COMMENTARY

Bats in Indian coffee plantations: doing more good than harm?

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Many bat species occur in Indian coffee plantations and despite sporadic reports of damage to commercial coffee crops, the literature shows little evidence for these claims. Measures that have been proposed to 'control' fruit bats are likely to be ineffective and even counter-productive. Instead, insect-eating bats should be encouraged by planters as they help control herbivorous and disease-carrying insects, while fruit bats pollinate flowers and disperse seeds of many useful plants and shade tree species. More research is needed to quantify any crop damage caused by bats and to look for sustainable solutions where necessary.

Daily, as night falls over the shaded coffee estates of South India, countless small-winged mammals take to the air – bats. Although many bat species occur in such agricultural and agro-forestry ecosystems, there remains little awareness of their diversity and roles as pollinators, dispersers of seeds and as controllers of insect pests. The nocturnal habits of bats and the difficulties in identifying species have led to misconceptions, often compounded by superstitions, fears and myths. As a result, despite the beneficial effects that bats have in agro-ecosystems such as coffee plantations, they are sometimes labelled pests and inappropriate measures are suggested to control them.

A recent article in *Indian Coffee*[1] that reported apparent damage caused by bats to coffee in South India is a case in point. The article mentions sporadic reports from Kerala and Kodagu (four reports since 1987) of damage to coffee bushes by one bat species, apparently the short-nosed fruit bat (*Cynopterus sphinx*). Although the extent of damage is not quantified, the article goes on to recommend measures that coffee planters may adopt to 'manage' these animals, including bursting crackers, burning sulphur and using ultrasonic repulsion devices. It presents an incomplete and misleading picture, possibly because of a poor understanding of bat ecology and behaviour. For instance, the suggestion on 'installing Ultra sonic [*sic*] bat repelling devices' will in all likelihood have little effect on the short-nosed fruit bat, which does not use ultrasound to navigate. Instead, it might harm the insect-eating bats, which do navigate using ultrasound, thereby reducing their potential role in controlling insect pests of coffee. Here, we present information from peer-reviewed scientific studies on the role of bats in agriculture, including coffee plantations, an overview of Indian bat diversity and the need for scientific studies on bats in coffee plantations. We also discuss why the measures suggested in the article[1] are premature and inappropriate.

Role of bats in agriculture

The presence of bats is likely to be beneficial to coffee production because of their overall role in insect pest control. Of the currently estimated 1293 bat species in the world, over two-thirds eat insects, providing free pest control estimated to be worth about US$ 22.9 billion annually in the US alone[2]. Another study from Texas estimated that economic benefits to cotton growers from pest control by bats were 2–29% of the US$ 6 million crop[3]. No study has yet assessed the contribution of bats to human health, but many are known to feed on mosquitoes and insects that spread malaria and other diseases. Bates[4] suggests that 'an individual small bat may take the equivalent of 5000 mosquitoes each and every feeding night'.

Research from Mexico showed an 84% increase in insects during the wet season if bats were excluded from coffee plantations[5]. In another study[6], when bats were excluded from plants by mesh cages, insect numbers increased by 65% and leaf damage increased by 68%. Bats may, however, have only a moderate effect on the control of coffee pests that are more active during the daytime, such as the berry borer (*Hypothenemus hampei*) that is eaten by birds[7]. While these studies are from tropical Latin America, there is no reason to imagine a very different scenario in our coffee-growing regions. A recent study[8] from Indonesian cacao plantations that are similar to shade coffee plantations in structure showed that cacao yield was 31% higher (equivalent to economic benefit of US$ 730 ha/year) when birds and bats were present relative to controls where they were excluded.

While insect-eating bats are important in pest control, fruit bats are important in plant pollination and seed dispersal. In India, fruit bats are the sole or key pollinators of many plants, including many economically important species such as mahua (*Madhuca latifolia*), durian (*Durio* sp.), wild banana (*Musa* sp.), silk cotton (*Bombax ceiba*), and wild jamun (*Syzygium* sp.), some of which only flower at night[9–12]. Many of our fruit bats are also known to be key seed dispersers for forest and shade trees, e.g. wild figs (*Ficus* sp.), white cedar (*Melia* sp.) and wild date (*Phoenix sylvestris*). At least 300 plant species rely mostly on the fruit bats of Asia and Africa for their pollination and/or seed dispersal and these plants produce around 500 economically valuable products like dyes, timber, medicine and fibres[11].

