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Moonlight inhibits and lunar eclipse enhances foraging activity of fruit bats in an orchard

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We studied the effect of the lunar eclipse that occurred on 9 January 2001, on the foraging activity pattern of fruit bats in an orchard under natural conditions. In addition, we observed bats when foraging on ripe black grapes *Vitis vinifera* for three days before and three days after the eclipse. The number of bat-visits was continuously recorded every hour between 1800 and 0600 h. A bat-visit indicates an individual bat either flying towards or away from the orchard. The total number of bat-visits during the night of the lunar eclipse was significantly higher compared to both the pre- and post-lunar eclipse days. There was no significant difference in the intensity of foraging between the pre- and post-lunar eclipse days. We captured short-nosed fruit bats *Cynopterus sphinx* using mist nets that were set in the vicinity of the orchard.

MOONLIGHT is an environmental factor that inhibits the nocturnal activity pattern of a few species of bats, both under natural[1–5] and laboratory[6] conditions. Apart from bats, moonlight also influences the activity pattern of other nocturnal mammals such as North American desert rodents[7–9], temperate rodents[10,11], desert and arctic lagomorphs[12,13], the marsupial *Caluromys philander*[14] and primates[15,16]. All these studies show that when there is an increase in the intensity of moonlight, animals reduce the use of open space and restrict their foraging activity to the periods of darkness. Our recent

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study made during three complete lunar cycles showed that the total number of feeding bouts of the short-nosed fruit bat *Cynopterus sphinx* was negatively correlated with the per cent moonlight each night[17]. Such observations led us to predict that there should be an increase in the activity of bats during the period of a lunar eclipse compared to periods before and after the eclipse. In order to test this prediction, we undertook a study on the foraging activity of fruit bats in a grape orchard during a lunar eclipse that occurred on 9 January 2001, and compared it with nightly foraging three days before and three days after the eclipse. *C. sphinx*, one of the fruit bats, visits the grape orchards every day for foraging (Singaravelan, unpublished). It has a body mass of about 48 g and forearm length of about 68 mm, and mainly lives either solitarily or as a harem consisting of a male with five to 12 females in foliage roosts, e.g. in the 'tent' of the creeper plant *Vernonia scandens*[18], in kitul palm trees *Caryota urens*[19] and inside the dried fronds of palm trees *Borassus flabellifer*[20]. *Rousettus leschenaulti*, another fruit bat, also visits the same orchards but the number of bats captured in mist nets each night was relatively less compared to *C. sphinx* (Singaravelan, unpublished). It has a body mass of about 95 g and forearm length of about 80 mm and usually lives in temples as huge colonies[21].

We observed bats when foraging on ripe grapes (*Vitis vinifera*) in an orchard for seven consecutive nights from 6 to 12 January 2001. The grapes were cultivated under a bower system in the orchard that covered an area of about 2024 m^2 in the Cumbum valley, about 95 km west of the Madurai Kamaraj University campus (9°58′N; 78°10′E). The number of bat-visits was recorded every hour for the whole night from 1800 to 0600 h, for a total of 84 observation hours. A bat-visit was taken to have occurred whenever a bat flew either towards or away from the orchard. The available moonlight enabled us to observe the flight of bats. In the absence of moonlight, a red-filtered torch was used for observation. Two mist nets were erected at two different sites to capture and to identify bats visiting the orchard. The sites were chosen randomly every day in order to avoid bats becoming aware of mist nets which they may then avoid. The intensity of the moonlight was measured using an UDT optometer. While analysing the data, the observations were divided into three categories – pre-lunar eclipse nights (6–8 January 2001), lunar eclipse (full moon) night (9 January 2001) and post-lunar eclipse nights (10–12 January 2001). One-way ANOVA with Tukey's multiple comparison was used to test the level of significance at less than 0.05.

