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Greater short-nosed fruit bat (*Cynopterus sphinx*) foraging and damage in vineyards in India

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The Greater short-nosed fruit bat *Cynopterus sphinx* (Vahl, 1797) is one among the 14 species of Old World fruit bats occurring in the Indian subcontinent and has been recently reported to cause economic loss to commercial fruit crops. We studied the temporal patterns of foraging and magnitude of loss caused by *C. sphinx* in Andhra Pradesh, India. Observations carried out over a period of 36 nights in 1-ha plots of vineyards revealed that the species foraged in groups of 2–8 individuals with two peaks in foraging activity reflecting their behavioural adaptability in response to food quality and quantity. The magnitude of loss due to foraging of *C. sphinx* gradually decreased from the periphery of the plot to the centre. Along the periphery the extent of damage was > 90%. No damage was recorded in the central regions of either plots. Greater short-nosed fruit bat foraging in vineyards cause a revenue loss of ca. US$ 590 ha^{-1}.

Key words: Chiroptera, *Cynopterus sphinx*, foraging, vineyards, temporal patterns, India

INTRODUCTION

The Greater short-nosed fruit bat *Cynopterus sphinx* (Vahl, 1797) is a common species in many parts of India and Sri Lanka (Bates and Harrison, 1997). It roosts alone or in small groups in so called 'tents' constructed from leaves of *Polyalthia longifolia*, *Vernonia scandens*, *Borassus flabellifer*, *Corypha umbraculifera*, *Corypha* spp., *Livistona chinensis*, *Roystonia regia*, *Areca catechu*, altered flower and fruit clusters of *Caryota urens*, under the leaves of *Musa* spp., in the leaf clusters of *Persea gratissima*, clumped leaves of *Philodendron giganteum*, stems of *Saraca asoka*, in the cavities of bark and aerial roots of *Ficus* spp., and in man-made structures (e.g., Brosset, 1962; Khajuria, 1979; Advani, 1982; Bhat, 1994; Bhat and Kunz, 1995; Balasingh *et al*., 1995; Storz and Kunz, 1999).

Cynopterus sphinx feeds on fruits, flowers, and leaves of at least 30 species of plants (Phillips, 1980; Advani, 1982; Balasubramanian, 1988; Balasubramanian and Bole, 1993; Bhat, 1994; Rajan *et al*., 1999). This bat visits fruit-bearing plants that have both 'steady state' (production of a small number of fruits over an extended time period) and 'big-bang' (production of a large number of fruits over a short period) phenological patterns (Elangovan *et al*., 1999). Harem males forage relatively close (< 1 km) to day roosts, whereas non-harem males and females forage at greater distances from day roosts (Marimuthu *et al*., 1998; Nair *et al*., 1999). The depredatory nature of *C. sphinx* on commercial crops such as *Psidium guajava*, *Mangifera indica*, *Musa* spp., and *Vitis vinifera* across its range is well documented (Phillips, 1980; Advani, 1982; Bhat, 1994; Verghese, 1998; Rajan *et al*., 1999; Srinivasulu and Srinivasulu, 2001).

Excepting a few studies on foraging ecology, control (Verghese, 1998), and magnitude of loss (Srinivasulu and Srinivasulu, 2001) not much had been reported on the foraging behaviour and damage due to *C. sphinx* in vineyards in India. We report observations on the temporal patterns of foraging by *C. sphinx* in vineyards and magnitude of loss caused due to their foraging forays. We predict that the frugivorous bats first exploit resources that give them immediate benefit and *C. sphinx* feeds opportunistically on grapes that are very rich in carbohydrate and water. We further hypothesise that the short-term abundance of grapes in vineyards induces group foraging behaviour.

Materials and Methods

We observed *C. sphinx* visiting a vineyard in Gundla Pochampally village in the northern suburbs of Secunderabad (17°27'N, 78°27'E) in Andhra Pradesh, India. The vineyard, where the green variety of *Vitis vinifera* is grown, has a long history of fruit bat damage. Our investigation spanned 36 nights (8 in pre-ripening, 22 in ripening and 6 in harvesting periods) between December 1999 and March 2000. The vineyard encompasses four 1-ha plots of grapevines, two of which were investigated in this study. The vines are grown under the 'pergola' (or 'bower') system of cultivation involving training of vines on the overhead trellis (ca. 2 m above ground level) of 8–10 gauze galvanized iron mesh supported by means of granite stone pillars.

