ACTION
TAYAM-PEH

SAVING THE NICOBAR FLYING FOX

the bp conservation programme

Technical Report for BPCP follow-up grant
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Ecology and conservation of the endemic Nicobar flying fox (*Pteropus faunulus*) in the Nicobar group of islands, India

Bandana Aul
Field Assistants: Saw Ivan, Martin Ton, Emanuel and Samuel

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Summary

Action Tayam-peh is a community based conservation project in the Nicobar Group of Islands which aimed to determine the ecology and threats to the Nicobar flying fox (*Pteropus faunulus)*, an endemic species of flying fox restricted to the North and Central Nicobar Group of Islands. In a survey funded by BPCP in 2003, the Nicobar Flying fox was rediscovered after almost a century. They survey also confirmed that the species was locally extinct in its type locality (Car Nicobar Island).

As a follow to the survey, eleven individuals of *P. faunulus* were radio collared to determine foraging ranges and for locating the day roost in the Central Nicobars. Foraging range size, calculated from 50% Utilization Density Kernels, ranged from 31.63ha to 1,602.03ha. Males (n=6) appeared to use smaller, more contiguous areas (range: 31.63-643.69ha) than the two females (416.19ha and 1602.03ha). Roost sites were distinct from foraging areas, separated by a maximum distance of 12.35km (mean: 7.05km; min: 2.11km). Day roosts of *Pteropus faunulus* were located for the first time during this study and approximately 25 fruit trees were recorded in its diet. *P. faunulus* is a solitary roosting species and selects roosts well camouflaged in the canopy. Day roosts may not be permanent (two males shifted roosts during the study) and foraging areas might shift according to fruit availability and season. The dietary habits and niche overlap of the three species of fruit bats found in the Central Nicobar Group (*P. melanotus*, *P. faunulus* and *Cynpoterus brachyotis*) was examined via direct observation in the foraging areas as well as through interviews with bat hunters. Seasonally occurring fruits were preferred by the two flying fox species to more easily available perennial fruiting species like *Ficus* as against the *C. brachyotis* which foraged on all the available fruits in a season. Of the 37 species of fruits used a 21% overlap was observed among the three fruit bats. Roost location, fruit colour preference along with vertical and temporal foraging distinctly separated the two *Pteropus* spp from the *Cynopterus*. The two *Pteropus* spp revealed much stronger dietary overlap (76% shared species) and *P. faunulus* favoured gaps and trees at lower heights while *P. melanotus* favoured the canopy and heights.

Direct threat due to hunting and habitat loss and indirect threat due to poor legislative measures and human intrusion in cave for nest collection attributed to the declining populations of bats in the islands. Most of the hunting of fruit bats is carried out in the foraging sites and few in the day roosts. Hunting of other fauna was also recorded most of which are schedule I species. Education programmes in the local language were carried out in 11 villages in the Central Nicobar Islands in three islands (Nancowrie, Kamorta and Katchal Islands). Target groups included hunters and villagers living close to the roost sites. The education programmes addressed the need to minimise hunting and disturbance to the bats in the area.

1. Introduction

1.1 General introduction

Bats are important members of tropical ecosystems, and in South East Asia comprise of one-third of the mammalian fauna (Cranbrook 1987). The genus *Pteropus* lives mainly on islands (Cheke and Dahl 1981; Banack 1998). Large flying foxes (Megachiroptera, Pteropodidae; forearm length > 110 mm) are a group of species particularly worthy of conservation attention. Old world fruit bats eat the fruit, nectar or flowers, and occasionally on leaves with a small amount of insects (Fujita and Tuttle 1991; Marshall 1983; Dumount 2003). More than 300 plant species from 59 families, and these plants rely on the bats for seed dispersal and pollination (Fujita and Tuttle 1991). Frugivores rely on fruits to supply all or part of their nutritional requirements, so in addition to a variety of external fruit characters such as colour, size, and phenology, the nutritional quality of fruits taken is essential for them (Thomas 1984; Hall and Richards 2000). The natural diet of most species of *Pteropus* is poorly known, although the reverse is true of their utilization of commercially grown fruits (Richards 1990). When selecting food resources, plant visiting bats make at least four choices: (1) the kind of plant foods that are available; (2) how much of each food type is available, (3) where the food is located and (4) how long the food is available (Elangovan et al. 2000). Fruits of many tropical plants are patchily distributed in space and time (Fleming 1982) and few studies have examined how and when plant-visiting bats exploit these resources. In part, this also reflects the difficulty of directly observing behaviour of free ranging bats as they forage (Law 1992; Banack 1998). They perform important ecological functions that contribute to forest maintenance and renewal, through pollination and seed dispersal (Rainey et al. 1995). Their large size, colonial roosting habits, and large foraging areas make them susceptible to hunting and habitat degradation, which are leading causes of their decline (Mickleburgh et al. 1992; Mildenstein 2002). In fact, large flying foxes are one of the most threatened subgroups of bats, particularly in Southeast Asia (Mildenstein 2002).

Their role in forest development, and typically large foraging areas, means that conservation efforts aimed at flying foxes can benefit both the forests and the creatures inhabiting them. The relatively strong interactive role of flying foxes in the forest ecosystem has made them attractive for conservation research; megachiropterans are thought to be a relatively important species group to forest regeneration processes, due to their role in pollination and seed dispersal (Rainey et al. 1995). Dietary studies of threatened tropical species can provide information helpful for conservation and management purposes as (1) what animals eat is important. Foraging habitat is one of the most fundamental limiting resources for wildlife, including bats (Findley 1993). (2) Wildlife managers can manage plant communities, rather than the wildlife that ultimately depends upon the vegetation because of the relative stability of plant communities. (3) Flying fox home ranges can cover hundreds of square kilometres of area, and thus large megachiropterans can serve as "umbrella" species, in the sense of species whose home range encompasses the home ranges of many other species sharing the same general habitat (Liat 1966; Marshall 1983; McWilliam 1985-86; Pierson and Rainey 1992; Suter et al. 2002). Lastly, (4) given the social nature of the conservation effort, large megachiropterans can fill the role of "charismatic megafauna", or "flagship" species, due to their size, conspicuousness, and interesting appearance and habits. Habitat fragmentation deserves special attention as a potential cause of the decrease of biodiversity in tropical forests (Myers 1988; Janzen 1994; Laurence and Bierregaurd 1997) and studies conducted on species playing crucial roles in ecosystems functioning are particularly useful because any change in their diversity or abundance may cause ecological dysfunction and subsequently result in a cascade of secondary extinctions inside fragments (Cosson et al. 1999).

Bats are particularly important in oceanic islands where they are often the only flying animals big enough to transport larger seeds. Fruit bats have been shown to be the sole pollinator and seed disperser of the silk cotton tree (*Ceiba pentandra*) on the island of Samoa in the south Pacific (Elmqvist et al. 1992). Fruit and nectar feeding bats play a pivotal role in the ecology of the rain forests where they live, sharing the role of seed dispersal and pollination with birds and insects.

1.2 Global scenario

About 25% mammals and 11% bird species are currently threatened with extinction (IUCN 1996). An understanding of the impact of extinction processes on different species is vital for ensuring that viable populations of native species can be conserved and maintained. Comparative studies of birds and mammals species have suggested that conservation attention should be focused on large species that reproduce slowly and that are restricted to small geographical areas. However the importance of these biological characteristics for predicting species extinction risk may be dependent on type of environmental disturbances prevalent in the area (Jones et al. 2002).

