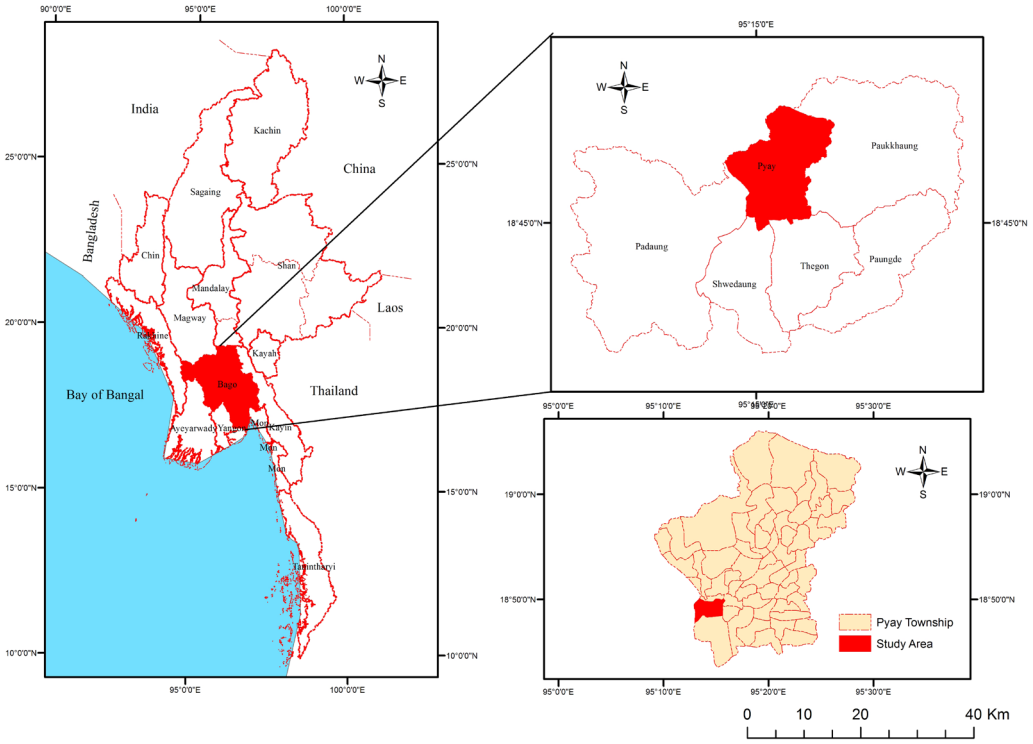

Figure 1. Location of Pyay Township in Myanmar.

Images 1 & 2. *Pteropus giganteus* from Pyay Township, Myanmar. © Than Than Htay.

RESULTS

Study colony

The study colony comprised 1799±128 individuals (n=4) in June 2017 on the first count. The number of bats did not markedly change until March 2018 although this month was the breeding season of the bats—juveniles were not able to fly and therefore could not be counted. The number of bats increased in April 2018 to 2171±271 individuals as young bats were volant and could be counted at that time.

Food resources

Pteropus giganteus was found to feed on 10 species of fruits, flowers and fruits of a single species, and both fruits and leaves of three species (Table 1). Of these, six

Table 1. Food resources exploited by *Pteropus giganteus* in the Municipal Office Compound in Pyay Township, Myanmar.

	Plant species	Food type	Food resources		
			F	R	C
1.	*Albizzia lebbek* Benth	Fruit/ leaf	-	+	+
2.	*Bombax ceiba* L.	Fruit/ flower	-	+	+
3.	*Ficus racemosa* L.	Fruit	+	+	-
4.	*F. virens* Aiton	Fruit/ leaf	+	+	-
5.	*Syzygium jambos* (L.) Alston	Fruit	+	+	-
6.	*Psidium guajava* L.	Fruit	+	+	-
7.	*Tamarindus indica* L.	Fruit/ leaf	-	+	+
8.	*Mangifera indica*	Fruit	+	+	-
9.	*Ziziphus jujuba* Lam	Fruit	-	+	+
10.	*Terminalia catappa* L.	Fruit	-	+	+
11.	*Musa sapientum* L.	Fruit	-	+	+
12.	*Mimusops elengi* Roxb	Fruit	+	+	-
13.	*Morinda angustifolia* Roxb	Fruit	-	+	+
14.	*Calophyllum inophyllum* L.	Fruit	-	+	+

F - Feces collected below day roosts | R - Rejecta and large seeds | C - Food items carried into day roosts by bats | + Available | - Not available.

species of fruits were observed in faeces below the day roosts and feeding perches and 13 species of fruits and three species of leaves as rejecta and large seeds under the day roosts. Five species of fruits, one species of fruit and flower, and two species of leaves were carried into the day roost by bats and eaten there.

Feeding habits

Fourteen species of plant resources were consumed by *Pteropus giganteus* (Table 1). Of these, the seeds of *Ficus racemosa, F. virens*, *and Psidium guajava* were observed from faecal pellets. The pulp of these fruits was consumed and the seeds appeared to be swallowed. The leaves of *Albizzia lebbek* and *Ficus virens* were chewed and the soluble contents were extracted. The fibrous contents were discarded as fibrous pellets. Petioles and veins were common in these pellets. The flowers of *Bombax ceiba* were also observed beneath the day roost.