To investigate the temporal patterns of foraging, the number of foraging bouts (a bout was recorded when the bat collected a fruit from a bunch with or without landing) were recorded from 1830 to 0430 h for ten nights during the ripening and the harvesting periods. Magnitude of fruit loss was assessed throughout the study period by a quadrate sampling method, involving 25 quadrates, each measuring 7.5 m^2 — in five sets including two outer squares, two inner squares, and a quadrate in the approximate centre of the main plot (Srinivasulu and Srinivasulu, 2001). The outer sets consisted eight quadrates each in outer square 1 and outer square 2 that were 5 m apart. The placement of quadrates in both the squares ensured sampling from all the four corners and those exactly between them. The inner sets were placed 10 m inside the outer square 2 and consisted four quadrates each in two inner squares that were 12 m apart. The placement of the quadrates in inner square 1 corresponded to the four corners of the main plot, while that of inner square 2 corresponded to the centre of the four sides. The last quadrate was placed in the approximate centre of the main plot.

All the observations were carried out from randomly selected points, each night a separate spot was selected, using the available light sources (200-watt tungsten bulbs) that are placed at regular distances (15 m apart) in the vineyard by the farmers. The lights and nylon netting of 61 cm width hung around the bower are traditionally deployed to discourage bat visitations. The farmer or his assistants circumambulate the vineyard three times a night to check both human and non-human intrusions. One-way ANOVA and the Scheffé test, which is considered to be one of the most conservative post hoc tests, were used to determine the differences in peak hours of foraging activity and percent damage caused in relation to the distance of vines from the periphery of the main plot (Minitab Inc., 1995; Sokal and Rohlf, 1995).

Results

Visits of *C. sphinx* to the vineyard began about 45 minutes after sunset and foraging was observed to continue up to an hour before sunrise. These bats foraged in groups of 2–8 individuals. They took only the ripe fruits from the bunch and in their forage search, either in flight or while clinging to the branches, tended to damage the whole bunch and other adjacent bunches, resulting in high percentage losses. These bats seldom remained in the vineyard to feed, but instead carried the grapes to nearby feeding roosts or diurnal roosts, repeating the forays several times in the night. The percent visitation to the vineyard increased manifold

(72% increase) during the ripening and harvesting stages (late January to early February), resulting in 81% of damage observed.

The temporal pattern of foraging bouts of *C. sphinx* in vineyards showed a bimodal peaks of foraging activity (Fig. 1). The number of foraging bouts reached a peak during the pre-midnight hour (2200–2300 h) and another extended period of foraging was observed post-midnight between 0200–0300 h ($F_{10, 99}$ = 40.93; $P < 0.001$). Interestingly, during the pre-midnight hours bats were observed in smaller groups of 2–5 individuals, but during the post-midnight hours they were in larger groups of up to 8 individuals.

The magnitude of loss due to foraging of *C. sphinx* gradually decreased from the periphery of the plot to the centre (Fig. 2). Along the periphery the extent of damage was > 90%, while inside it was much lower. No damage was recorded in the central regions of either plots. The mean damage (± SD) caused was significantly higher among the outer squares (OS1 versus OS2: 95.7 ± 2.57 versus 81.5 ± 4.02); outer square and inner square (OS2 vs. IS1: 81.5 ± 4.02 vs. 53.8 ± 7.45); and inner squares (IS1 vs. IS2: 53.8 ± 7.45 vs. 3.5 ± 4.49; Scheffé test statistics ranging from 8.21 to 12.79, in all cases $P < 0.01$). There was a significant variation in damage caused in relation to the distance from the periphery ($F_{3, 44}$ = 243.33, $P < 0.001$), with all the pair groups being apart except for IS2 and the centre of the plot (C).

A total of 1,576 grape bunches, each weighing ca. 750 g, were damaged by short-nosed fruit bats amounting to a yield loss of 1,182 kg of grapes. At a rate of US$ 0.5 kg^{-1}, the revenue loss due to short-nosed fruit bat depredation accounted to ca. US$ 590 ha^{-1}.

Discussion

As predicted, *C. sphinx* foraged on grapes in groups and attuned its foraging forays to its energy requirements. The pattern of nightly visits by *C. sphinx* to fruit-bearing trees is under the influence of food availability, quality, and quantity (Fleming, 1988; Elangovan *et al*., 1999). Generally, *C. sphinx* predominantly feeds on nectar and fruits (energy rich resources) in the early hours of the night and later on leaves (energy poor resources — Elangovan *et al.*, 2000, 2001). Carbohydrate and water rich resources are preferred during the pre-midnight hours as the bats have no access to these during the prolonged day-roosting period. Plant-visiting animals first seek