Of the 58 species and numerous subspecies in the Pteropus genus five are thought to be extinct, *Pteropus brunneus* and *P. tokudae* having become Extinct (EX) within the last 50 years. Hunting bats for food has long been practiced in most of the areas where fruit bats and man coexist. They can be found for sale, alive or dead, on markets in Indonesia and Malaysia where they are eaten by the Chinese and Manadonese communities. Some communities believe eating fruit bats can cure such diverse ailments as asthma, kidney complaints and even tiredness (Fujita and Tuttle 1991), but in most places they are simply seen as good eating. The market for fruit bats (*Pteropus* spp. and *Acerodon* spp.) for sale on islands like the Commonwealth of North Mariana Islands (CNMI), Guam and Saipan, where they are eaten as a luxury food item, has boomed over the last 3 decades, placing great pressure on the populations of bats on those and neighbouring Pacific islands. Bat populations have been hit hardest on the islands of Palau, Chuuk and Pohnpei, which have become the main exporters of fruit bats in the region (Pierson and Rainey 1992; Wiles 1992). A number of case studies have proved that flying foxes all over the world are threatened with extinction due to habitat loss and hunting pressure. This impact is especially prominent on islands. The Mariana's fruit bat (*Pteropus marianas*) was reported to be in serious danger of extinction if its population decline was not halted. This arose due to the demand for personal consumption and commercial exploitation by market hunters. They are a delicacy with the native Chamorro cultures (Lemke 1986). These bats are native to the Mariana Islands and today <500 individuals have been reported. These bats are presently under strict protection laws. The Philippine fruit bats, *Pteropus vampyrus* and *Acerodon jubatus* are faced with the same plight today most of which are essential to the forest as pollinators and dispersers. They were also victims of habitat loss due to an increase in population. Although the case studies provided here present a very bleak picture, the need for conservation of these "winged keepers of the forest" has not been ignored and a number of conservation efforts have provided a silver lining for these species, to name a few – Action Comoros, Save the Roddy Project have been quite successful in their attempts. Since no information exists on the diet of flying foxes in the Nicobar Group of Islands, the present study was conceived to gather basic information on the flying foxes in the Nicobar Islands. Being the pioneer attempt to gather information of the flying foxes in the islands, this study does not attempt to comprehensively characterize the diet of the two sympatric species in the field work restricted to a year. However, it is intended to provide detailed information of at least some of the food plants and a description of the potential day roosts of the Nicobar flying fox, a firm basis for initial conservation action. Locally extinct from its type locality the Nicobar Flying Fox was the focus in the present study to initiate a community based conservation programme in its narrow geographical range.

1.3 **Regional Scenario**

Legal protection of bats in India has long been ignored. The Fruit bats with the exception of *Latidens salimalii* are still listed in the Schedule V of the Wildlife (Protection) Act, 1972, classifying them as vermin. This is irrespective of the fact that some species are endemic to either mainland India or to the Andaman and Nicobar Islands. Such is the plight of the Nicobar flying fox, listed under Schedule V and as vulnerable (VU) in IUCN. Very little is known on the ecology of this species. Being restrictive in distribution these species might become extinct if current trends of hunting and habitat loss continue in the islands. The previous study (Aul & Vijayakumar 2003, Aul 2006) elucidates the inadequacies in the current protected area network for the conservation of bats assemblages in the islands. Only three islands Battimalv, Tillangchong and Megapode islands are wildlife sanctuaries and one (Great Nicobar) is a biosphere reserve, with two national parks. None of these protected areas encompass the range of Nicobar flying fox. All the larger Islands in the Central Nicobar and North Nicobar remain unprotected (Pande et al. 1991).The patterns of species distribution and endemism have not been taken into account while designing the current protected areas. The proportion of habitat loss is greater on North Nicobar and Central Nicobar; with an average of 45% and 21% of the natural forest cover loss over the past few decades (Sankaran 1998). Furthermore the Andaman and Nicobar protection of Aboriginal Tribes Regulation (1956) deters government officials from taking strong decisions that would endanger their own positions in case of any repercussions. Thus, it is important that a local community based conservation initiative backed by an intensive ecological research on the Nicobar flying fox, to help conserve this only endemic species of flying fox in India and to develop a feeling of ownership so that the success of survival of the species will be insured even after the research team leaves the study area.

The present study opened avenues for addressing questions rising due to the diseases due to the consumption of bat meat. This could be a deterrent for the locals who eat this species. Cox et al. (2003) and Banack (2003) have discussed the biomagnifications of cyanobacterial neurotoxins and neurodegenerative disease among the Chamorro people of Guam. These ethnic groups boil the bats (*Pteropus* sp) in coconut cream and eat them whole, including the wing membranes and brain. They were reported to die of amyotrophic lateral sclerosis/ Parkinson-dementia complex (ALS-PDC), a neurodegenerative disease similar to amyotrophic lateral sclerosis, Parkinson's disease and Alzheimer's disease. This was related to the consumption of cycads by fruit bats in the area. The presence of cycads in the Nicobar may lead to similar effects in the people who eat Nicobar flying fox, though this needs to be investigated.

1.4 Studies in the past

Much of the existing information on bats were derived from general faunal explorations, especially birds, in the past (Abdulali 1976a) and from sporadic listing of bats primarily in the Andaman group of islands (Abdulali 1976a, b; Das 1998; Deb 1998). Some of the major studies were by Miller (1902) who listed 12 species of bats including other small mammals including the first description of the endemic Nicobar flying fox. Hill (1967) listed 25 species of bats collected by Humayun Abdulali, from the Andaman and Nicobar Islands. Rao (1992) reported the Andaman horseshoe bat (*Rhinolophus cognatus*), an endemic species in the Andaman Islands and the Nicobar bat (*Pteropus faunulus).* Rao et al. (1994) reported the presence of *Pteropus melanotus* and *P. giganteus* foraging at dusk in North Reef Island and an insectivorous bat, *Rhinolophus* sp. Das (1998 and 1999a) reported three species of which two were insectivorous bats and a frugivorous species from Mount Harriet National Park and seven species of bats from the Rani Jhansi Marine National Park in the Ritchie's Archipelago, two of which were new records to the islands *(Rhinolophus reflugens and Hipposideros cinerus).* The past sporadic studies give a presence/absence indication of the species only in specific island and clearly indicate that there were no efforts to determine the status, distribution and conservation priority of any of the species present in the islands. The taxonomic identity of these species needs to be verified as no method was described and reports claimed of sighting *P. melanotus* and *P. giganteus* foraging at dusk on North Reef Island (Rao et al. 1994). The exact distributional data for many species is also ambiguous and no exact locations were provided for a number of species recorded.

1.5 Studies undertaken by the team

The first phase of the survey on the bats of Andaman Islands was conducted in 2002- 2003 and resulted in the identification of 17 species of bats and the discovery of an un-described bat species, on which taxonomic work is in progress (Aul 2002). Phase II of the work was to survey the Nicobar Group of islands for determining the bat fauna in the islands (BPCP bronze award) and this was successful in identification of 12 species of bats (Aul and Vijayakumar 2003; Aul 2006). The survey of both the island groups was clearly indicative that lack of information of each faunal group, including bats was adding on to the decline in the species populations in the islands. A total of 3 new records and 1 new species was the outcome of the survey apart for identifying > 300 day-roosts of the species in the Andaman and Nicobar Islands (Aul 2002; Aul and Vijayakumar 2003; Aul 2006). Phase III of the study was to study the diet and roost characteristics of *Pteropus faunulus* (Nicobar Flying fox) and identify the threats to the species in the islands and the aim was to involve the local communities in the conservation of the Nicobar Flying fox (BPCP follow up project). Our team facilitated the present project which integrated scientific research, education and community participation for the conservation of the Nicobar Flying fox. The effort was to "educate the causal agents: The Nicobarese" rather than providing short-term solutions.

1.6 Fruit bats in the Central Nicobar Group of Islands

In the Nicobar Group of Islands, the frugivores (Chiroptera: Pteropodidae) are represented by *Pteropus melanotus*, *P. faunulus*, *Cynopterus sphinx* and *C. brachyotis* (Aul 2002; Aul and Vijayakumar 2003; Aul 2006). P. vampyrus though reported to be a seasonal migrant to the Nicobar Islands (Hill 1967) was not recorded in the survey by our team. *Pteropus melanotus* and *P. faunulus* are the largest bat species in the Nicobar Group. *C. sphinx* occurs in the South and North Nicobar group of islands while *C. brachyotis* is present in the Central Nicobar group of islands. Little is known about their movements within the islands and no information exists on their diet and roost characteristics. Study on the movement within the islands will provide important understanding of spatial and temporal patterns of habitat use and possible gene flow, and thus enhance the conservation efforts for island species. *P. faunulus* is an endemic species of flying fox geographically limited to the North and Central Nicobar Islands only. In the Central Nicobar Group (Map 2), the pteropodids are represented by *P. melanotus*, *P. faunulus* and *Cynopterus P. melanotus* is the largest fruit bat with an average fore arm of (165.5±8.03 mm) followed by the *P. faunulus* (118.5±11.5 mm) and *C. brachyotis* with a fore arm of (73.25 mm). *P. melanotus* and *P. faunulus* are sympatric species occurring in the same geographical area. We have collected information on the diet of the three fruit bats in the Central Nicobars to access if there is any dietary overlap between the species. If there is an overlap how do the species maintain a distinct niche in the islands? Secondly, we have attempted to answer the probable reason for a small geographical range of the *P. faunulus*. Thirdly, the lack of any past information on the day roosts or population of the *P. faunulus* as well as the *P. melanotus*, radio telemetry was used to track 7 individuals of *P. faunulus* to their day roost. The damage caused by tsunami has resulted in the destruction of the mangrove habitats in the Nicobar group, whether the destruction of the mangrove resulted in loss of prior day roosts is uncertain.