Characteristics of food resources

Colour

Pteropus giganteus within the Municipal Office Compound consumed fruits of a variety of different colours, including yellow, green, red, and purple (Table 2). The majority of the fruits observed in this study, however, were yellow, green, and orange. All the leaves were green in colour.

Odour

Eleven species of fruits produced an odour that could be detected when the fruits were held close to the nose of a human observer in the field. Nevertheless, the odour emitted by different species of fruits was markedly different (Table 2).

Growth form

Of the 14 species of food plants exploited by *P. giganteus*, 10 were tall trees and four were small trees. Shrubs and herbs were not included among the bat food sources in this study (Table 2).

DISCUSSION AND CONCLUSION

Of the 14 species of plants eaten by *Pteropus giganteus*, four species, namely *Ficus racemosa*, *F. virens, Terminalia catappa*, and *Musa sapientum*, were available to bats throughout the year; other plant species that had a long fruiting season were *Psidium guajava, Mangifera indica,* and *Ziziphus jujuba.* Therefore, these plant species may be important for maintaining the population of *P. giganteus*. Some of the food plants are agricultural (or those used by humans): *Syzygium jambos, Psidium guajava, Tamarindus indica, Mangifera indica, Ziziphus jujuba*, and *Musa sapientum*. There is, however, no known negative interaction between fruit bats and fruit-growers in the study area. In this study, bats consumed fruits of a variety of different colours displayed openly by plants so that they are easily accessed by bats in flight. Fruits also tended to have distinct odours as well. Many samples of faeces contained seeds which are dispersed by bats (Image 3). In contrast, seeds in some rejecta pellets, such as *F. virens* (Image 4), were parasitized by fig wasps and were no longer viable. Some fruits were observed in both faeces and rejecta under the day roost. Kunz & Diaz (1996) suggested that one of the consequences of seed dispersal by bats is that the survival and growth of trees from such seeds may ultimately provide roost trees for other bats. In addition to dispersing seeds over a wide area, the concentration of seeds deposited beneath roosting sites may give rise to a clumped distribution of seedlings. *Pteropus giganteus* often defecate or drop seeds during flight, which potentially disperses seeds over a large area each night (Oleksy et al. 2017). Dietary studies can provide the concept of dietary importance to the conservation of *P. giganteus*. In the present study, most plants in the diet of *P. giganteus* were from the forests of Pyay environs and this together with the fact that forests are critically important for the diet of *P. giganteus* may

Table 2. Characteristics of food resources exploited by *Pteropus giganteus* in the Municipal Office Compound in Pyay Township, Myanmar.

	Family	Plant species	Growth form	Food colour	Odour
1.	Mimosaceae	*Albizzia lebbek* Benth	T	Green	Y
2.	Bombacaceae	*Bombax ceiba* L.	T	Orange	N
3.	Moraceae	*Ficus racemosa* L.	T	Mauve	Y
4.	Moraceae	*Ficus virens* Aiton	T	Brownish	Y
5.	Myrtaceae	*Syzygium jambos* (L.) Alston	T	Dark purple	N
6.	Myrtaceae	*Psidium guajava* L.	ST	Greenish-yellow	Y
7.	Caesalpiniaceae	*Tamarindus indica* L.	T	Reddish-brown	Y
8.	Anacardiaceae	*Mongifera indica*	T	Yellow	Y
9.	Rhamnaceae	*Ziziphus jujuba* Lam	ST	Reddish	Y
10.	Combretaceae	*Terminalia catappa* L.	T	Pinkish	Y
11.	Musaceae	*Musa sapientum* L.	ST	Yellow	Y
12.	Sapotaceae	*Mimusops elengi* Roxb	T	Orange	Y
13.	Rubiaceae	*Morinda angustifolia* Roxb	ST	Creamy	Y
14.	Clusiaceae	*Calophyllum inophyllum* L.	T	Green	N

T - Tree | ST - Small tree | Y - Yes | N - No. Plant growth form follows Kress et al. (2003).

Image 3. Seeds apparent in the *Pteropus giganteus* faeces collected below day roosts in Pyay Township in Myanmar: a - *Syzygium jambos* | b - *Psidium guajava* | c - *Mangifera indica* | d - *Mimusops elengi* | e - *Ficus racemosa* | f - *Ficus virens*. © Than Than Htay.

Image 4. Rejecta pellets and food remnants of *Pteropus giganteus* collected in Pyay Township in Myanmar: a - *Albizzia lebbek* (leaf) | b - *Albizzia lebbek* (fruit) | c - *Bombax ceiba* (flowers) | d - *Ficus racemosa* | e - *Ficus virens* (leaf) | f - *Ficus virens* | g - *Syzygium jambos* | h - *Psidium guajava* | i - *Tamarindus indica* | j - *Mangifera indica* | k - *Ziziphus jujuba* | l - *Terminalia catappa* | m - *Musa sapientum* | n - *Mimusops elengi* | o - *Morinda angustifolia* | p - *Calophyllum inophyllum*. © Than Than Htay.

indicate the role of forest in maintaining the population of this species. The information in this study suggests that there exists a considerable potential for future research on the management and conservation strategies of fruit bats.

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