Bats and Limestone Karst Conservation

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Bats and Limestone Karst Conservation

From an ecosystem point of view -

- After rodents, Bats form the bulk of mammal diversity found in terrestrial ecosystems of the SE - Asian tropics and sub-tropics.

- Bats are ecologically very diverse and perform vital ecosystem functions through plant pollination and seed dispersal.

- Bats have shared a long evolutionary relationship with flowering plants in the SE - Asian tropics and sub-tropics, and, as a result, Fruit Bats play an important role in the development and structuring of vegetation communities.

- Bats are a key agent in colonisation and reforestation of cleared areas due to the enormous amount of seeds consumed by many species and their ability to transport them over long distances.

Bats and Limestone Karst Conservation

From a species conservation point of view -

- Globally, limestone karst ecosystems represent a key habitat for bats, due to the abundance of caves they contain which provide perfect roosting sites. In SE Asia, limestone karst ecosystems support larger bat populations than any other habitat.

- Limestone karst ecosystems provide crucial habitat for many globally threatened and rare bat species.

- Bat guano provides an important energy input for cave dwelling communities, which typically include many specialised and endemic species.

Bats and Limestone Karst Conservation

From an economic point of view -

- Numerous economically important plant species throughout the tropics and sub-tropics are dependent upon bats for their survival. One example of this is Durian *Durio zibethanus*, whose regional export value exceeds one hundred million dollars every year.

- Bats are recognised as primary consumers of nocturnal insects, some of which are detrimental to humans e.g. mosquito.

- In certain parts of the world, the major importance of bats as a predator of agricultural pests has been very clearly demonstrated.

- Managed properly, bat colonies and their habitat can serve as tourist attractions capable of generating substantial revenue.

- In many parts of the world, bat guano provides a very valuable source of fertiliser for local agriculture.

Bats in South East Asia

Some General Facts about Bats

- Bats are found throughout most of the world, except for the most extreme deserts, polar-regions and remotest oceanic islands.
- Distinguished from all other mammal orders by their capacity for true flight.
- One of the most successful groups of mammals in the world - After Rodentia (Rodents), bats form the second largest mammal order, with over 1,000 species currently described.
- Most species (ca. 90%) are confined to the tropics and subtropics.
- Bats are split into two sub-orders, the **Mega-chiroptera** (Fruit-bats or flying foxes) and **Micro-chiroptera** (mostly insect-eating bats).
- 10 families, containing 65 genera and over 300 species are known to occur in the Indo-Malayan region.

Bats in South East Asia

Megachiroptera: Old World Fruit Bats (Flying Foxes)

- Contains one family, the Pteropodidae, with 42 genera and approximately 173 species.
- Confined to Europe, Asia, Africa, Australia and islands in the Indo-Pacific Oceans.
- Approximately 64 species arranged in 25 genera are known for the Indo-Malayan region.
- Range from relatively small to very large. Weight ranges from 15 g to > 1.5 kg.
- All Megachiroptera navigate by sight and smell, with the exception of species within the *Rousettus* genus, which are also known to echolocate using a system of clicks produced by the tongue e.g. *Rousettus leschenaulti*.
- Diet consists of fruits, flowers, nectar and pollen.
- Majority roost in trees and foliage, sometimes forming very large colonies, while some roost in smaller groups e.g. Rousette bats *Rousettus* sp. and Dawn Bat *Eonycteris spelaea*.

Fruit Bat (flying fox) genera in SE-Asia
– Some examples

Left:

Cynopterus sphinx

Right:

