



## Nectar-feeding bat, *Cynopterus sphinx* pollinate *Parkia speciosa* flowers and increase fruit production

C. Vanlalnghaka

Department of Zoology, Government Serchhip College, Serchhip 796181, India

Received 10 March 2014 | Revised 14 May 2014 | Accepted 20 May 2014

### ABSTRACT

A study was carried out to establish the relationship between *Parkia speciosa* (local name *Tah-lim*) and nectar-feeding bat, *Cynopterus sphinx* with respect to pollination, and effects on fruit production. Eight flowering trees of *P. speciosa* from Lengteng Wildlife Sanctuary were selected for experimentation. During the flowering season of stink bean from August to November, 2013 visual observations were made twice a week during the night at 18:00 to 05:00 h. *C. sphinx* visits the capitulum and collects the nectar by landing on the capitulum. Duration of nectar collection by bat is around one second, and then visited the next flower to collect nectar simultaneously. To ascertain the pollination by bats, we captured the bats using mist nets. The yellow cream colour pollen was attached on their facial, neck region, abdomen and wings. This reveals that this bat provides a vital reciprocal service to *P. speciosa* flowers in terms of pollination. The present study also revealed that seasonality and availability of flowers influenced the frequency of bats. Also compared the average number of fruit production between frequently and randomly visit of *P. speciosa* trees by bats and observed that frequently visited trees by bats produced more fruits than randomly visited trees ( $P > 0.05$ ).

**Key words:** *Parkia speciosa*; *Cynopterus sphinx*; Lengteng; nectar-feeding; pollination.

### INTRODUCTION

Bats are very important pollinating agents. Flowers visited by bats are observed in wide range of geographical areas. Bats pollinated more than 500 species of plants including many economically important species.<sup>1</sup> Bat and flower

interaction appeared to be an important factor in terms of reproduction and population structure of plants.<sup>2</sup>

Many species of *Parkia* flowers are visited by nectar-feeding bats which helped in pollination. Nectarivorous bat *Eonycteris spealaea* visits flowering plant of *Parkia speciosa* and *Parkia timoriana*. It is found that this bat is the most effective pollinator when compared to other pollinators.<sup>3</sup> Pollination of *Parkia biglandulosa* by *Cynopterus*

Corresponding author: Vanlalnghaka

Phone: +91-9862799668

E-mail: [drcnghaka@yahoo.com](mailto:drcnghaka@yahoo.com)

*sphinx* was studied.<sup>4</sup> Nectar-feeding bat, *Pteropus giganteus* visiting capitula and feeding on nectar from *P. biglandulosa* was also reported.<sup>5</sup> During the flowering seasons, flowers of *Parkia nitida* was visited and pollinated by nectarivorous bats.<sup>6</sup> Flowers of *Parkia bicolor* were visited by nectar-feeding bat *Megaloglossus* and helped in pollination.<sup>7</sup> *Parkia biglobosa* flower was pollinated by bat.<sup>8</sup> The capitula of *Parkia pendula* were visited by four species of phyllostomid bats and helped in pollination.<sup>9</sup> Bat-pollination of *Parkia velutina* flowers has been reported in Southeast Asia.<sup>10</sup> Observations were made on two bats *Epomorphorus gambianus* and *Nanonycteris veldkampii* visiting *Parkia clappertoniana* flowers and both bats appeared to be important pollen-vectors.<sup>11</sup> Flowers of *Parkia* species were visited and pollinated by nectar-feeding bat, *Eidolon helvum*.<sup>12</sup>

Pollination is one of the most important factors in fruit production. Reproductive success and fruit production of different species of trees by bat were reported. In Mexico, the reproductive success of bombaceous tree *Ceiba grandiflora* was depending on bat.<sup>13</sup> Casas and coworkers also reported that nectar-feeding bat is responsible for fruit production of *Stenocereus stellatus*.<sup>14</sup> Other bat biologists also observed that plants in cultivation were pollinated more effectively, perhaps by receiving genetically diverse pollen from nectar-feeding bats, and therefore set more fruit when compared to plants in wild and managed *in situ* in La Mixteca Baja, Central Mexico.<sup>15</sup>

The objective of the present study was undertaken to evaluate the role of pollination of *C. sphinx* on *P. speciosa*, to determine effect of flowering seasonality on magnitude of foraging, and to assess the effects on fruit production of this tree by nectar-feeding bat.