Bat diversity in India

Indian bats include 'flying foxes' and other fruit bats and insect-eating bats. The name 'flying fox' is given to one specific group of large-bodied fruit-eating bats, including the Indian flying fox (*Pteropus giganteus*), the bat often seen roosting in large numbers hanging upside down on tall countryside trees (Figure 1). Bates[4] recorded 123 bat species in South Asia, of which 109 are mainly insect-eating (a few also eat small animals like mice), and 14 eat mainly fruit and nectar. While insect-eating bats use ultrasound to navigate and catch prey (echolocation), most fruit bats rely on eyesight.

In the Western Ghats, where much of India's coffee is grown, 52 species are known to occur – 6 fruit bats and 46

Figure 1. (Left) Indian flying fox with a pup on a fig tree in Nagarhole National Park, Karnataka (photograph: Albin Abraham Jacob, India Biodiversity Portal, indiabiodiversity.org, Creative Commons BY-NC-ND 3.0). (Right) A lesser dog-faced fruit bat (*Cynopterus brachyotis*) on a coffee bush in the Anamalai hills, eating an offered piece of ripe banana (photograph: Claire Wordley).

insect-eating species[13]. The fruit bats include Salim Ali's fruit bat (*Latidens salimalii*), named after the famous Indian ornithologist – a rare and threatened bat, protected under Schedule I of India's Wildlife (Protection) Act, 1972. There are almost certainly other rare bat species yet to be discovered – our field studies in the Anamalai hills have documented around 19 species in tea and coffee plantations and adjoining forests including one insect-eating species new to the Western Ghats[14]. We have recorded bats foraging actively for insects in coffee plantations throughout the night, especially along rivers and streams, where many mosquitoes and other insects breed.

Bats: 'pests' or 'pollinators + pest-controllers + planters'?

While the positive role of bats in pest control, pollination and propagating plants through seed dispersal has been generally overlooked, the negative role of fruit bats in crop damage has probably been overstated. For 11 of the 14 South Asian fruit bats, there is no quantitative evidence that they feed on any commercial crops. The other three species – the Indian flying fox, fulvous fruit bat (*Rousettus leschenaultii*), and the short-nosed fruit bat – do sometimes feed on fruit crops. The short-nosed fruit bat is most often accused of crop damage in India, but while there are incidental observations of crop damage, research has found bats to be responsible for less damage than initially thought. For example, these bats were blamed for high levels of damage to grapes, but a study found that they caused only 4% of the observed damage[15]. Also relevant for orchards is the timing of harvest in relation to fruit ripening and bat visits[16]. In mango and guava orchards, about 60% of the fruit damaged by bats was ripe or overripe and thus unfit for sale[15]. Similarly, a study carried out in Israel on the Egyptian fruit-bat (*Rousettus aegyptiacus*) that was believed to be a pest, found that the bats ate mainly figs (*Ficus*) and only minimally consumed two commercial species, leading the authors to suggest that 'the definition of the fruit-bat as a major agricultural pest should be re-examined'[17]. Bats always prefer the ripest foods; one researcher reports fruit bats refusing under-ripe fruit even when they had not eaten for 18 h (Merlin Tuttle in *BATS* magazine, 1984).

Conflict between bats and farmers mostly occurs when bats have lost their native fruits through habitat loss[18]. As more native fruit trees are cut and surrounding forests or sacred groves (*devara kadu*) are lost, bats may more likely turn to crops for food. Many of the great banyan (*Ficus benghalensis*), peepal (*Ficus religiosa*) and other trees that once added cool shade, utility and grandeur to our roads, and which provided food to thousands of bats, birds and other animals, are being relentlessly and needlessly cut[19]. If native shade trees or forests decline or disappear from the landscape, then ecological problems may follow, such as declining pollination from bees[20] or increased pest incidence[7]. Vijayalakshmi *et al.*[21], whose description of bats causing damage to coffee is cited in Uma *et al.*[1], note that 'In the past such attacks rarely occurred'. They suggest it may be related to recent changes in land use and cropping practices, but it may also be related to loss of native shade trees in coffee estates or reduction of surrounding forest cover.