Macroglossus sobrinus

Fruit Bat (flying fox) genera in SE-Asia
– Some examples

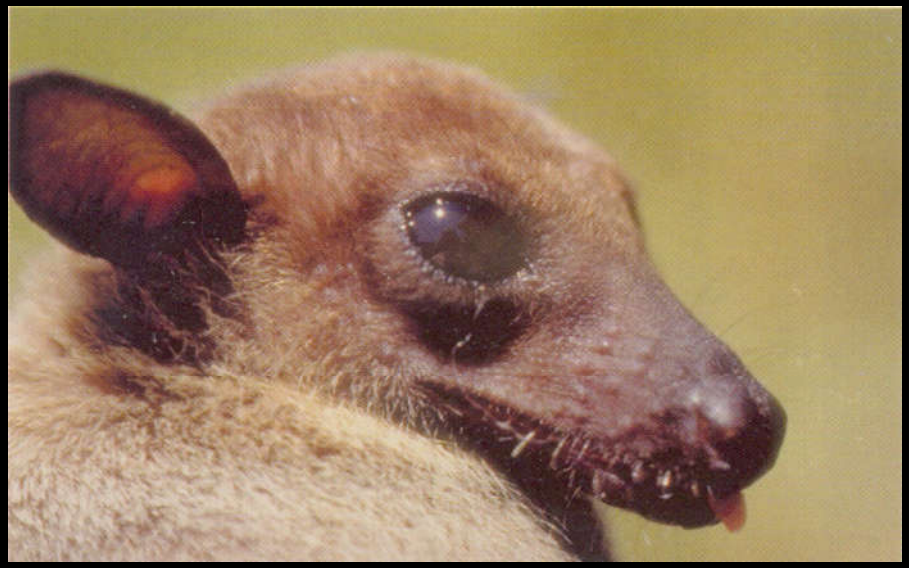
Pteropus giganteus

Rousettus leschenaulti

Fruit Bat (flying fox) genera in SE-Asia
– Some examples

Right:

Megarops niphanae



Left:

Eonycteris spelaea

Bats in South East Asia

Microchiroptera: Echo-locating Bats

- Contains four modern super-families, which contain 18 families, ca. 147 genera and well over 800 species.

Super-family (No. of families)	Global Distribution	Families occurring in SE Asia
Emballonuroidea (3)	Throughout, except polar regions etc	Rhinopomatidae, Emballonuridae and Craseonycteridae
Rhinolophoidea (4)	Throughout, except North & South America and the West Indies	Nycteridae, Megadermatidae, Rhinolophidae & Hipposideridae
Phyllostomoidea (4)	North & South America, West Indies	None
Vespertilionoidea (7)	Throughout, except polar regions etc	Vespertilionidae and Molossidae

- There is a fifth superfamily, the Palaeochiropteryigoidea, containing three families. These are all extinct, and known only from the fossil record.

- Around 40 genera containing around 232 species are known for the Indo-Malayan region.

Bats in South East Asia

Microchiroptera: Echo-locating Bats

- Micro-chiropteran bats range from very small to moderately large in size. Forearm lengths range from 22.5 to 115 mm.

- They include the world's smallest mammal, Kitti's Bat *Craseonycteris thonglongyai* (Craseonycteridae), which weights barely two grams and measures only three centimetres (pictured right).

- All navigate and seek and capture using a system of echolocation based on ultrasonic signals produced in the larynx.

- Microchiropteran bats display nearly as wide a variety of eating habits as all the rest of mammals in the world put together. Their diet includes insects, pollen, fruit, flowers, flesh and blood.

- The most common diet among Micro-chiropterans is insects (over 79 genera).

Bats in South East Asia

Carnivory in microchiropterans is restricted to certain larger species that regularly eat other bats, small rodents, birds, frogs and lizards.

Megadermatidae: Megaderma spasma

Nycteridae:

Nycteris javanica

A small number of bat species specialise in piscivory (fish-eating)

Fisherman Bat

Noctilio leporinus

Myotis ricketti

Bats in South East Asia

Microchiroptera: Echo-locating Bats

- Sanguivory, feeding on blood, is practised only by three species, which are restricted to tropical and subtropical areas of south and central America.
- Until very recently, it was believed that fruguivorous (fruit and flowers) and nectivorous (nectar and pollen) micro-chiropterans did not occur in SE Asia.
- Microchiropteran bats roost in a wide range of habitats, although most prefer more enclosed situations than the open habitats chosen by fruit-bats.

  The sub-group includes many gregarious species, sometimes forming very large colonies containing millions of bats.
- Micro-chiropteran bats also vary a lot in appearance.

Echo-locating Bats in SE-Asia

– Selected species in the Hipposideridae family

Hipposideros armiger

Hipposideros pomona

Coelops spp.