Pteropus faunulus is the only endemic fruit bat in the Nicobar Group of Islands and is restricted geographically to a group of six islands in the Central Nicobars (Aul & Vijayakumar 2003; Aul 2006). It is listed under the Appendix II of the CITES and has been assigned VU (Vulnerable) status in the IUCN assessment (Ballie and Groombridge, 1996). *Pteropus faunulus* was described in for the first time in 1902 from Car Nicobar, the northernmost Island in the Nicobars (Miller 1902) and after almost a century was rediscovered during the survey conducted in 2003 (Aul & Vijayakumar 2003; Aul 2006). During the past survey in the year 2003-2004 the team was unable to locate the species in its type locality (Car Nicobar) and its absence in Car Nicobar suggested a local extinction. Car Nicobar is also the worst affected island in the Nicobar Group of Islands primarily due to the current developmental activities and large-scale habitat alterations (ANI Census report, 2001). Even in other Islands of the Central Nicobar group less than 10 individuals were sighted over a period of 10 months of extensive survey 8 of which were hunted and 2 were pets. The population of this fruit bat appears to have declined in its entire range according to secondary sources. Habitat loss, hunting and agricultural/urban disturbance are the most serious and common threats to *P. faunulus*. The increasing human population is rapidly decreasing the available habitat, as the native forest is cleared for agriculture and trees are felled for timber and firewood. In most Islands, the low land evergreen forests have already been converted to coconut and areca nut plantations. Tsunami has resulted in the disturbance of the species in the islands by causing large scale destruction of the coastal habitats and settlements. The immigration of the coastal settlements further inland has resulted in the clearing of prime forest land for settlements and thus increasing the pressure of habitat loss of the species.

1.7 The stakeholders

The Nicobarese make up for the largest indigenous group in the archipelago Numbering around 30,000 (ANI Census report, 2001), the Nicobarese have their origins in the Austro-Asiatic cultural complex with sometimes strong, and sometimes subtle inter-island variations in cultural expressions as well as dialect.

The Nicobarese at present represent an economic portfolio that combines subsistent activities (such as fishing, hunting and gathering) with that of a market based economy mainly in the export of copra (dehydrated coconuts) in exchange for rice, sugar, cloth, fossil fuels and other products. The Indian welfare and development programmes and efforts to mainstream the Nicobarese have had inevitable consequences on the ecology of the islands.

The advent of air guns from Port Blair and mainland India provided a quicker and more efficient way to hunt birds and bats. In contrast to the traditional way of hunting using crossbows where the hunt was limited, the presence of air-guns has triggered an increasing trend to shoot bats and birds. Most of the hunting is carried out at the foraging sites and few in the roosting areas. The seasons of the fruiting of the silk cotton tree and a number of preferred fruit trees by bats coincides with the reproductive time of the fruit bats.

The hunters shoot down these bats and adopt the orphaned babies. To prevent the bat from flying away the forearm bone is removed and the wings are clipped in some instances (Aul and Vijayakumar 2003). The belief that its meat is a cure for asthma encourages hunting in the islands. Even the bones and other part like wings find place in the traditional medicine use. The concept of the trade of these flying foxes is not prevalent in the islands yet. There is no legal protection for the fruit bats as they are listed in schedule IV of the Indian Wildlife (Protection) Act, 1972, classifying them as vermin. The Nicobarese are also currently exempted from the Indian Wildlife (Protection) Act, 1972.

2. Study Area

2.1 Andaman and Nicobar Islands

The Andaman and Nicobar Islands (06° 45' N to 13° 41'N and 92° 12' E to 93° 57' E) sprawl in a crescent from south off the Myanmar coast to near Sumatra (Map 1). Politically most of the islands are a part of the Republic of India, with a few northern islands are administered by Myanmar. Biogeographically the islands have been divided into two major divisions, the Andaman archipelago consisting of more than 500 islands and islets and Nicobar archipelago consisting of around 23 islands (Rodgers and Panwar 1988). The Andaman Islands are considered to be extensions of the Arakan Yomas range, a southward trending branch of the eastern Himalayas that merges in the north with the ranges in north-eastern India, forming a complex of sub parallel north-north-east trending ridges. The same ridge rises 135 km south of the Ayeyarwadi ridge in the Bay of Bengal. The Nicobar group is the continuation of the Mentaweri Islands to the south and south west of Sumatra (Rodolf 1969; Das 1999b).

The Andaman and Nicobar Islands exhibit a diversity of forest types, each with its own distinctive floral components (Champin and Seth 1968). Some of the larger islands display a veritable mosaic of forest types. The tropical forest ecosystems continuously recycle water. Since most islands have very few perennial rivers and streams, inland wetlands are restricted. Small ponds are formed by rainwater accumulating inside the forest. Mangroves are found in both the island groups but are more extensive in the Andaman group. The mangrove cover in the Andaman Islands is approximately 929 km^2 and about 37 km^2 in the Nicobar Islands (Anon 1986; ANI FD 1999).

Grasslands are a unique feature in only few islands in the Nicobar Islands. They occur as patches on low hillsides, interrupted in some places by pristine forest patches, on the islands of Car Nicobar, Chowra, Bompuka, Tressa, Trinket, Kamorta and Nancowrie. These islands make up the Northern and Central Nicobar group of islands with the exception of Katchal and Tillangchong in the central Nicobar, which lacks grassland habitats.

These islands contain some of the last remaining pristine rainforest habitats, with unique assemblage of flora and fauna distinct from the mainland (Rodgers and Panwar 1988). The islands, along with northeast India, form the western boundary of the Indo-Burma biodiversity hotspot (Myers et al. 2000). The mammalian fauna of the Andaman and Nicobar Islands comprises of a rich assemblage, of rodents and bats (Miller 1902; Hill 1967; Saha 1980; Pande et al. 1991). Endemism is high among many groups of vertebrates including mammals, birds, amphibians, reptiles and invertebrate such as earthworms, arachnids, molluscs and termites (Rao and DebRoy 1985). Very little information exists on the ecology and distribution of most faunal groups (Rodgers and Panwar 1988).

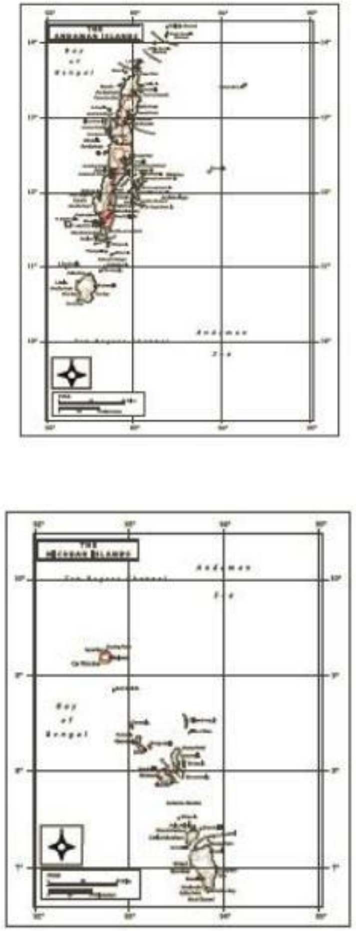
Biodiversity loss is an important conservation issue facing the scientific community over recent years. Greater portion of the earth's biodiversity is restricted to the "biodiversity hotspots", a network of eco-regions of extreme diversity and endemism (Myers et al.

2000). But unfortunately these regions are also centres of high human population density, making them highly prone to species extinction (Cincitta et al. 2000). This problem is acute in the tropical islands of the world, where the species extinction due to anthropogenic activities is forecasted to be relatively high (Vitousek 1988; Fritts and Roda 1998). Although only five percent the earth's surface is covered with Islands, they contribute a greater percentage to the earth's biodiversity (Simberloff 1974). The Andaman and Nicobar Islands of the Indian region is no exception, they contain some of the last remaining pristine rainforest habitats, with unique assemblage of flora and fauna distinct from the mainland (Rodgers and Panwar 1988). Increasing human population, habitat conversion, deforestation, exotic species introduction and other development activities are causing a great threat to the faunal and floral diversity of these Islands (Nair 1989; Saldanha 1989; Sankaran 1995).