## MATERIALS AND METHODS

### *Study site*

Lengteng Wildlife Sanctuary (23°50'31.99"N to 93°12'35.39"E) was selected for carrying out

the research. This sanctuary is situated in Champhai district in the eastern part of the state of Mizoram, adjacent to the Murlen National Park. The wildlife sanctuary is located around 200 km east of the state capital Aizawl. The sanctuary covers an area of 60 sq km. The altitude of the sanctuary varies from 400 to 2300 meters above sea level. The important fauna species found in the Lengteng Wildlife Sanctuary are tiger, leopard, sambar, ghoral, serow, barking deer, wild boar, hoolock gibbon, *Rhesus macaque* and nine species of bats. This sanctuary host sub tropical semi-evergreen forest in which different species of timber trees are naturally growing including *Parkia speciosa*.

### *Plant species*

*P. speciosa* commonly known as stink bean is a plant of the genus *Parkia* in the family Fabaceae. This tree is found in tropical Southeast Asia including north-east India. The trunk of the tree appears straight with smooth bark that varies in colour from light grey to brown or dark brown and umbrella shaped crown. A mature tree can grow up to a magnificent 40 m (130 feet) tall, although 20 m (65 feet) or less is more common and bears flower of cream coloured, consisting of multiple florets in a light-bulb shaped mass at the end of long stalks during the months of August and November. The flowers secrete nectar that attracts bats, wasps, moths, etc. These tiny flowers mature and die. Long, twisted, translucent pods emerged in a cluster in an average of 5 to 25 pods. When these pods become mature, within them will reside the petai beans or seeds. Mature pods are about 40 cm (15 inch) long, light green in color, contain up to 15 seeds and looked like twisted ribbons.

## OBSERVATIONS

During the flowering season of *P. speciosa* from August to November, 2013 visual observations of bats visit to flowers were made twice a week at every alternate night from 18:00 h to

05:00 h. Observations were made throughout the entire flowering season. Duration of nectar collection, behaviour and visitation frequency of bats were done by visual observations with the help of cell-four battery torch-lights (Andslite DMRX4X), headlamps (Andslite RHL-1), digital SLR camera (Canon DS126291), and video camera (Sony HDR-XR350V). Apart from this, the total number of capitula available was determined by cluster sampling method.<sup>16</sup> During each observation, the number of foraging flights and feeding strategies of bats were recorded every hour throughout the night. Bats were captured by mist-nets (Avinet-Dryden NY 13053-1103) other than observation nights, to ascertain the pollens stuck in the body of bats. Pollens were carefully collected using paint brushes and kept in the test-tubes for further identification. Bats were released immediately after identification and collection of the pollens from the body parts.

Observations on effects of fruit production of *P. speciosa* were made till the fruits were ready for harvest. Eight flowering trees of *P. speciosa* were selected for carrying out this experiment: four trees are growing along the edge of the sec-

ondary forest while other four trees are growing in land clearing near the village. The four trees growing in the secondary forest (~1120 m altitude) grow at the average of 15 m distance away of each tree. These trees are located near the dense wild banana forest in which a large number of *C. sphinx* are roosting. Whereas four other trees are planted by farmers close to the human inhabitant (~600 m altitude) near Selam village and only few *C. sphinx* bats are found roosting under the palm leaf. The distance between the trees growing in the secondary forest and planted near the village is 8 km. When the fruits get mature for harvesting during January, we visually counted the number of fruits and compared the fruit products of each tree. Statistical comparison of fruit production between frequently visits and randomly visits by bats to this plant was done by Student's *t*-test.

## RESULTS

These studies reveal that during the flowering season from August to November, nectar production emerged in the nectar ring of capitula of *P. speciosa*. The visitor *C. sphinx* directly land on



Figure 1. (A) Cynopterous sphinx landing on the capitula of *Parkia speciosa*, trips to lick on the nectar (pointed at arrow mark). (B) cream coloured capitula, bearing a multiple florets in a light bulb shape mass at the end of long stalk.