Bats also play a role in dispersing seeds and planting trees. Traditional coffee estates in India have demonstrated excellent coffee production under diverse native shade, especially figs (*Ficus*). Some of the naturally grown shade trees were probably originally planted by bats. In our work on rainforest restoration in the Anamalai hills[22], we have found that seedlings grown from tree seeds dropped by bats show high germination and vigorous growth. Many of these seedlings have been provided as native shade trees for use in coffee, vanilla and cardamom estates in the Anamalai hills and are growing well. Recognizing that bats pollinate plants, disperse seeds and eat insects in coffee estates will help develop a more balanced understanding of their roles.

Looking ahead

The mere presence of bats or incidental observations of them eating fruits or leaves is insufficient to assess whether a species causes any real damage. To realistically determine this, one has to answer several basic questions. How often does the specific fruit or leaf appear in the diet of the bat? What is the population of the focal bat species in the area? Is the damage as a percentage of total (coffee) crop negligible or significant? Establishing whether such damage occurs year-round or at particular times, and whether it is widespread or only occurs in specific locations, will also help identify possible causes and solutions

to reduce any damage. Estimates of damage should be balanced against benefits of pest control, pollination and seed dispersal conferred by bats.

There have been no studies into how much damage is done by bats, or on the effectiveness of the methods for reducing bat damage in coffee (as acknowledged by Uma *et al.*[1]). It would be useful for Indian coffee research institutes to collaborate with bat ecologists, in carrying out research to better understand the roles of bats in coffee-growing landscapes. Until this is done, it is premature to blame bats for damage or propose measures that may well prove to be useless, costly or counter-productive for coffee farmers. Any methods that aim to exclude birds or bats from coffee bushes will remove their valuable role as insect predators – one cannot exclude only the fruit bats. The methods suggested[1] – such as bright lighting at night, making loud noises, burning sulphur or bursting crackers – are disruptive and will also disturb other animals, including pest-controllers such as insect-eating bats and birds[7].

To minimize potential bat damage, a more effective and sustainable management plan than such disruptive methods[1] is likely to be the growing of 'bait crops' of preferred fruit trees as suggested for buffering of orchards[16,23]. In the coffee landscapes of South India, there are numerous native tree species suitable for shading arabica and robusta coffee. Planters could nurture native tree species useful as shade, timber, home-garden, or avenue trees in coffee plantations that would also provide food for bats; for example, figs (*Ficus* sp.), white cedar (*Melia* sp.), jamun (*Syzygium cumini*), and the Western Ghats rudraksh (*Elaeocarpus tuberculatus*). Some figs provide year-round food for bats (and other wildlife), potentially keeping them away from seasonal crops. The Indian laburnum tree (*Cassia fistula*), with its beautiful pendant showers of yellow flowers and tamarind (*Tamarindus indica*) may be useful, because the leaves of these trees provide alternate food for short-nosed fruit bats[12]. A diverse landscape of native shade tree species, forest patches and sacred groves will ensure a natural food supply for bats throughout the year.

Populations of many of our bats, including flying foxes, are in decline due to destruction of roosting and foraging sites, hunting, pesticide use, pollution, and disease outbreaks[24]. Bats breed slowly and so their numbers can decline quickly. For example, pregnant female short-nosed fruit bats produce a single pup after a gestation of four to five months, suckling the young for an additional one or two months. Under best conditions, they may breed twice in a year[25]. Several Indian fruit bats are rare and restricted to small areas of the country and the status of many other species is also precarious. Protecting fruit bats is important both to keep our forest ecosystems healthy as well as to safeguard our economic options on many products into the future. Indian coffee rightly prides itself in being shade-grown, and traditional farms in Kodagu and Wynaad grow coffee under the shade of more than 200 native tree species[26]. Coffee grown under native shade trees is a valuable commodity, a pleasure to walk through and a way of farming that also retains native wildlife. Efforts should be made to ensure that it remains so in the future.

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