Bats*

The echolocating bat *Icaronycteris index* 'was' 52.5 million years old – it is now extinct (http://en.wikipedia.org/wiki/Icaronycteris). Kitti's hog-nosed bat *Craseonycteris thonglongyai,* the smallest bat in the world, was discovered only in 1974 and is already on the list of endangered species. The large flying fox *Pteropus vampyrus*, the largest bat in the world, is on the list of threatened species (http://www.jwaller.co.uk/batgroup/biology.asp).

To understand the biology and importance of conservation of bats, a one-day workshop was conducted by John Altringham and Anita Glover from the University of Leeds, UK with an invited lecture by G. Marimuthu, Madurai Kamaraj University, Madurai. A summary of the lectures is presented here.

Evolution

Bats have been around for 65 million years. 'They must have been around to witness the extinction of dinosaurs (Altringham)'. Molecular studies in the last few years have made it possible to completely re-classify bats, which form the most diverse order of mammals constituting over 20% of all mammal species, with 1100 plus species worldwide. Earlier belief was that the fruit bat evolved from an earlier primate whereas other bats evolved from an insectivore. But studies recent show that all bats had a common ancestor.

Feeding

Around 200 of the 1100 species are nectar feeders and pollinators, like the short-nosed fruit bat and the long-tongued bat. Some are solely nectar feeders; some others are fruit eaters and seed dispersers like the Mariana fruit bat. The vast majority (800 plus species) are insect eaters and pest controllers, like the pallid bat.

Roughly 20 species are carnivores, such as the fringe-lipped bat and the Australian ghost bat. The fisherman bat catches fish swimming close to the water surface. Some bats can switch-off their echolocation and use only vision and passive hearing, in order to hunt prey unawares.

Roosting

Flying foxes make prominent, noisy, smelly camps in the open. The Honduran white bat (*Ectophylla alba*) males make tents and attract females. The midrib of the leaf is chewed so as to form a tent-like shelter. Bats with suckers on wrists and ankles, like the *Myzopoda aurita* of Madagascar, stick to shiny leaf surfaces. The mouse-tailed bat and Australian ghost bat are common cave dwellers in small groups. The long-fingered bats use caves as nurseries. In temperate climates, caves are used for hibernation. Several hundred thousands of grey bats can roost in a single cave site; they are vulnerable to disturbance.

Life history strategy and population biology

Bats give birth, usually, to a 'single', 'blind' and 'naked' pup weighing 20–30% of the mother's weight. The gestation period is proportional to the size: 40 days for a 5 g bat and 5–6 months for a 1 kg fruit bat. There are exceptions such as the vampire bat: 8 months for a 30 g bat. Small bats fly in ~3 weeks and are weaned in ~5 weeks. Many bats exhibit adaptations deviating from their normal mammalian faces, mostly for echolocation. For example, the horseshoe bat has horseshoe shaped leaves in front to focus sound.

Bats become sexually mature in 1–3 years but may not be 'experienced' parents till eight years. They have complex social structures and a wide range of mating systems. They can have large home ranges, with unpredictable shifts due to food availability. Migratory, fast-flying bats often have near-panmictic populations whereas gleaning bats with limited mobility have highly structured populations.

They can fly for several months over cross-country boundaries and between islands and are often migratory. A recent study tracked the flight of two Malayan flying foxes from central Indonesia to Malaysia in 3–4 months. They live long – 15 to 25 years is common; over 40 years has been recorded.

Ecosystem services

Bats perform important services in their capacity as 'predators', 'pollinators' and 'seed dispersers', thereby having a great ecological and economic impact. For example, the lactating females of the Brazilian free-tailed bat *Tadarida brasiliensis* can ingest two-thirds of their body weight in one night. A colony of 4 million in Bracken Cave, Texas is estimated to consume 13,000 tonnes of insects in one summer. The prey of *T. brasiliensis* include many species of insect larvae which are important agricultural pests. They save US$ 0.75 million in the form of pest control services for a US$ 5.5 million cotton industry in south-central Texas.

Extreme specialism can develop between some plants and their bat pollinators. For example, *Anoura fistulata* has a 85 mm tongue – 150% of its body weight. It is the single pollinator of *Centropogon nigricans*. This is an example of co-evolution. Bat pollination is important especially in the case of pollination of the tequila agave, agave palmieri and the saguaro cactus (a keystone species of the Sonoran Desert) by *Leptonycteris curasoae*. It is a case of optimal foraging.

Bats transport many seeds over long distances. The seeds are undamaged and often result in improved gene exchange and colonization, and reduced competition and seed predation. About 289 plant species in 59 families depend on Pteropodids for seed dispersal and/or pollination. Sixty five per cent of these plants are used to make food, medicines and wood products for human use.

Threats to bats

Ten major caves in Mexico, each with 0.5–4.0 million bats have undergone 70–

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100% decline. *Nyctimene santacrucis* of Solomon Islands, *Acerodon lucifer* of Philippines and *Pteropus loochoensis* of Japan are some extinct bat species. The existence of *Pteropus tokudae* came to be known only from museum specimens; it became extinct in 1974.

