**Tales of the night: Chapter I**

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**Keywords**: bat, bioindicator, chiroptera, keystone species

It is a spectacle to experience the sight of hundreds of bats emerging from the shadow of caves in a perfectly choreographed flight maneuver, before eventually disappearing into the vanishing tinge of the dusky sky. Bats, the only volant mammals form the second largest mammalian order Chiroptera (chiro= hand, pteron= wing) comprising of more than 1300 species (Fenton and Simmons 2014). They show extraordinary specializations in their ecology, anatomy and physiology and a diverse dietary habit feeding on anything from nectar, pollens, leaves and fruits, to insects, small mammals and vertebrates, other bats, fishes as well as blood (Kunz *et al.* 2005). Most bats can echolocate emitting ultrasonic sounds for spatial orientation, social contact as well as for foraging (locating and hunting prey), others have strong sense of smell and are well adapted for herbivory. And a small group of bats (the vampire bats of central and south America) possess thermal sensors to choose prey and feeds on blood of wild mammals as well as livestock and less frequently humans (Kunz *et al.* 2005; Fenton and Simmons 2014). In this article, I will share some contributions of bats to our ecosystem that ultimately benefits us in many ways. I will also share some concerns regarding their continuous decline due to human mediated alteration of our environment as well as continuous persecution resulting from superstition and ignorance (Figure 1). We will save the discussion of their unique capabilities of time keeping and other idiosyncrasies for another chapter of 'Tales of the night'.


**Figure 1. An Indian flying fox (*Pteropus giganteus*) colony near Bangalore. These bats suffer heavily from destruction of roosting trees and persecuted as agricultural pests and also due to their possible role in zoonotic diseases.**

**Bats as bioindicators**


**Figure 2. The endangered Mauritius fruit bat (*Pteropus niger*) endemic to Mauritius. Destruction of forest, mass culling and illegal hunting has greatly contributed to drastic decline in its population size**

Bats occupy an amazing array of habitats are found widely across the globe inhabiting major ecosystems. They are keystone species contributing towards the sustenance of eco-systems they inhabit and performs many important ecosystem services (Kunz *et al.* 2005). However, bats are also extremely sensitive to disturbances to their habitats, ecology and climate. Over the past few decades, volumes of research studies have revealed that bat communities can be specifically tracked to obtain important estimates of biodiversity, level of pollution and effect of climate change (Jones *et al.* 2009). For example, frugivores and insectivores can be tracked to understand changes in plant and insect communities (Jones *et al.* 2009). Similarly, mass mortalities in flying foxes due to sudden warming in parts of Australia (Welbergen *et al.* 2008) indicated adverse impact of climate change over the population. Many island bats like the Dark flying fox of the Reunion and Mauritius islands, the Guam flying fox endemic to Guam, the Christmas Island pipistrelle found native to the Christmas Island have already gone extinct and many other species face imminent risk of extinction (IUCN) (Figure 2). Even, more commonly occurring species experience drastic loss in population size and risk extinction locally as well as globally.

**Ecosystem services: agrodiversity, forest regeneration and pest control**

Contribution of bats to the ecosystem benefits humanity in many ways. Fruit bats are pollinator for many plant species which are economically important (banana, mango guava, durian, coconut, ficus, cocoa etc.) as well as species critical for eco-system functioning (agave, various cacti species, baobab tree etc.). Flowers of such species employ multitude of tactics to attract and recruit fruit bats, they open in the night, emit strong odor, and are often large and white in color to ensure that they are located easily in the darkness. Agave plants are primarily pollinated by the nectar feeding long-nosed bats, who in turn are heavily dependent of the nectar and pollen of agave mainly to meet their energetic requirement (Arita and Wilson 1987). Compared to many other biotic pollinators, bats are often efficient long-distance pollinator (Fleming *et al.* 2009). Over 500 species of flowering plants are pollinated by bats (Fleming *et al.* 2009) (Figure 3).

Growing body of evidence proves that fruit bats are excellent agents of fruit and seed dispersal and germination and greatly accelerates regeneration of forest cover over degraded patches. Fruit bats like the flying foxes inhabiting the Old World biomes can aid in dispersal across tens to hundreds of kilometers and often across isolated islands where many times they are the sole pollinators (Jones *et al.* 2009). In the New World Tropics, dispersal of seeds of pioneer plant species by fruit bats is essential for regeneration of forest cover (Kelm *et al.* 2008). Research suggests that seeds ingested by bats influences germination, for example, bat-consumed seeds with their pulp removed show better germination in the neotropical tree species, *Calophyllum brasiliense* (Marques and Fischer 2009). In addition to their role in pollination, dispersal and germination, bats significantly contribute towards the increase of genetic diversity within their host species by mixing gene pools from different and many times faraway populations. Such act helps maximizing agrodiversity among cultivated plant species as well as forest diversity. In the face of the ongoing episode of human mediated habitat fragmentation, long distance pollination by bats are often responsible for maintaining gene flow and connectivity of plant populations (Fleming *et al.* 2009). Successful management of fruit bats can


**Figure 3. Sequel for bat pollination (plant: *Ceiba pentandra*)**

effectively aid in the regenerating forest cover thereby forming the base of effective conservation and management of native biodiversity.