Left:

Hipposideros rotalis

Aselliscus stoliczkanus

Echo-locating Bats in SE-Asia

– Selected species in the Rhinolophidae family

Above:

Rhinolophus malayanus

Below:

Rhinolophus pearsoni

Echo-locating Bats in SE-Asia

– Selected species in the Vespertilionidae family

Kerivoula picta

Myotis annectans

Ia io

Pipistrellus pipistrellus

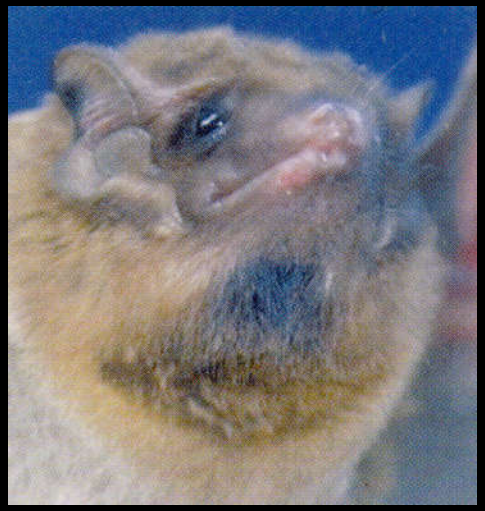
Echo-locating Bats in SE-Asia
– Other families

Family Mollosidae*, Tadarida plicata*

Right:

Rhinopoma hardwickii

Family Rhinopomatidae



Family Emballonuridae

Left:

Taphozous melanopgon

Right:

Emballonura alecto

Family Emballonuridae

Bats in Limestone karst

- Globally, limestone karst ecosystems represent a key habitat for bats, due to the abundance of caves they contain which provide perfect roosting sites.
- Many of the 1,000 bat species currently known are cave dwelling.
- In SE Asia, where limestone karst ecosystems are extensive, these support significantly larger bat populations than any other habitat.
- Bat colonies may number from hundreds to thousands to millions of individuals. In SE-Asia, such large colonies occur only in caves.

Bats in Limestone Karst

The number of bat species known or expected to roost in caves in East Asia by country

Country	National Total	No. of cave roosting species		Percentage[2]
		Echo-locating Bats	Fruit bats[1]	
Mongolia	12	11	0	91.7
China	90	76	2 (3)	86.7
Thailand	108	99	4 (7)	95.4
Lao PDR	90	38	2 (3)	44.4
Cambodia	38	28	2 (3)	78.9
Vietnam	64	49	2 (3)	79.7
Malaysia (incl. Brunei)	112	95	6 (9)	90.2
Indonesia	175	110	19 (21)	73.7
Philippines	70	45	4 (5)	70.0
Papua new guinea	91	51	8	64.8

Sources: Figures are taken from Mickleburgh et al. (2002); Vermuelen & Whitten (1999).
1 = Numbers in parentheses include occasional inhabitants; 2 = Not including occasional inhabitants.

Note: Some figures above are likely to underestimate the true extent of diversity for countries where faunal knowledge is still incomplete e.g. Vietnam.

Bats in Limestone Karst

Data from Vietnam indicates that limestone karst sites areas harbour greater bat diversity than non-limestone sites.

Site Name	Latitude (˚ N)	Area (Km ^{2})	Altitude – Range (m a.s.l.)	Recorded Species
Hoang Lien Son	22	246	380 – 3,143	17
Na Hang	**22**	**275**	**300 – 1,067**	**39**
Cuc Phuong	**20**	**222**	**50 – 648**	**≈ 42**
Pu Hoat	19	679	100 – 2,452	24
Pu Mat	**18**	**934**	**100 – 1,841**	**39**
Huong Son	18	440	60 – 1,200	25
Vu Quang	18	559	30 – 2,286	19
Phong Nha – Ke Bang	**17**	**413**	**150 – 400**	**32**
Kon Ka Kinh	14	417	570 – 1,748	14
Kon Cha Rang	14	159	800 – 1,452	17

Note: As few sites in Vietnam have been systematically surveyed, differences in species totals are probably also partially a product of differences in survey effort carried out at these sites.

Bats and Limestone Karst

- Similarly, limestone karst ecosystems also provide crucial habitat for many globally threatened and rare bat species in Vietnam.

  The majority of localities known for globally threatened bat species (*Hipposideros turpis*, *Rhinolophus paradoxylophus, Myotis longipes*) found in the country are limestone sites.

- However, attempts to evaluate the relative importance of sites in Indochina for bat conservation are constrained by limited knowledge about the biogeography and status of bats within the region.

- In terms of seasonal movements of bats within the area, almost nothing in known.

- On a larger scale, currently very little is also known about the ecology, roosting and habitat requirements of the majority of bat species that occur in SE Asia.

Family Vespertilionidae, *Myotis formosus*

Ecosystem maintenance – Services Provided

Megachiroptera: Old world Fruit Bats (Flying foxes)

- Bats have shared a long evolutionary relationship with angiosperms (flowering plants with enclosed seeds) –

  Angiosperms are thought to have achieved worldwide dominance over the gymnosperms around 90 million years; Fruit Bats have been in existence for at least 35 million years.