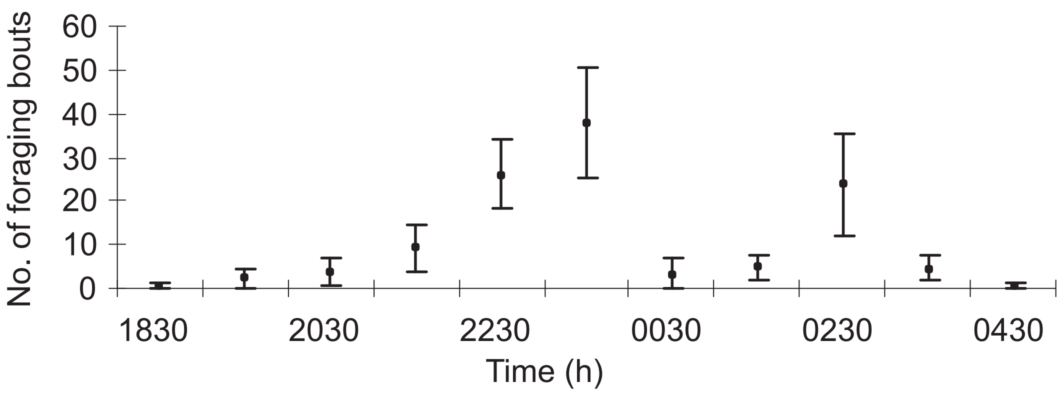

FIG. 1. Temporal patterns of the number of foraging bouts ($\bar{x}$ and min–max) by *C. sphinx* in vineyards (n = 10 nights)

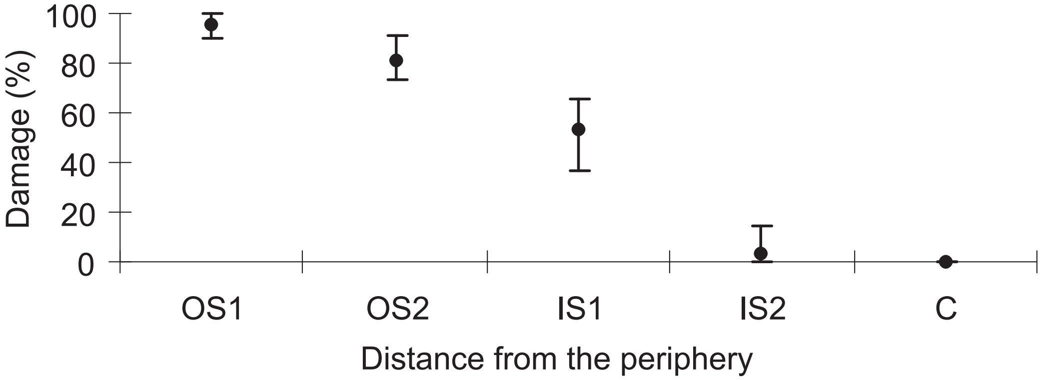

FIG. 2. Relationship between the distance from the periphery and percent damage ($\bar{x}$ and min–max) to grape bunches by *C. sphinx* (OS: outer squares, *n* = 16; IS: inner squares, *n* = 8; C: centre, *n* = 1)

food that yields the highest net energy return (Fleming, 1993; Richards, 1995). Grapes are rich sources of carbohydrates and water, and *C. sphinx* prefers to feed on them. Group foraging by these bats on 'big-bang' fruiting trees showed peak feeding bouts in the post-midnight hours, but in grapes the group foraging activity showed a bimodal pattern as has been reported earlier in *Terminalia catappa* from south India, on which *C. sphinx* foraged solitary (Elangovan *et al.*, 1999).

We also observed that the presence of human beings guarding the vineyards induces great pressure on the foraging behaviour of *C. sphinx*. When the risk is present, the mean foraging bouts are minimal, especially between 1900–2000, 1200–0100 and 0400–0500 h. As a result of 'pergola' system of vine growing, the canopy tends to form a continuous complex of leaves and branches that are sometimes impenetrable. Thus, Greater short-nosed fruit bats prefer to feed on grape bunches that are not very far from the periphery, ensuring quick escape if disturbed.

To mitigate the damage caused due to *C. sphinx*, it is important to consider its foraging behaviour and resort to non-destructive control measures including nylon netting (Verghese, 1998) and increased illumination. Earlier studies indicate a negative correlation between depredatory activities of *C. sphinx* in vineyards and moonlight (Nair *et al.*, 1998; Elangovan and Marimuthu, 2001; Singaravalen and Marimuthu, 2002). Our study indicates that the abundance of fruits in vineyards promotes group foraging that is under the influence of temporal availability of resources and more importantly presence of risk.

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