Project Update: May 2022

Objectives:

- To quantify benefits of insectivorous bat guano and insect pest control vis-à-vis conventional fertiliser and pesticide inputs.
- To develop analytical models to assess net benefits in the utilisation of ecosystem services from insectivorous bats, and trade-offs with potential costs to people (e.g., cultural costs, disease risks).
- To derive indicators of "irreplaceability" for insectivorous bats and apply them in conservation planning and community outreach in agroforestry systems.

Progress update:

I received the Rufford 2nd small grant in March 2021. Fieldwork could not be immediately conducted after receiving the grant, due to the 2nd (delta) wave of the Covid-19 pandemic in India and the lockdown situations, restrictions on travel, and precautionary measures.

Therefore, to compensate for the lost time, I adopted a modelling approach to understand impact of bat predation rates in controlling insect herbivory and thereby rice production. For this predator-prey-resource model, I included data on bat foraging rates from earlier work and included information from literature sources on insect reproductive patterns and herbivory intensity. I also undertook a review of literature related to insectivorous bat guano and its use in agriculture, to inform my plans for experimental studies. In October-November 2021, I targeted the rice-paddy season in one of my field sites (Sirsi) and conducted intensive overnight acoustic monitoring of bat activity in one organic and one conventionally managed rice-paddy field for about 15 nights each. I also published a paper on habitat use by insectivorous bats in a forest-rubber plantation landscape in *Frontiers in Conservation Science* (https://www.frontiersin.org/articles/10.3389/fcosc.2021.751694/full), based on the work supported by my 1st Rufford Small Grant, which is connected with the current project. The details of the major work carried out are provided below.

Analytical model:

I developed an analytical model to quantitatively understand the effects of bat predation on changes in insect pest abundance and population dynamics, and the related changes in damage of rice paddies from insect herbivory. The basic model has components on pest or prey population dynamics under the influence of variable bat predation rates and in turn, the resultant impact on insect herbivory affecting rice growth and production. I considered the moth life cycle (a stage-structured matrix model) to represent a typical insect pest of rice as the core component of the model, because moths are a dominant prey item for most bats.

Predation of adult moths by bats, and herbivory of rice shoots by moth caterpillars were both modeled as Lotka-Volterra consumer resource models, with the model for rice shoots being a density-dependent population growth model. Bat foraging rates, based on actual field data collected from acoustic monitoring, was input as the main driver of adult moth populations in the model.

Acoustic monitoring to assess bat foraging rates:

I managed to complete the first lap of acoustic monitoring fieldwork from October-November 2021, during the peak rice paddy growing season. Luckily this window fell between the second (April-June) and third (December-January) Covid-19 waves in India. Overnight acoustic recordings of insectivorous bats were carried out with bat detectors in paddy fields (Figure 1) in one of my field sites (Sirsi in Uttar Kannada district) in the Western Ghats.

- During this field season, I conducted overnight acoustic recordings using bat ultrasound detectors in two types of paddy fields for 15 recording nights each.
- The paddy fields differed in their management practices (conventional and organic) and locations (valley and plateau paddy) in terms of proximity to the Western Ghats.
- I set up bat detectors in the two types of paddy fields, well before sunset and they would start recording automatically at sunset when bats would start to emerge. Detectors were matched for trigger intervals (sleep-wake cycles during recordings), which thereby generated the same amounts of data per recording night.
- Two detectors were deployed simultaneously in the two selected fields, for 11.5 hours per night each, from before sunset to just before dawn break. This together resulted in recordings of over 340 hours across both fields.
- The acoustic analyses from these data are underway and the results would then be fed into the model.

Figure 1. Detector setup deployed in paddy fields and a narrow-space flutter detecting bat foraging off paddy shoots.