- In the tropics and sub-tropics, Fruit Bats are now known to play an important role in the development and structuring of vegetation communities through **pollination**.

- This relationship has led to the development of recognisable characteristics in flowers of plant species heavily dependent upon bats.

- Typical characteristics of bat-pollinated flowers include:

  - The flowers are positioned away from the plant to allow easy access
  - They are large, commonly dull coloured, and produce lots of pollen and nectar
  - They open at night and are strongly scented

Ecosystem maintenance – Services Provided

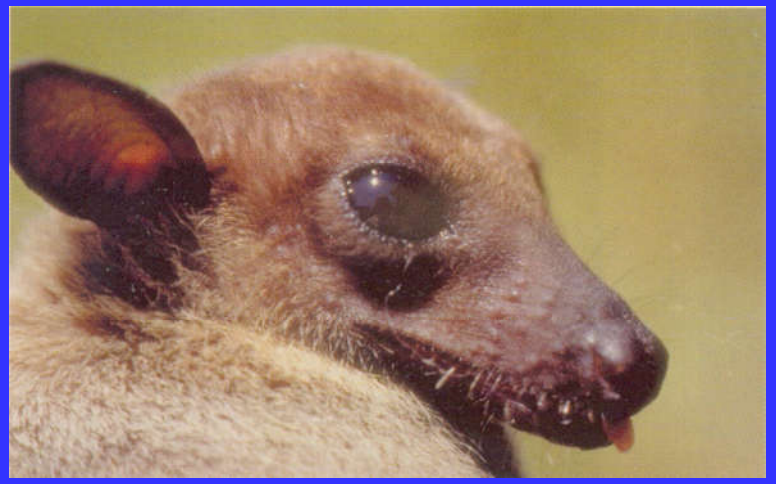
Megachiroptera: Old world Fruit Bats (Flying foxes)

A good example of a highly bat-dependent group of species displaying these characteristics is *Sonneratia* species. *Sonneratia* species form a major component of mangrove ecosystems in SE Asia and Australia. Species in the genus have showy, nocturnal flowers and are primarily pollinated by three species *Eonycteris spelaea*, *Macroglossus minimus* and *Cynopterus brachyotis*.

As a result, these species help to maintain a vegetation type that plays an important role in coastal stabilisation and local economies as a breeding ground for fisheries and production of timber and fuel wood.

Cynopterus brachyotis

Macroglossus minimus



Eonycteris spelaea

Ecosystem maintenance – Services Provided

Megachiroptera: Old world Fruit Bats (Flying foxes)

Seed Dispersal

- Fruit Bats are also known to play a vital role in the maintenance of species-rich forests throughout the tropics through **seed dispersal**.

- Seed dispersal by bats offers three immediate advantages to a plant:

  1. It allows seeds and seedlings to escape from natural enemies such as invertebrate and vertebrate seed-eaters, herbivores and fungal pathogens.

  2. It reduces the competition seedlings would experience if they germinated at high densities around the parent plant.

  3. Dispersal by creatures as mobile as bats, allows the plant species a better opportunity to colonise new habitats.

- Independent tests carried out in Africa and south America have also shown that some seed species actually have higher germination and survival rates in the wild after passing through the guts of bat.

Ecosystem maintenance – Services Provided

Megachiroptera: Old world Fruit Bats (Flying foxes)

Seed Dispersal

- In certain ecosystems, Fruit-bats represent the major vertebrate pollinators and seed dispersers e.g. on many islands in the Indo-Pacific Ocean. In these circumstances, bats assume the role normally occupied by flower-visiting sunbirds, hummingbirds and sugar-gliders and by fruit-eating birds, monkeys and rodents elsewhere in the tropics.

  The importance of the role performed by bats in these ecosystems is such that bats are considered ‘keystone species’. Researchers believe that decline or loss of these would have catastrophic impacts on the forests of these islands. For many tree species, reproduction and seed dispersal would simply cease.

- Throughout SE Asia, Bats also play a key role in the re-colonisation and reforestation of cleared areas. This is due to the ability of many species to carry seeds long distances.

- Some researchers believe that the importance of the role played by bats in this is increased by the relative reluctance of many other seed-dispersing mammals to forage in open areas e.g. rodents.