Habitat destruction, degradation and fragmentation result in loss of roots, foraging habitat and food. Roads are barriers to bats as they are to birds and terrestrial mammals, and contribute to reduced breeding success and foraging territory. Laws are needed to protect entire habitats.

Introduction of the brown tree snake in northern Marianas has ravaged the Mariana fruit bat. The white nose syndrome – an emerging disease associated with fungal infection – has killed hundreds of thousands of bats in north-east USA in the last three years. Increase in human population and improvement in hunting efficiency have led to a decrease in many bat populations. Unsustainable hunting of the Malayan fruit bat is going on in Malaysia/Indonesia. Bats are hunted for use in medicines to treat asthma. Threats also arise due to human intolerance, superstition, ignorance and perception of bats as crop pests.

Changes in fruiting and insect availability due to climate change will affect bats similar to butterflies and birds. Certain bat species are adapted, physiologically and morphologically, to narrow climatic ranges. If the climate becomes warmer and these bats move to cooler areas, then the bats living at the highest altitudes would have nowhere to go!

Bats as biodiversity indicators

Some of the benefits in considering bats as 'biodiversity indicators' are due to their key position in food webs, low fecundicity/long life, abundance, speciosity, ecological diversity and well-developed survey methods. Drawbacks include their nocturnal nature, high mobility, our limited knowledge of many species, and difficulty in sampling and identifying some species.

Methods for studying bats

Bat detectors can detect bats from their echolocation calls. The calls are counted and logged against time. This method is not labour intensive and can be used for extensive surveys handling large data sets. The heterodyne bat detector can be used to record 'to listen again only', as the call structure is lost. The frequency division bat detector provides recordings with frequency/time plots. The best research tool, which offers sonograms for detailed analysis, is the time expansion bat detector. It should be kept in mind that bats can change their calls depending on their current habitats. Automated loggers can be used to record echolocation calls at cave entrances and roost sites for even three weeks continuously.

Solid state recorders enable rapid data download to computers via USB port and easy file management. Bat calls can be stored in two formats: MP3 or WAV. MP3 files are adequate for most uses; but in case high-quality recordings are required for analysis and archiving, WAV is preferred in spite of the larger file size.

A large number of software are available for bat call analysis. The 'BatSound' software provides amplitude/time and frequency/time (sonogram) plots, power spectra, call duration and other parameters. Here, MP3 files must be converted to WAV for analysis.

Night vision scopes and cameras are also available. These can be used, in conjunction with echolocation recordings, in playback experiments to understand bat behaviour. Acoustic lures (synthesized bat calls) can be used in combination with catching. This increases the chances of detecting rare, quiet and forest-interior species.

Bats are also caught using mist nets and harp traps. This enables accurate species identification and data collection on sex, age, reproductive status and biometrics. A knowledge of generic bat anatomy is necessary to identify bats once they are caught.

They can then be marked using fur clips, cyalume tags, rings, passive integrated transponder (PIT) tags and radio tags. The technique for marking depends on whether short-term, long-term or individual-specific observations are required. Samples can be collected using biopsies, fur, endo- and ecto-parasites for use in molecular genetics, stable isotope analysis and measure of fitness.

But catching bats can be invasive and labour intensive. The capture efficiency varies between habitats and sites, and quantification is difficult unless large numbers are caught. Also species bias arises due to differences in foraging styles, flight and echolocation performance. A survey protocol is necessary that provides a quantitative measure of activity. It should sample all available habitats with equal representation. The measure of activity is not defined by the number of bats, but by a relative measure of activity. Methods for detector surveys include spot counts, transects or a combination of both. Some aspects to remember are boundaries in habitat categorization, patch sizes in complex habitats, and temporal considerations such as emergence time, commuting, peak insect density and seasonal habitat use.

South Indian bats

Of the 19 bat families worldwide, nine are found in south India. They include *Pteropodidae*, *Emballonuridae*, *Molossidae*, *Rhinopomatidae*, *Vespertilionidae*, *Miniopteridae*, *Rhinolophidae*, *Hipposideridae* and *Megadermatidae*. An ongoing research work by G. Marimuthu is on prey (frog) detection and capture by the carnivorous Indian false vampire bat. Catching prey on land is possible both in light and darkness; echolocation is not essential. The bat lands, pounces on its prey, covers it with the wings and then catches with its mouth. It responds only to moving live frogs and dead frogs pulled noisily. The responses are better to the prey's rustling sounds on dry sandy floor and asbestos compared to wet sandy floor. For detecting and capturing prey on water, echolocation and darkness are essential and the head of the live frog should be above the water surface. Here the bat exhibits searching flights and captures suddenly. The prey is chewed and ingested.

Recently, a species of *Myotis* was found in UK which is morphologically similar to the other *Myotis* species but has a distinct echolocation call. While various species are being discovered, the old, the new and the not-yet discovered species are threatened with extinction or are already extinct. There is an urgent need to protect these 'small mammals with big ideas (Altringham)'.

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