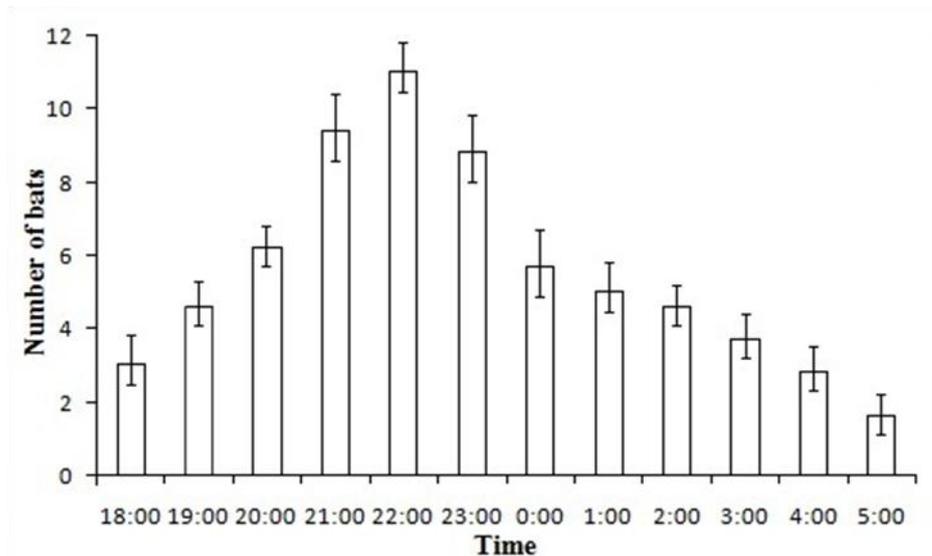


Figure 2. Average number of bat visits to the flowers during foraging bout.

capitula to feed on the nectar for a duration of one second (Figure 1). One bat visits an average number of five capitulum in one foraging bout, then rested in the adjacent trees to digest the nectar. We also observed that an average of 58 individuals of *C. sphinx* visited a mean of 450 capitulum per night. The peak of bat visits to capitula was recorded from 21:00 to 23:00 h (Figure 2).

These observations also found that the seasonality and availability of capitula control the frequency of bat visits. During the peak flowering season (ca. 650), a maximum number of bat-visits per night (ca. 80) was recorded (Figure 3). There was significant positive correlation between foraging activity of bats and number of available flowers ( $r = 0.958$ ;  $P < 0.1$ ). The present study shows that about 98 % captured bats are found loaded with pollen on their facial, abdomen and wings as it landed directly on the capitula to feed on the nectar. This reveals that nectar-feeding bat, *C. sphinx* is an important pollinator of *P. speciosa*.

Apart from this, our observations show that the fruit productions of *P. speciosa* fully depend upon bats' visit. Comparison of fruit production was made between frequently visited trees and

randomly visited trees by bats. Four of frequently visited trees by bats are growing along the edge of secondary forest, whereas other four of randomly visited trees by bats are planted near the village. Frequently visited trees by bats produced approximately 25 pods in capitula whereas randomly visited trees by bats produced approximately 8 pods in capitula. Average number of 745 pods was produced by frequently visited trees by bats and average number of 152 pods was produced by randomly visited trees by bats in one petai plant (Figure 4). This result shows that *C. sphinx* play an important role in fruit production of *P. speciosa* plants. The statistical test shows that frequently visited *P. speciosa* by bats are significantly important for fruit production than randomly visited by bats ( $P < 0.05$ ).