Bats started visiting the orchard individually about 30 min after sunset. They typically landed on a bunch of grapes after briefly hovering over them, removed a single fruit and flew away. Removal of fruits was preceded by a few stretches of straight flights in inner passages of the orchard. The bats never stayed on bunches of fruits, instead they carried fruits away, presumably to a feeding roost. The total number of bat-visits during the three consecutive pre-lunar eclipse nights was 63, 57 and 49, respectively. Similarly, the total number of visits during the three post-lunar eclipse nights was 46, 68 and 63, respectively. The number of bat-visits during these two periods was not significantly different ($F_{5,66} = 1.19$; $P = 0.32$). The number of bat-visits during the full moon day was also lower till the pre-midnight hours. However an enhanced number of bat-visits was evident during the period of eclipse, with a peak at 0200 h (Figure 1). The penumbral eclipse began at 2313 h and ended at 0427 h with a total eclipse at 0150 h. The number of bat-visits was significantly high compared to the pre-lunar ($F_{3,44} = 7.08$; $P < 0.001$) as well as post-lunar ($F_{3,44} = 8.19$; $P < 0.001$) eclipse days. The light intensity with the moon at its zenith during the full moon night was 0.3 lux. During the peak of the eclipse, the light intensity was 0.004 lux. During this entire study period, we had captured 21 individuals of the short-nosed fruit bat *C. sphinx* in mist nets. Even though individuals of a sympatric species *R. leschenaulti* were not captured during this period, we had captured them during our earlier observations made at the same orchard (unpublished data).

The enhancement of foraging activity of fruit bats during the period of eclipse supports our prediction and the findings in a previous study in which bright moonlight apparently inhibited bat activity[17]. Similarly, an increased activity of insectivorous bats was observed during the lunar eclipse that occurred on 13 March 1979 (ref. 22). In this study, the authors[22] had observed the

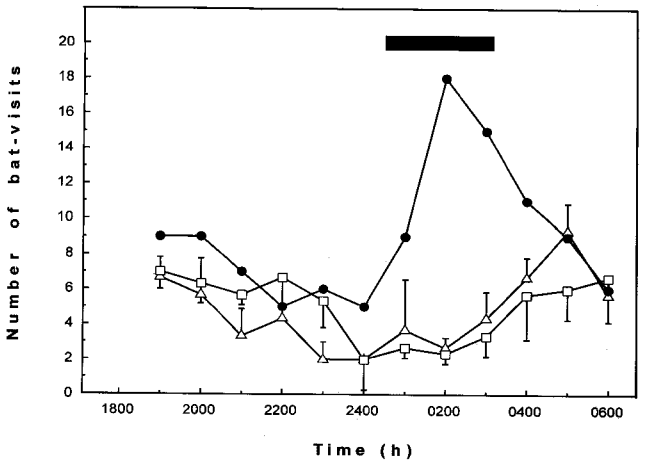

Figure 1. Mean number of foraging visits by fruit bats to the grape orchard during pre-lunar eclipse days (triangles; $n = 3$) and post-lunar eclipse days (squares; $n = 3$). Black circles indicate foraging visits during the day of the lunar eclipse. Horizontal black bar shows the period of lunar eclipse.

activity of bats only on the night of the eclipse and compared them with those of bats observed on the next full moon night that occurred on 12 April 1979. In contrast, moonlight did not modify the activity pattern of the microchiropteran bat *Myotis lucifugus*[23]. In this study the authors[23] observed bat activity only for one hour at the beginning and one hour at the end of the night. However, moonlight did influence the foraging activity of the same species in an another study[24]. Reith[25] suggested that the bats shift their activity by flying more under canopy or in shadow on moonlit nights. Such microhabitat shift during bright moonlight was also observed on ten species of vespertilionid bats[26].

The reduced feeding activity of bats during bright moonlight is generally viewed as an adaptation to avoid nocturnal predators[3,27]. We have noted a barn owl *Tyto alba* and an Indian great horned owl *Bubo bubo* perching on trees in the vicinity of our orchard. However, we have not observed predation on fruit bats while they were foraging. Interestingly, red fig-eating bats *Stenoderma rufum* did not modify their activity in response to moonlight possibly because of absence of bat predators in the study area[28]. We have previously observed that a *C. sphinx* chased away a conspecific that was feeding on a fruit *in situ* in a *Psidium guajava* tree during a full moon night. Our study clearly shows that bright moonlight suppresses the foraging activity of fruit bats in the orchard.

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Conservation of a flagship species: Prioritizing Asian Elephant (*Elephas maximus*) conservation units in southern India

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The Asian elephant (*Elephas maximus*) is believed to number about 45,000 in the wild and is distributed across several populations over South and Southeast Asia. It is an important flagship species for the conservation of biodiversity as well as being a cultural symbol of the people of this region. We analyse a Geographical Information System database of administrative forest divisions constituting four Project Elephant Reserves designated for southern India, in an attempt to prioritize them for specific conservation action and funding allocation. We compute a conservation value for each of these divisions by using five variables characterizing habitat, population and biodiversity attributes. We also compute threat values for each, using two variables which represent the most significant threats. Based on a cluster analysis we demonstrate that divisions with high conservation values have large elephant distribution areas, preferred habitat areas and elephant

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