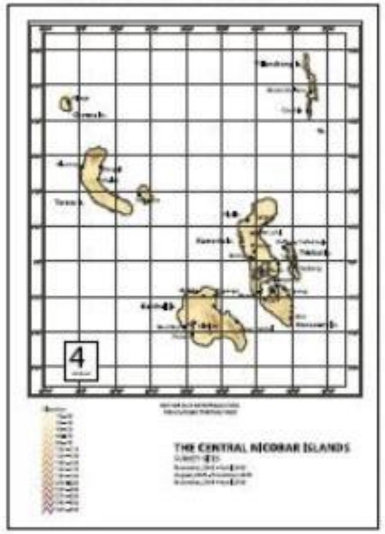
The Andaman and Nicobar Islands are rich in terms of biodiversity. Large mammals are absent in both Andaman and Nicobar Islands (Rodgers and Panwar 1988). Geographic isolation of these islands has resulted in high degree of endemism. Endemism is more pronounced in land animals. Out of 55 terrestrial and 7 marine mammal species reported so far, 32 species are endemic. Common mammals found here are Andaman wild pig *(Sus scrofa andamanensis),* Crab eating macaque *(Macaca fascicularis umbrosa),* Andaman masked palm civet *(Paguma larvata tytlerii),* Dugong *(Dugong dugon),* Dolphin *(Delphinus delphis),* Whale *(Balenoptera musculus),* Spotted deer *(Axis axis),* Andaman spiny shrew *(Crocidura andamanensis),* Nicobar tree shrew *(Tupaia nicobarica nicobarica),* Nicobar Flying fox (*Pteropus faunulus*), Andaman horseshoe *bat (Rhinolophus cognatus)* and Lesser short nosed bat *(Cynopterus brachyotis brachysoma).* Very little information exists on the ecology and distribution of most faunal groups (Rodgers and Panwar 1989), including the bats, the taxonomic group for the study. Baseline information for most bat species of Andaman and Nicobar Islands is virtually nonexistent and the information on the species distributional patterns and ecological requirements would be of great theoretical interest besides being crucial for management and design of protected areas in the islands (Das 1997, 1999b).

2.2 Central Nicobar Group of Islands

The Central Nicobar Islands comprise of Nancowrie, Kamorta, Trinket, Katchal, Tressa, Bompuka and Chowra Islands (Map 2). The present study was conducted in Nancowrie, Kamorta and Trinket islands, in the Central Nicobar Group. Kamorta Island (188.2 sq. km) is the largest island among the three islands chosen for the study (Nancowrie: 66.9 sq. km; Trinket: 36.3 sq. km). Trinket Island has been vacated after tsunami as it has been declared as unsuitable for inhabitation by the Andaman and Nicobar Administration. The habitat in the three islands is similar and is dominated by grasslands, evergreen forests interspaced with coconut and areca nut plantations.



Map 1: The Andaman and Nicobar Islands



Map 2: The Central Nicobar Group of Islands

2.2.1 Habitat description

Although, the islands themselves are not very large in terms of area, they are marked by high levels of habitat diversity. The major habitat types observed in these islands are: (i) Mangrove forests, (ii) Littoral forests, (iii) Evergreen forests and (iv) Grasslands. Each of these habitat types is unique in floristic composition and community structure. A brief description of each and their occurrence and distribution in the Central Nicobar Islands is given below. These descriptions have been sourced from unpublished data .

2.2.1.1 Mangrove forests

The mangrove forest of these islands is dominated by different species of *Rhizophora* sp, *Bruguerea gymnorrhiza, Sonneratia caesolaris* and *Nypa fruticans.* Extensive tracts of mangrove forest dominated by *Rhizophora apiculata and R. mucronata* are observed on the west coast of Kamorta Island namely in Bandar Khadi, Derring Harbour and select area of Nancowrie harbour close to Champin and Hitui Villages and Trinket Bay in Trinket. All the creeks running in to the mangroves are bordered by *Nypa fruticans* and *Pandanus leram andamanesium* swamps.

1 Description of habitats has been mentioned in Champion and Seth (1968) but detailed information on vegetation have not been carried out in the Central Nicobar Islands. Suresh Babu, provided the preliminary inputs for habitats in the Central Nicobars.

The tall mangrove trees and *N. fruticans* serve as excellent perches for waders and also as potential roosts for *Pteropus melanotus*. Much of this habitat has been lost due to tsunami, and therefore is now a drastically modified habitat with only a few surviving trees.

2.2.1.2 Littoral forest

The littoral forest formation in the Central Nicobars is dominated by *Terminalia bialata, T. catappa, Syzigium javanicum, Thespesia populnea, Dillenia pentagyna, Barringtonia asiatica,* and *Ficus benjamina*. These forests are usually found in low elevation and flat areas along the coast. The largest patches of these were located in Nancowrie bay, Kamorta east coast and on Trinket Island. Tsunami has damaged these forest and lone few survivors were seen in select areas in Nancowrie and Kamorta.

2.2.1.3 Evergreen forests

The evergreen forests in the Central Nicobars have very high tree species diversity (richness in Kamorta 82 per ha and 108 per ha) which is a remarkable feature considering the size of The evergreen forest patches bordering the grasslands are typically stunted and are markedly taller in the gentle slopes and valleys.

In the evergreen forest tracts the commonly encountered species are *Myristica andmanica*, *Knema andamanica*, *Sandoricum koetjape*, *Chisocheton* sp., *Bentinckia nicobarica*, *Barringtonia racemosa, Fagrea* spp and *Ficus* spp.

2 Pers. comm. Suresh.

Most of the fruits consumed by the frugivores in the Central Nicobar Islands were recorded within the evergreen forests and the canopy heights varied from 5 m to 30 m and fruit colour from green to yellow to red to purple in some of the fruit bearing species. An abundance of lianas, canes and climbers constituted the lower strata in these forests.

2.2.1.4 Grasslands

The grasslands of Central Nicobars form a unique habitat with annual and perennial grass species forming climax vegetation. Commonly observed grasses include *Themeda* spp, *Heteropogon contortus* and *Chrysopogon* spp. These grasslands are scattered with stands of *Pandanus odoratissmus* and *Bentinckia nicobarica*.

The described habitat is common throughout the Central and Northern Nicobar Islands with a few exceptions like Katchal and Tillangchong Islands which do not support the grassland type vegetation and the topography of these islands is undulating as compared to the flat topography of the rest of the Nicobar group which has a relatively flat topography. Katchal and Tillangchong islands are hilly and bear more resemblance with the southern group of islands.

Tillangchong however did not support mangrove creeks prior to tsunami though it supported large areas of *Nypa fruticans* swamps. These were potential roosting sites for *Pteropus melanotus*. Amongst all the Islands in the Central and Northern Nicobar group (Map 2), Tressa Islands has the largest grassland habitat and the least in Chowra Island. Trinket Island as compared to the other islands in the group supported stunted vegetation and most of the forest was extracted with the economically important and useful trees extracted for construction activities in the settlements. Nancowrie, Chowra and Car Nicobar Islands have practically no primary evergreen forests and the same have been converted to plantations. Some pristine patches of evergreen forest are still present in small areas in Kamorta (north: New Laful area); Katchal (West Bay and Southern areas);

Bompuka (mostly all); Tressa (Central, Kalasi, Minuk area). Habitat shrinkage due to loss in tsunami as well as unsustainable forest clearing for the new settlements is on the rise.

2.2.2 Climate

The wet season in the Central Nicobar Islands extends from April to mid October with the dry season also receiving rains intermittently. Cyclones were also observed in February and April with little damage to some places in Kamorta. The seasonal variation in the Nicobars based on observation as well as local information is depicted in Table 1.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry	■	■	■	■								■
Light showers				■	■				■	■	■	■
Heavy rains					■	■	■	■	■			

Table 1: Weather conditions in the Central Nicobar Islands

3. Materials and Methods

Field investigations were conducted in three phases. . Phase I (October 2005- February 2006) was to identify the foraging areas and prepare a check list of fruits consumed by *P. faunulus* and *P. melanotus* in the islands. Phase II (January 2006 - March 2006) was to estimate foraging range size for *P. faunulus*. A total of 11 individuals belonging to *P. faunulus* were radio collared and released at the point of capture. Phase III was to identify the threats prevalent to the bat fauna with emphasis on the flying foxes in the islands. Key members were identified from different villages and hunters were encouraged to join the team for education campaigns and surveys. Phase III went along with Phase I and II and information was gathered collectively regarding the diet and threats to the flying foxes in the islands. We relied on local information, natural history characteristics and visual and telemetric observation of collared *Pteropus faunulus* individuals to estimate behaviour, foraging range and reaction to the radio tags.