## DISCUSSION

The study revealed that seasonality and availability of flowers influenced foraging frequency of bats. From this observation, the peak visits to capitula by *C. Sphinx* was recorded during 21:00 h to 23:00 h and this foraging periodicity is characterized by unimodal pattern of activ-

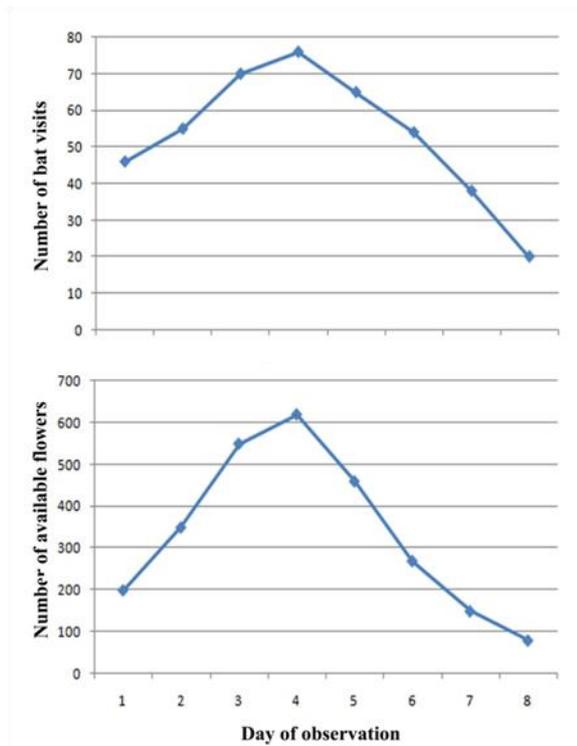


Figure 3. Number of plant visiting bats and available capitula during the days of observation.

ity. The same pattern of activity peak is very common among frugivorous and nectar-feeding bats. In contrast, bimodal patterns of activity have also been reported in several species of bats.<sup>17</sup> Present study found that the foraging activity of bats was directly proportional to the availability of flowers. It was strongly supported by the positive correlation ( $r = 0.958$ ;  $P < 0.1$ ) between the number of flowers and the frequency of bat visits.

Bats were captured by mist-net near the *P. speciosa* trees. From captured bats, about 98% bats were found loaded with pollen on the ventral side of their fur. Since this bat directly landed on the capitula to feed on the nectar, huge number of pollens were stuck on its fur. This bat frequently visited the flowers and then carried pollen from one flower to another flower. Similar pattern of collection of pollen of *P. biglandulosa* by *C. sphinx*, was also reported.<sup>4</sup> *C. sphinx* also carrying pollen of *Careya arborea* on the abdomen, wings and head was also recorded.<sup>18</sup> The same behaviour of pollen-carrying by the nectar-feeding bat, *C. sphinx* is also observed in *Ceiba pentandra* plants, this bat carried

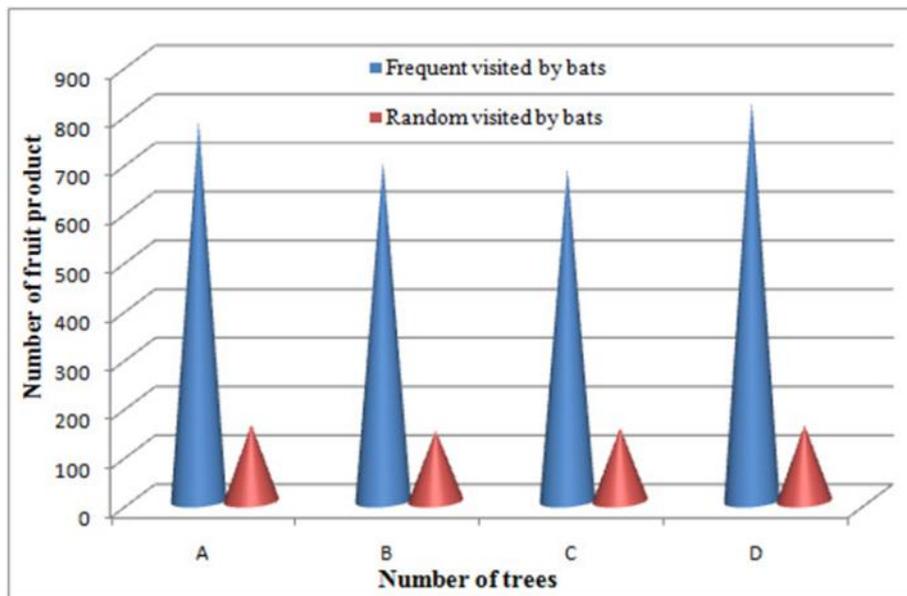


Figure 4. Comparison of the average number of fruit product of *Parkia speciosa* between frequently visits and randomly visits by *Cynopterus sphinx* during the year 2013.

the pollen on its head, abdomen and wings. Similarly, it is also observed on the bodies of *Rousettus leschenaulti* and *P. giganteus*.<sup>19</sup> It has been observed that the nectar-feeding bat, *E. spealaea* visited capitula and feed-on nectar of *P. speciosa* under natural condition and carried pollen on the ventral side of the body.<sup>3</sup> The presence of pollen on the ventral side of these bats show that they are important pollinators to flowering plants.