Bat habitat use in forests and rubber plantations:

My paper in the journal *Frontiers in Conservation Science* described how insectivorous bats can use plantation habitats in forest-plantation habitat mosaics (Figure 2). Effects of land-cover change on insectivorous bat activity can be negative, neutral or positive, depending on foraging strategies of bats, especially so in tropical agroforestry systems with high bat diversity. Therefore, I investigated foraging habitat use by three insectivorous bat guilds in forests and rubber plantations in the southern Western Ghats of India, in relation to: (1) land-cover types and vegetation structure, and (2) plantation management practices. I hypothesised that activity of open-space aerial (OSA) and edge-space aerial (ESA) bat guilds would not differ; but narrow-space, flutter-detecting (NSFD) bat guild activity would be higher, in structurally heterogeneous forest habitats than monoculture rubber plantations. Interestingly, I found that bat activity of all guilds was highest in areas with high forest cover and lowest in rubber plantations. Higher bat activity was associated with understorey vegetation in forests and plantations, which was expected for NSFD bats, but was a surprise finding for OSA and ESA bats. In terms of management practices, intensively managed rubber plantations with regular removal of understory vegetation had the lowest bat activity for all guilds. Intensive management can undermine potential ecosystem services of insectivorous bats (e.g., insect pest control in rubber plantations and surrounding agro-ecosystems) and magnify threats to bats from human disturbances. Low intensity management and maintenance of forest buffers around plantations can enable persistence of insectivorous bats in tropical forest-plantation landscapes. This paper is the first contribution on the impacts of rubber plantations on insectivorous bats in India. An important message of the paper was to highlight the value of forest cover and understorey for bat activity, irrespective of foraging strategies of different guilds. These results are the basis of my ongoing work and are useful in fine tuning the model for quantitative assessments of the value and future relevance of ecosystem services of insectivorous bats to agriculture, across different landscape contexts.

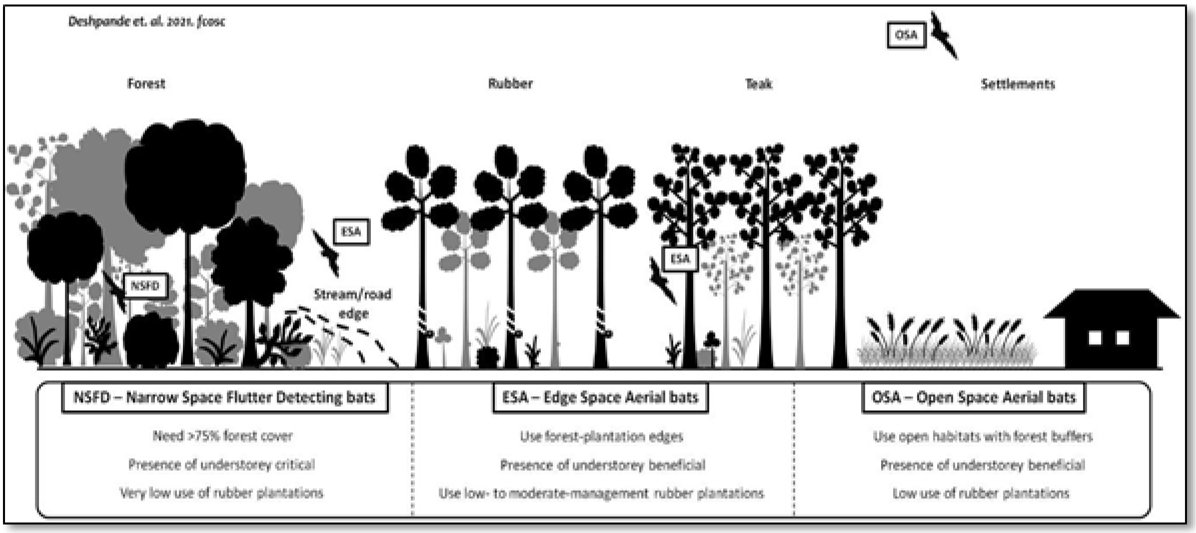

Figure 2: Schematic diagram summarizing the main results of this study.

Publication citation:

Deshpande, K.*, Kelkar, N., Krishnaswamy, J. & Sankaran, M. (2021) Stretching the habitat envelope: Insectivorous bat guilds can use rubber plantations but need understory vegetation and forest buffers. *Frontiers in Conservation Science*. 2:751694. https://doi.org/10.3389/fcosc.2021.751694