3.1 Phase I: Determining foraging area and fruits in the diet of the *Pteropus* spp

Two main methods were used in the determination of foraging areas and for preparing a checklist of the fruits consumed by the *Pteropus* spp on Kamorta, Nancowrie and Trinket Islands. (1) *Foraging areas* – Extensive surveys of the islands of Kamorta, Trinket and Nancowrie was conducted to prepare a checklist of the fruits available in the forest that had a probability of being consumed by bats. The observations were made of the fruits available, colour of the fruit, taste, odour and accessibility of the fruit. Visual observations in the night of fruiting trees were made to determine the bat species utilizing the resource available. Confirmation of fruits consumed by *P. faunulus* resulted in permanently tagging the trees with engraved aluminium tags as a reference point for setting mist nets for capturing individuals for radio telemetry studies. The codes were in number following the initials PF i.e. a *P. faunulus* tree. Repeated observations were made in the same area to rule of the possibility of a fruit being consumed only on a chance basis and to check for consistency.

Observation were made by four individuals in teams of two each equipped with flashlights and binoculars (Bushnell 10X40). *Pteropus* spp were distinguished from each other by the pelage colour of the head and back. The difference in pelage patterning and colouration is the easiest diagnostic field characteristic available to distinguish the two species. The number of individuals of *P. melanotus* and *P. faunulus*, height (m) of foraging, time of arrival at the feeding site (h) and behaviour with other individuals was recorded. The number of bats feeding at the same time were recorded only by a single individual from each team placed in separate area to avoid an over counting of number of individuals. (2) *Bat hunter interviews* - Local information and interviews with bat hunters were conducted in 11 different villages in 3 islands and 4 follow up interviews with one key informant from different villages was conducted.

The purpose of the interview was also to collect information on the dietary components as well as any known roosts of the flying foxes, the frequency with which bat meat appeared in the diet, any medicinal use of the species and preference of hunters between the two sympatric species. The interview followed an informal discussion about the bat species in the area, during which the hunters information was evaluated based on photographs of each species and descriptions. The interviews were evaluated for their degree of certainty based upon the distinction made between each species, the clarity and depth of their information by the informant. The interviews and discussions were critical in determining key people and target groups in the area as well as identifying the threats to the Flying foxes in the islands.

3.2 Phase II: Radio collaring studies and foraging range estimations

P. melanotus and *P. faunulus* were sampled using mist nets with mesh size 25 mm set up at the foraging sites in Kamorta Island. Morphometric details: weight (g), sex, forearm length (mm), wingspan length (m) and the details of the metacarpal measurements were recorded for the two flying foxes. Age class (adult or sub adult) was based on the degree of closure of ephiphyseal growth plates of the phalanges (Kunz et al. 1996). Each bat was fitted with necklace bands and a number code unique for each individual. All the individuals were also given a unique colour code *P. melanotus* was fitted with a yellow colour ring in the necklace band while the *P. faunulus* was fitted with a white colour ring in the necklace. A total of 25 individuals of *Pteropus* spp were were sampled and given necklace bands, 7 of which were *P. melanotus* and 18 were *P. faunulus*. Eleven individuals' *P. faunulus* (9 males and 2 females) were fitted with radio transmitters.

The transmitters used were not equipped with activity sensors and would function even if the animal was stationary. At the time radio transmitters were fixed no female was recorded to be either lactating or pregnant. Transmitters were fit around the neck of the animal using two methods (1) two individuals were attached with wire bands and (2) nine individuals were attached with crochet thread. This was to ensure the wearing of the collar in time and also to minimize the damage that might be caused by wire bands.

All collars had a weak link designed to wear off with time. Collars weighed 3.25 g (Type PD -2C), had a battery life of 12 weeks (Holohill Systems Ltd, Canada). We monitored the output with a TRX 2000 receiver (Wildlife Materials Ltd, Illinois USA) and 3-element Yagi antennas (Wildlife Materials, Carbondale, Illinois). The body weights of the individuals ranged from 110 g to 220 g, and the weight of the transmitter package represented from 2.8 to 1.4% of the animals weight. This was well within the recommendation of 5% of the body mass for small michrochiropterans weighing less than 100 g (Aldridge Brigham 1988). Bats fitted with radio transmitters were released in 2 days from the day of the capture at the point of

Plate 1: Morphological differences between the two *Pteropus* spp

capture and were intensively monitored from the following night. To ensure re-hydration of captives, bats were offered 15% honey solution and were fed on fruits consumed by it in the wild in case of prolonged captivity. The release of the transmitter fitted bats was not done on the date of capture itself to ensure that the collar was comfortable on the individual and it did not make an attempt to destroy it.

Receivers were moved as necessary to track the individual and sometimes to improve reception or to record multiple bearings on a stationary bat. Bearings were taken by a hand held geographic positioning system (Garmin, 12 channel GPS unit). Many positions were initially determined by triangulation when a bat was stationary long enough for bearings to be sighted from two or more points. The exact positions were recorded from single bearings along which distance was estimated from signal strength and gain (Law and Lean 1999; Winkelmann et al. 2000). Bearings were taken when we were <120 m to <2m from the transmitter. On most of the nights the radio collared bats were monitored between 1800 and 0200 h.

Because *P. faunulus* did not spend much time in flight in the foraging area and continued feeding on the same tree for more than 3-4 h and because all the radio-collared individuals foraged in the same foraging area it was possible to monitor more than 1 individual in the same area. The observer switched the frequencies on the receiver to record presence of any other radio-collared individual in the same area while tracking the radio collared bats in the island.

At the maximum 2-3 bats were monitored in a single night. With the exception of FREQ 017 ♂ and FREQ 082 ♂, loss of radio contact with the collared bats was rare. In case of disruption of radio contact with a moving bat, contact was re-established by walking towards the bearing of disappearance or from an elevated point close to the same.

Only on locating the species to a particular point, such as a fruiting tree was taken as positive fix. The time of exit was the time the individual took flight and headed off to its day roost at the end of its foraging bout. The individual was followed till the signal grew faint and was no longer received. This point was used to ascertain the direction the individual was headed in and day searches for the day roost commenced from this point. Two days were allocated to each individual to ascertain which direction it exited and the same direction was used as the starting point for the search of day roost.

3.2.1 Data Analysis

Various probability density estimation methods can be used to measure the home range of both individuals and populations of a species: in this study, estimates of foraging ranges were made by drawing 50%, 75% and 95% utilization density kernels from positive fixes obtained for each individual using the Animal Movement Extension to ArcView3.2 (Hooge and Eichenlaub 2000). The Kernel Utilization Density method is used based on a non-parametric statistical procedure to calculate the probabilities of an animal being at various locations in space at a particular time. We used a Non-metric Multidimensional Scaling procedure (McCune and Mefford 1999) to explore gradients along which the three species separate themselves.

3.3 Phase III: Identification of threat to the bat fauna in the islands and awareness campaigns

Direct observation in field and Bat hunter interviews identified the threats to the flying foxes in the islands as well as to the other fauna in the Nicobar Group. Two main target groups were identified with which our team worked closely. Group I included the “hunters” in the Nicobar Islands. The hunters in the Nicobars are the local community members who hunt the fruit bats for meat. The hunting communities were critical as they have the most extensive information on the location of day roost of flying foxes as well as caves in the islands.

The second group was the village heads and communities who are the authorities and it was critical that they be sensitized about the wildlife problems in the Islands. The village heads were crucial in implementing a no hunting season in their villages. We organized education programmes in the villages in the Central Nicobar Islands with emphasis on the importance of the fruit bats in the islands as well as the other fauna in the islands. These programmes were imparted using slide shows, some games and talks in local language. Youth were encouraged to give talks to their villages after they were trained by us and this was extremely successful in increasing the local participation.

4. Ecological studies on the fruit bats

4.1 Identification of foraging areas

Foraging areas of the *Pteropus* spp and *Cynopterus brachyotis* were recorded in a number of sites on Kamorta and Nancowrie Islands (Table 2). Trinket Island was not used as a foraging area by the two flying foxes during the survey months. In the past survey in 2003 (pre tsunami), *P. melanotus* and *P. faunulus* had been observed to forage at Trinket. *Cynopterus brachyotis* was observed to forage and roost on Trinket Island (n=5) apart from using Kamorta and Nancowrie Islands. The survey resulted in the identification of more than 30 species of fruit available in the forests (Appendix I). The *Pteropus* spp fed on 24 species of fruits and the nectar of *Ceiba pentandra*.