Majority of bats however are insectivore, either obligatory or facultative and in many cases act as effective biological control agents of arthropod pest management. Studies have shown that insect bats can eliminate tons of insects per night from farm lands. A colony of 20 million Mexican tree-tailed bats can consume 13000 tonnes of insect over one summer (Altringham 1996). Research from North America suggests that bats contribute around 23 billion annually (by consuming pests and reducing pesticide application) to the agricultural industry in US alone. In the absence of bats, agricultural industry would require to spend additional 4–53 billion USD annually on pesticides alone. But these estimates only include the benefits of pest management and do not include other indirect effects to the environment due to reduce use of pesticides (Boyles *et al.* 2011), which adds more economic value to their services. Additionally, excrements of insect bats, called guano are rich in nitrogenous compounds are acts as effective fertilizer and are regularly mined in countries like providing

livelihood for many. Some insect bats are carnivorous, like the false vampire bats commonly found in the subcontinent. These bats prey upon small mammals like rodents and act as biological control for mammalian pest.

**Persecution: superstition and ignorance**

While contribution of bats is etched in oriental cultures as positive associations, western cultures nurture largely negative stereotypic myths. Within a large collective mindset across the globe, bats rule the realm of the dark and are usually associated with everything evil. Regardless, many communities not only hunt them and harvest every part of their body in the belief that these could cure almost every possible disease but also consume bats as bushmeat (a source of cheap protein), leading to mass annihilation of colonies often comprising thousands of animals. Such activities act as important stressor for bat communities and significantly contribute towards their decline.

Bats are very gregarious in nature, most species can utilize diverse types of natural formations (also manmade structures), and some like the short-nosed fruit bats from south and southeast Asia can even modify plant-parts to construct simple tents wherein they spend their day (Kunz *et al.* 2005). Males of the commonly occurring short-nosed fruit in south Asia regularly uses foliage roosts. They chew and modify the underside of leaves of the plant (e.g Palmyra palm) creating a semi-permanent tent-like structure that lasts for years.


**Figure 4. Endangered Rodrigues fruit bat (*Pteropus rodricensis*) endemic to Rodrigues island.**

Bats often cohabit with humans and livestock. Human contacts are unavoidable due to anthropogenic loss of natural habitats, forcing bats to live in close proximity with humans. However, this association has proven particularly costly for the species as they face merciless persecution and are not only hunted for meat and medicine but also exterminated for their possible role in spreading deadly viruses among humans. Added to this are human mediated destruction of natural habitats and the vagaries of climate change, factors which have collectively resulted in an accelerated loss in their number, diversity, distribution as well as local extinctions in many cases (Figure 4).

Despite the importance of bats towards maintaining an ecological balance, scientific studies of bats are not a prominent component of the peer-reviewed literature. Lack of enough scientific research means that in many cases we are losing precious biodiversity even before they get discovered, a situation particularly acute in South and Southeast Asia (Kunz *et al.* 2005; Fenton and Simmons 2014). For the little fraction that we are aware of, bats seem to be an enigma gradually enfolding a bewildering array of behavior so intertwined with nature that their demise can certainly spell doom

to many natural ecosystems. This has also prompted in many scientific studies addressing their biology, ecology as well as evolution. Among these studies, researches dealing with association of bats with deadly disease outbreaks have become particularly illuminating for humanity in general. Bats carry numerous viruses like SARS, Ebola, Nipah and Rabies virus, but rarely show signs of infection. However, such viruses, if transmitted to livestock or humans causes high mortality, and widespread epidemics (Han *et al.* 2015; Plowright *et al.* 2015). We now know that, direct spread of virus from bats to humans is rare and most infection find their way into humans through livestock. Some studies have also pointed out that bats shed more viruses when under stress. Many documented bat borne disease outbreaks can be linked to close proximity of bats with humans wherein, human settlements have encroached into forest lands and bats are forced to stay close to human settlements, in many cases roosting (nesting) close to livestock. As they shed viruses though excrements, or saliva, the viruses are picked up by livestock and gradually transmitted to humans. Scientists, on a regular basis are discovering novel mechanisms by which bats make themselves immune to viral diseases and believe that bats can form an effective model system to study immunity to virus infections ultimately helping us to devise better technology to combat viral infections and outbreaks.

There is a lesson for us to learn from bats and that is, there are other organisms in this world who are different from us, but nonetheless intelligent and with unique capabilities. The web of life binds us all intricately into a matrix of coexistence that has lasted for over millions of years. It is for us to decide if we still want to cohabit with our neighbors, or consider this diversity as alien, remove them from our surroundings and keep curating the earth as our kitchen garden, to our own peril.

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