Adequate pollination is also essential to fruit yield. Without sufficient pollination, they may blossom abundantly but will not bear fruit. This result shows that frequently visited trees by nectar-feeding bat significantly play an important role in fruit production than randomly visited trees by bats. The captured bats carry pollens on the ventral site. Then, these bats visited the next four to five flowers to fetch the nectar in one foraging bout, give a chance to pollinate the flowers and help in reproductive success. It is also found that the presence of a huge number of flower visiting bats play significant role in fruit production of *P. speciosa*. From the present observation, frequently visited flowers by bats bear more fruits than randomly visited. While randomly visited flowers by bats produced less fruits, these flowers are visited by other pollinators such as bees, moths, butterflies, etc., during day and night. Since these pollinators have small body mass, they can carry less pollen when they visit the next flowers. Meanwhile, bats have large body mass and they can carry more pollens in the same foraging activity.<sup>20,21</sup> Other bat biologists also found bats to be more effective pollinators than birds and bees.<sup>22</sup> More pollen movement from the pollinator influences the fruit production of the plants. The same was reported in Venezuela, during their visits to cacti flowers, bats function as effective pollinators and help in reproduction. They have demonstrated that bats are the only reliable resources that columnar cacti plants have for their sexual reproduction.<sup>23</sup> They also observed that two species of nectar-feeding bats, *Leponycteris curasoae* and *Glossophaga langirostris* have been playing a significant role for fruit production of cacti plants.

The increase in the production of fruits in tomato by native bees has also been observed in Brazil.<sup>24</sup> The availability of capitula and the nectar reward may have a significant influence on the foraging behaviour of bats, and possibly on the reproductive success.<sup>4</sup> From this result, we can conclude that bats have significant influence on pollination, reproductive success and fruit production of flowering trees.

Economically, bats play an important role for farmers. This observation reveals that frequently visited trees by bats can bear fruits (pods) of an average number of 1000 in one tree. During this study the market value of one mature petai pod (fruit) is ₹ 10. Therefore one tree can earn approximately ₹ 10,000/- per annum. A farmer having 20 petai trees can earn approximately ₹ 2,00,000/- per year. Therefore, the nectar-feeding bat, *C. sphinx* is an important pollinator, and it is having a significant effect on fruit production of *P. speciosa*. From this observation, we can conclude that nectar-feeding bats are friend of farmers with respect to pollination as well as fruit production of their orchards if we conserve them.

## ACKNOWLEDGEMENT

The author is thankful to Principal and staff, Govt. Serchhip College for providing research facilities and constant encouragement. He also thanked to the anonymous reviewer who helped in improving this manuscript. This study is funded by Science and Engineering Research Board (SERB), New Delhi (Research Grant No. SF/FT/LS-28/2010 dated 2-5-2012), for undertaking SERB Fast-Track Young Scientist Research Project to author.

## REFERENCES

1. Heithaus ER, Opler PA & Baker HG (1974). Bat activity and pollination of *Bauhinia pauletia*: plant pollinator coevolution. *Ecologia*, **55**, 412–419.
2. Fleming TH & Sosa VJ (1994). Effects of nectarivorous and frugivorous mammals on reproductive success of plants. *J Mammal*, **75**, 845–851.