Seasonally occurring fruits were preferred by *P. melanotus* and *P. faunulus* to the more easily available perennial fruiting species like *Ficus* sp whereas; *C. brachyotis* foraged on all the available fruits in a season. Of the 37 species of trees exploited, a 21% overlap was observed in fruits (and nectar) foraged on among the three bats, but roost type and location, fruit colour preferred and vertical and temporal foraging distinctly separated the two *Pteropus* spp from the *Cynopterus*. The two *Pteropus* spp revealed much stronger dietary overlap (76% shared species) but *P. faunulus* appeared to favour gaps and trees at lower heights than *P. melanotus*.

Island	Locality*	Species	Month
Kamorta	Kamorta jetty	P. melanotus, P. faunulus, C. brachyotis	November-March
	New Laful	P. melanotus, P. faunulus, C. brachyotis	April-June
	Munack	P. melanotus, P. faunulus, C. brachyotis	May-June /March-April
	Bada Enak	P. melanotus, P. faunulus, C. brachyotis	Jan-March
	Pilpillo	P. melanotus, P. faunulus, C. brachyotis	April-May
Nancowrie	Champin	P. melanotus, P. faunulus, C. brachyotis	December-Feb
	Hitui	P. melanotus, P. faunulus, C. brachyotis	December-Feb
	Tapong	P. melanotus, P. faunulus, C. brachyotis	June-July
Trinket	Tapiyang	Cynopterus brachyotis	June-July
	Trinket	Cynopterus brachyotis	November-Feb

Table 2: Foraging sites of Megachiropterans on Kamorta, Nancowrie and Trinket Islands

* see Map 2

4.2 Radio-telemetry studies of the Nicobar flying fox

A total of 18 *P. faunulus* individuals were netted, tagged and released during the study, but no recaptures were noted during the three months of radio collaring and trapping in foraging area. Only 8 of the 11 individuals collared (Table 3) could be tracked through the study period - one individual (M3) was hunted (the team retrieved the tag from a house in Chota Enak, Kamorta Island); another (M1) never returned to the area (it is possible that the latter was either hunted or moved away from the island) and only three fixes were obtained for one individual (M9), preventing use of these three bats in further analysis. The eight remaining individuals showed normal behaviour in comparison to non-collared individuals, and were observed to return to their foraging grounds (the point of capture) and forage with the individuals that were present in the foraging area but not tagged. Details and codes of the radio collared individuals are provided in Table 3.

3 Hunting was observed to be at its peak during this time as the trees being utilized by the individuals were clustered around villages where local inhabitants used air guns to hunt the two flying foxes. The presence of the team in these areas served as a deterrent to the hunting community but it cannot be confidently stated that the species will be at lesser risk once the team is away from field especially in the villages close to southern part of Kamorta.

Code	Freq (mHz)	Sex and No.	Date of release	# Positive fixes	Remarks
Y24	17	M1	06.01.06	0	Lost after release
Y32	41	M2	08.01.06	41	Successfully tracked
Y30	82	M3	08.01.06	0	Hunted, tag retrieved
Y31	104	M4	08.01.06	38	Successfully tracked
Y25	127	M5	12.01.06	33	Successfully tracked
Y27	148	F1	18.01.06	10	Successfully tracked
Y34	165	M6	18.01.06	21	Successfully tracked
Y33	187	M7	16.01.06	22	Successfully tracked
Y35	205	M8	25.01.06	22	Successfully tracked
Y37	226	F2	30.01.06	18	Successfully tracked
Y38	245	M9	30.01.06	2	Successfully tracked

Table 3: Details of radio-collared *Pteropus faunulus* collared at Kamorta Island

4.2.1 Day roost characteristics and foraging ranges of *P. faunulus*

Day roosts of *Pteropus faunulus* were located for the first time during this study using radio telemetry. Day tracking was successful in locating 7 of the tagged bats to their day roosts (5 males and 2 females). Collared individuals did not roost in clusters or groups but were found individually and confirmed the hypothesis of these bats to be living solitarily. The seven day roosts were distributed along the western side of the island and in Pulo (Bunder khari) and Daring Harbours just behind the mangrove creeks and on the eastern coast of Kakana Bay and New Laful Coast on Kamorta Island itself (see Fig. 3 and 4).

Unlike other flying foxes, *Pteropus faunulus* is a solitary rooster selecting roosts among well camouflaged trees in the canopy. Foraging range size (Fig 1 and Fig 2), calculated from 50% Utilization Density Kernels, ranged from 31.63 ha to 1,602.03 ha. Males (n = 6) appeared to use smaller, more contiguous areas (range: 31.63-643.69 ha) than the two females (416.19 ha and 1602.03 ha). Roost sites were distinct from foraging areas, separated by a maximum distance of 12.35 km (mean: 7.05 km; min: 2.11 km). Males appear to roost closer to foraging areas (range: 2.11 to 12.35 km; mean: 6.20 km; median: 5.92 km) than females (7.49 and 10.82 km; mean: 9.16 km).

Individuals left their day roots for foraging after sunset (1745-1800 h), taking

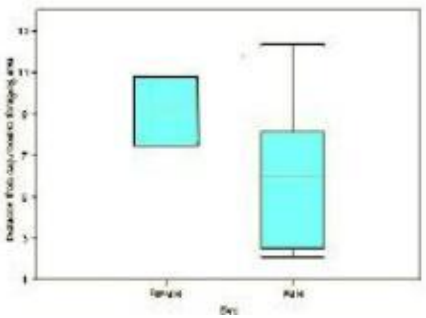


Fig 1: Box-plot of sex-based differences observed in daily shifts between day roost and centre of 50% utilization density kernels for seven radio-collared individuals (2 females)

a short, hovering flight over the roost tree before heading straight towards the foraging area, returning only during early morning hours (0345-0400 h). On resurveying the day roosts during the second month (after 60 days) two previously located day roosts of M2 and M4 were found relocated. Though the sample is biased heavily in favour of males, there is evidence of significant sex-based differences in the distance travelled between day roost locations and the centre of foraging activity, with the two females tending to move further than the males (see Fig.3). After the foraging time, the individuals would fly in a straight path towards their roosts.

Physiognomically, roost sites appeared to be similar: individuals roosted high up in well camouflaged canopy layer trees, often with dry leaves between foliage that reduced spotting probability from the ground (field assistants climbed up neighbouring trees to confirm the specific tree the individual was roosting in). On one occasion an individual (M2) that was roosting in a *Calamus* sp took flight as soon as it was detected to a higher tree 15m away from the first sighting. The species moves very silently through the forest and its flight cannot be detected by sound of the wings as *P. melanotus*.

Proximity to the villages did not appear to overtly affect selection of day roost sites: three individuals (M2, M7 and F2) roosted at sites within 1-2 km of habitation.

Collared individuals were observed to move between foraging and day roosts daily, maintaining day roosts sites throughout the radio tracking season. Only two individuals (M2 and M4) abandoned their day roosts following the cessation of *Ceiba pentandra* flowering in mid-March and we could not locate their new roost sites (see Fig. 4).

Fig 2: Box-plots of sex-based differences in foraging range sizes estimated from (a) 50%,(b) 75% and (c) 95% utilization density kernels for eight radio collared individuals (n=2 females)

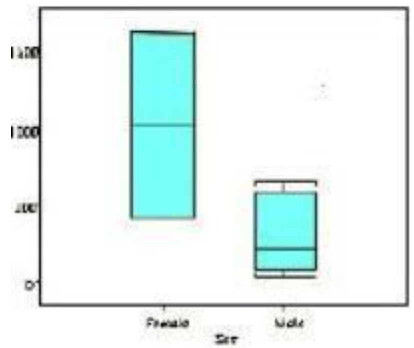


Fig 2 (a) 50% utilization density kernels

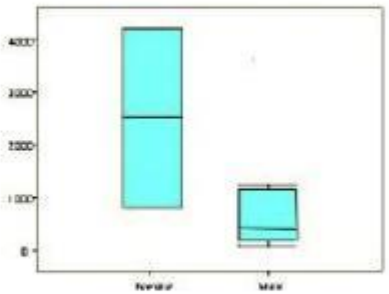


Fig. 2 (b) 75% utilization density kernels

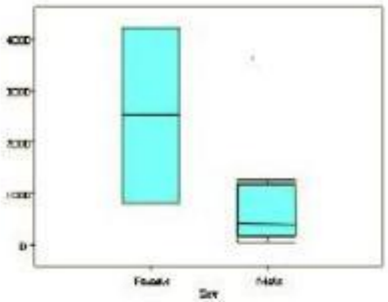


Fig. 2 (c) 95% utilization density kernels

Foraging ranges of the eight individuals were estimated from distributions of positive fixes obtained by telemetric tracking for each individual (see Fig. 3). Though the sample is biased heavily in favour of males (n = 6), use of the 50% utilization density kernels show some evidence for sex-based differencing in home range size, with males appearing to occupy smaller, more contiguous areas (range: 31.63-643.69ha) than the two females (416.19ha and 1602.03ha).