Ecosystem maintenance – Services Provided

Megachiroptera: Old world Fruit Bats (Flying foxes)

Seed Dispersal

- An indication of the potential of a single fruit bat for seed dispersal is given by Seba's Short-tailed Fruit Bat (Phyllostomatidae: *Carollia perspicillata*). Long terms studies on the species have shown that as many as 60,000 seeds may be eaten by a single bat in one evening.

  The quantity will depend on the fruit eaten, but is believed to average in the **tens of thousands**. Even if each bat consumed an average of only 1,000 seeds nightly, a single colony of 400 bats would disperse 146 millions seeds annually.

  For a variety of reasons many of these seeds will fail. However, even if only 10% of seeds were to successfully germinate, **146,000 new seedlings** would result each year from the seed rain produced by the colony.

Ecosystem maintenance – Services Provided

Megachiroptera: Old world Fruit Bats (Flying foxes)

Seed Dispersal

- All these facts serve to show that, from a plants perspective, fruit bats are very beneficial allies indeed. Apart from their work in pollination, they can consume enormous amounts of seeds and disperse these long distances across the landscape. On top of this, it appears that at least some seeds enjoy a better chance of survival as a result of travelling through the bats gut.

- Aside from their obvious ecological value, studies have also shown that these services possess significant economic importance. One of the very few studies on the subject so far identified at least 163 highly bat-dependent plant species yielding over 450 products used by humans.

  These include species such wild banana (Musa spp.), Durian (*D. zibethanus*), Kapok (*C. pentandra*), Petai (*Parkia speciosa* & *P. javanica*) and Duku (*L. domesticum*).

  Given that the annual revenues generated by these plant species alone exceed well over one hundred million dollars within the region, clearly flying foxes are mammals of economic importance.

Ecosystem maintenance - Other Important Services

Micro-chiropteran Bats and Insect Consumption

- Bats are recognised as primary consumers of nocturnal insects, some of which are detrimental to humans e.g. mosquito.
- In certain parts of the world, their major importance as a predator of agricultural pests has now been very clearly demonstrated.
- For example, studies on the Mexican Free-tailed Bat *Tadarida brasiliensis* at Bracken Cave in Texas have shown that the species is of regional importance to agriculture in northern America because it controls populations of corn earworm moths.

  Corn earworm moths are the number one agricultural pest in the USA in terms of damage caused.
- Intriguingly, the same studies have proven that the bats will ascend over a kilometre in altitude to feed on the migrating insects.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Ecosystem maintenance - Other Important Services

Micro-chiropteran Bats and Insect Consumption

The SE-Asian equivalent of *T. brasiliensis* is the **Asian Wrinkle-lipped Bat *Tadarida plicata***, which occurs in Indochina, the Philippines and Indonesia.

Similar to *T. brasiliensis*, *T. plicata* is renowned for forming large colonies. One example of this is the limestone caves near Ratburi, where the bat colony is estimated to number **three million bats**.

One Asian Wrinkle-lipped Bat will consume 7 grams of insects nightly, equating to 20 tons a night for the colony as a whole or some **7,300 tons** of insects eaten a year.

Threats to bat conservation in limestone karst ecosystems

Some considerations:

- Ironically, the very sites that are especially important for bat populations - caves in limestone karst - are also the sites where bats are at their most vulnerable.
- Bats are known to undertake seasonal movements – and these can lead to their concentrating at a small number of sites at certain times of the year.
- Bats have low reproductive potential; the vast majority of species in SE Asia may only give birth to one or two offspring a year.

Direct Persecution

Domestic consumption

Regional trade

Targeted eradication programmes

Indirect Threats

Use of caves as campsites or storage facilities.

Disturbance related to harvesting operations (mining, swiftlet-nests and guano).

Inappropriate site management (tourism related cave alterations, excess visitors).

Loss of roosting and foraging habitat.

Tropical storms.

Considerations for Bat Conservation in Limestone Karst Ecosystems

What do we need to know?

- Distribution of caves i.e. A basic cave register.
- Cave Status = Condition of in-cave environment.
  = Ecological context i.e. surrounding environment
- Species Composition and Abundance.
- Seasonal variations in use.

Put together, this data provides a basis for:

- Identifying representative networks of key sites for the bat fauna of an area.
- Prioritising areas for conservation management and on-the-ground protection activities.
- Identifying appropriate sites for educational and other purposes.
- Developing site management plans that recognise seasonal movements and changes in the bat fauna.

Thank You!

Artibeus jamaicensis