3. Bumrungsri S, Harbit A, Benzie C, Camouche K, Sridith K & Racey P (2008). The pollination ecology of two species of *Parkia* (Mimosaceae) in South Thailand. *J Trop Ecology*, **24**, 467–475.
4. Stephenraj D & Isaac SS (2010). Nocturnal pollination of *Parkia biblandulosa* by nectar-feeding bat, *Cynopterus sphinx*. *Curr Sci*, **99**, 24–25.
5. Sigaravelan N, Raja R & Marimuthu G (2007). Nectar-feeding strategies of Pteropodid bats of *Parkia biglandulosa*: the influence of agular variations in nacter rings. *Proc Indian Nat Sci Acad*, **73**, 127–135.
6. Hopkins HC (1984). Floral biology and pollination ecology of the neotropical species of *Parkia*. *J Ecol*, **72**, 1–33.
7. Grunmeier R (1990). Pollination by bats and non-flying mammals of the African tree *Parkia bicolor* (Mimosaceae). *Memoirs New York Bot Gar*, **55**, 83–104.
8. Lassen KM, Raebild A, Hansen H, Brodsgaard C & Eriksen EN (2012). Bats and bees are pollinating *Parkia biglobosa* in the Gambia. *Agrofor Sys*, **85**, 465–475
9. Piechowski D (2009). Flower and fruit development of *Parkia pendula* (Fabaceae, Mimosoideae). *Acta Bot Bras*, **23**, 1162–1166.
10. Van der Pijl L (1936). Fledermause und Blumen. *Flora*, **131**, 1–40.
11. Harris BJ & Baker HG (1959). Pollination of flowers by bats in Ghana. *Nigerian Field*, **24**, 151–159.
12. Marshall AG (1985). Old World phytophagous bat (Megachiroptera) and their food plants: a survey. *Biol J Linn Soc*, **83**, 351–369.
13. Quesada M, Stoner KE, Rosas-Guerrero VM, Palacios-Guevara C & Lobo JA (2003). Effects of habitat disruption on the activity of nectarivorous bats (Chiroptera: Phyllostomidae) in a dry tropical forest: implications for the reproductive success of the neotropical tree *Ceiba grandiflora*. *Oecologia*, **135**, 400–406.
14. Casas A, Caballero J & Valiente-Banuet A (1999). Use, management and domestication of columnar cacti in south Central Mexico: a historical perspective. *J Ethnobiol*, **19**, 71–95.
15. Arias-Coyotl E, Stoner KE & Casas A (2006). Effectiveness of bats as pollinators of *Stenocereus stellatus* (Cactaceae) in wild, managed in situ, and cultivated populations in La Mixteca Baja, Central, Mexico. *A J Bot*, **93**, 1675–1683.
16. Sarndal CE, Swenson B & Wreman JH (1992). *In Model Assisted Survey Sampling*, Springer-Verlag, New York.
17. Fleming TH (1982). *Ecology of Bats*. (ed. Kunz, TH), Plenum Press, New York, pp 287–325.
18. Raju AJS, Rao SP & Ezradanam V (2004) Pollination by bats and passerine birds in a dry season blooming tree species, *Careya arborea* in the Eastern Ghats. *Curr Sci*, **86**, 509–511.
19. Singaravelan N & Marimuthu G (2004). Nectar-feeding and pollen carrying from *Ceiba pentandra* by pteropodid bats. *J Mammal*, **85**, 1–7
20. Howell DJ (1979). Flock foraging in nectar-feeding bats: advantages to the bats and the host plants. *Am Nat*, **114**, 23–49.
21. Eguiare L, Martinez Del Rio C & Arita H (1987). El nectar y el polen como recursos: el papel ecologico de los visitantes a las flores de *Pseudobombax ellipticum* (H.B.K.) Dugand. *Biotropica*, **19**, 74–82.
22. Fleming TH, Tuttle MD & Horner MA (1996). Pollination biology and the relative importance of nocturnal and diurnal pollinators in three species of sonorant desert columnar cacti. *Southwestern Nat*, **41**, 257–269.
23. Nassar JM, Ramirez N & Linares O (1997). Comparative pollination biology of Venezuelan columnar cacti and the role of nectar-feeding bats in their sexual reproduction. *Am J Bot*, **84**, 918–927.
24. Carlos de Melo e Silva Neto, Lima FG, Goncalves BB, Lima Bergamini L, Ribeiro Bergamini BA, da Silva Elias MA & Franceschinelli EV (2013). Native bees pollinate tomato flowers and increase fruit product. *J Pol Ecol*, **11**, 41–45.