3 The sunset in the Andaman and Nicobar islands ranges from 1715 – 1730 h. It is pitch dark by 1730 – 1745 h.

Despite the marked separation between day roosts and foraging areas, the 50% kernel for all individuals was calculated at only 97.85 ha, concentrated towards the southern end of Kamorta, between the jetty area and the local veterinary hospital (Fig 3; Fig 4). The observed activity patterns are most likely related to the cluster of *Ceiba pentandra*, *Psidium guajava* and *Ficus* sp5, all of which were in fruit/ bloom in this area during the study interval. Between the end of February and mid-March a shift in flowering species (cessation of *Ceiba pentandra*, onset of *Ficus* sp, *Artocarpus lakoocha, Dillenia* sp*, Diospyros* sp) and spatial location of flowering (northwards) was observed and three individuals (M7; F1 and F2) were observed feeding on *Artocarpus lakoocha* , *Ficus* sp*, Diospyros* sp during this time, having shifted away from the southern part of the Island.

All collared individuals were trapped from this area. An asynchronous pattern of fruiting was observed for fruit trees on the three islands surveyed. For e.g. *Dillenia andamanica,* a preferred fruit of *Pteropus faunulus* with a strong peach smell starts fruiting in April and then again in November in an asynchronous pattern. Fruiting starts in March on north Kamorta, May on Trinket and October on Nancowrie. A similar cyclic pattern was observed in most of the other species. *Ficus* sp appeared in maximum diversity among the different family of plants in the diet of the flying foxes, occurring in low elevation forests, coastal patches, plantations, forest edges and elevated forests. These *Ficus* species were recorded to fruit throughout the year, and are possibly an important food source during crunch periods when seasonal fruiting ceases.

4.2.2 Feeding habits of *Pteropus faunulus*

A detailed list of plant species consumed by the Nicobar flying fox is provided (Table 4). Diet across collared individuals was not so varied and comprised of both native and planted fruits, with six of the individuals showing an apparent preference for planted species not native to the area, despite the occurrence of fruiting native species nearby.

Feeding bouts occurred from 1830 h to 0330 h and .. individuals feed on till dawn and were then observed to head straight for the day roost location. Within the foraging area, individuals selected specific trees on which repeated feeding bouts were observed. On some occasions (n=4) the individuals feed on a single tree for between 15 min and 2-3 h and then head to another feeding tree nearby or far removed from the tree it was first observed to feed on. Overlapping of both foraging areas and individual trees was observed but did not appear to cause any fights amongst individuals.

Radio collared as well as other individuals of *Pteropus faunulus* displayed mating behaviour during January and February. The individuals (M2; M5; M6; M7; M8 and F2) were observed to aggregate on *Casuarina* sp in the study area and a courtship display was observed which lasted for 60-90 min (n = 10) from 2000 to 2130 h. The flight of two bats resulted in chase and flight before settling back down on the tree, courtship lasting for 1-1.5 h. Flight between males and display was observed to be dominant during this time as well. After the courtship display the individuals returned to the foraging areas.

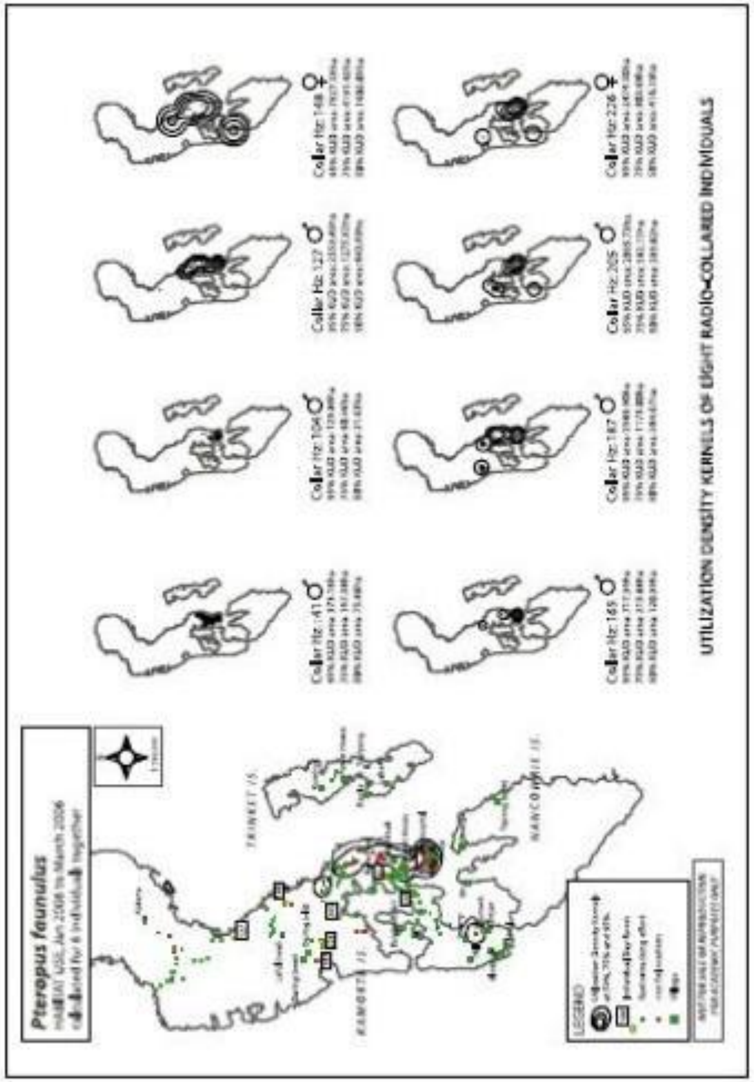


Fig 3: Foraging ranges of 8 ***Pteropus faunulus*** **individuals on Kamorta Island**

4 *Artocarpus lakoocha* was not found near settlements, and is a canopy layer tree, located within inland forest a little north of the Kamorta Jetty area.

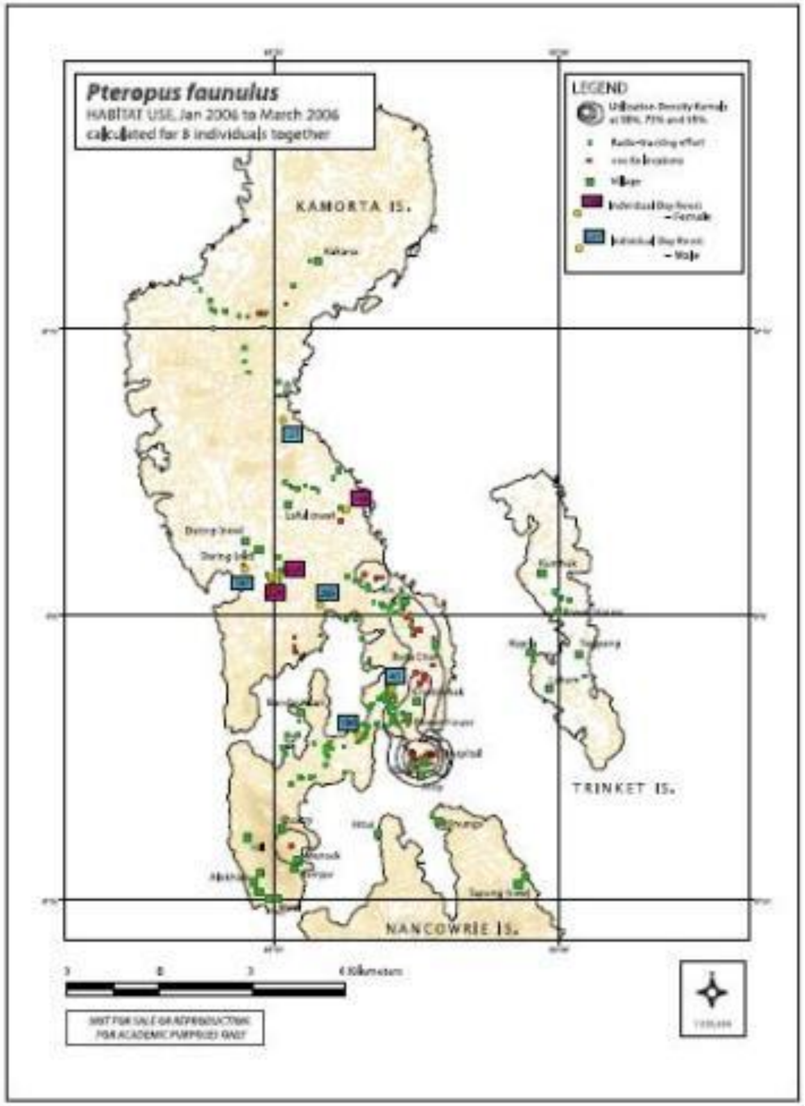


Fig 4: Estimated foraging range of the entire sample of eight collared individuals of *P.faunulus*

Species	Ht (m)	Location	Strata	Fruit colour	Re-	Vernacular name
Artocarpus lakoocha	30-40	Forest edges	Canopy	Green	Fruit	Lea
Bentinckia nicobarensis	15-20	Inforest, slopes	Gaps	Red	Fruit	Jungli supari
Bentinckia sp1	15-20	Inforest, slopes	Gaps	Red-Purple	Fruit	Huksuak/Jungli supari2
Buchnania sp	30-40	Forest edges	Canopy	Purple	Fruit	Kanap
Ceiba pentandra	30-40	Plantation	Canopy	White	Nectar	Didu
Dillenia andamanica	20-25	Forest edges	Gaps	Yellow	Fruit	Luinch
Diospyros sp	30-35	Inforest, elevated areas	Canopy	Green	Fruit	Hinlanch
Elaeocarpus macrocerus	30-35	Inforest, elevated areas	Canopy	Green	Fruit	Kumlang
Ficus sp4	15-20	Inforest, elevated areas	Middle	Red	Fruit	Pong
Ficus sp5	15-20	Forest edges	Canopy	Yellow	Fruit	Lanup
Ficus sp6	20-25	Forest edges	Canopy	Red	Fruit	Pong yaniaak
Ficus sp7	20-25	Forest-grassland edges	Canopy	Yellow	Fruit	Lanup (big tree)
Mangifera camptosperma	30-35	Inforest	Canopy	Yellow	Fruit	Flat mango
Myristica sp	20-25	Inforest, elevated areas	Gaps	Red	Fruit	Aukceya
P. leram andamanesium	5 to 10	Grassland	Middle	Red	Fruit	Big pandanus
Psidium guajava♦	5 to 10	Plantation	Middle	Green	Fruit	Planted guava
Semecarpus anacardium♦	5 to 10	Plantation	Middle		Fruit	
Magifera indica♦	20-25	Plantation	Canopy	Yellow	Fruit	Manga
Sando□ ic□ m koetjape	25-30	Inforest, elevated areas	Canopy	Yellow	Fruit	Khutta Phal
Syzigium sp2	25-30	Forest-grassland edges	Canopy	Purple	Fruit	Epoh
Syzigium sp3	25-30	Inforest	Canopy	Purple	Fruit	Epoh tahane
UID sp2	20-25	Inforest	Canopy	Green	Fruit	Amai
UID sp4	20-25	Inforest, elevated areas	Canopy	Green	Fruit	Taminion
UID sp5	25-30	Coastal forest	Canopy	Green	Fruit	Mitai/Coastal Badam
UID sp6	10 to 15	Inforest	Gaps	Purple	Fruit	Hihiluia/Kumpa

Table 4: Plant species consumed by *Pteropus faunulus* in Kamorta, Nancowrie and Trinket islands

♦planted species; UID: Un-identified species

4.2.3 Fruit preference of *Pteropus faunulus* during Jan 2006-April 2006

Radio tracking was conducted during the months of Jan 2006-April 2006 and the following species were fruiting during these three months. *Ceiba pentandra*, *Ficus* sp7, *Ficus* sp3, *Artocarpus lakoocha*, *Psidium guajava*, *Diospyros* sp were found during the radio tracking of *P. faunulus*. In January *C. pentandra* and *P. guajava* were in maximum abundance and by mid February *A. lakoocha* and *Ficus* sp 3 started to fruit. *Diospyros* sp fruiting was seen in April. Individuals were seen to forage in the same area (Fig. 3) and the territories overlapped (M2, M4, M6, M7 and M8) were tracked to use the same tree (*C. pentandra*) together. No interferences were seen in between individuals of the same species or between the two sympatric species of flying foxes for a common resource. Each individual used a separate flowering branch for feeding and returned to its daily during the tracking period till the cessation of the flowering and onset of the fruit of *C. pentandra*. *P. guajava* was also consumed more regularly by (M4, M6 and M8) and the individual would stay and feed on the fruit of *P. guajava* the whole night alternating it with a short foraging bout to *C. pentandra* tree and then returning to the same tree for feeding. M3 had been hunted and was tracked to a hunter's house in Kamorta. With the onset of *A. lakoocha* mid February a shift of some specie to the new fruit was seen (M2 and M5). *Diospyros* sp fruiting was ready by end March early April and a sole M5 was recorded in Munack, south east of Kamorta Jetty area (Fig. 4).

4.3 Niche separation among three species of fruit bats

Niche separation among the three fruit bats was broadly seen in three categories (1) separation in terms of roost sites, (2) separation by foraging time and habits and (3) separation by diet. In terms of roost sites the differences between the tree fruit bats was distinct with *P. melanotus* using roost in *Nypa fruticans* swamps in colonies ranging from 400-500 individuals while *P. faunulus* is a solitary species roosting well camouflaged in the canopy. *C. brachyotis* was observed to exploit the fronds of *Cocus nucifera* and live in a group of 5-6 individuals in a single roost. The foraging time of the three fruit bats was separated as *C. brachyotis* was the earliest (1745-1800 h) to reach a foraging site and continue (0200-0300 h) for a much longer time while *P. faunulus* arrived around 2000 h and continued till 0300-0400 h. *P. melanotus* was a late arriving (2300 h) at the feeding sites and left at 0400 h. There was very little difference between the two *Pteropus sp*ecies in terms of the diet as they fed on similar species at different height with *P. melanotus* feeding in the upper canopy level heights and *P. faunulus* exploiting the middle canopy level height and gaps. *C. brachyotis* was distinctly foraging in the lowest level among the three. Based on the date it was observed the *P. melanotus* preferred to forage in the inland forest as compared to the agro forests while *P. faunulus* was sent to select species not native to the islands (*Psidium guajava*, *Mangifera indica*) in the case where options of both native (*Artocarpus lakoocha*, *Ficus* sp) were also fruiting at the same time. *C. brachyotis* did not show any specific preferences to the location and could be termed as a generalist feeder.

4.3.1 Niche separation by roost site characteristics

The day roosts of the three fruit bats in the islands were distinct and showed a clear demarcation in the tree species selected for roosting on as well as habit. It was postulated before the start of the project that the two species of flying foxes roosted together in the same roost in the islands but field data collected proved otherwise. A distinction of niches was observed between the two sympatric flying fox species in the roosts used. *Cynopterus brachyotis* too was observed and the results are represented in Table 5. *P. melanotus* roosts in large colonies in mangrove trees deep inside the creek and in the evergreen forests on tall and robust trees. The prime habitat used as day roost were mangrove trees and *Ficus* sp in the Andaman Islands while in the Nicobars the day roosts were located in the mangrove trees as well as *Nypa fruticans*. A maximum of ca. 2000 and a minimum of 20-30 individuals were observed at a single roost. No day roosts were observed in the forest of the Nicobars except a rare sighting of a single individual in the evergreen forest of Kamorta Island. No other sighting of such roost was observed on the Island. This sighting was post tsunami in the month of February. Tsunami destroyed all of the potential roosts used by *P. melanotus* including those located in mangrove and on *Nypa* palms. Immediately after the tsunami (January 2005) ca. 10-15 individuals were observed to temporarily use the littoral forest of Kamorta Island, selecting to roost on *Casurina* sp. A re-survey of the same site in March 2005 showed that the roost had been abandoned.

A roost located on Tillangchong Island where *P. melanotus* was roosting on *Nypa fruticans* was destroyed by Tsunami. A subsequent survey in April 2006 survey showed that this roost had been re-established, probably because the *Nypa* palms are fast growing and were almost restored to normal in their original areas, unlike mangrove species which take more time to recover. The population of this roost (>500 individuals) was the largest I encountered post tsunami. None of the day roosts were located close to habitation. On Kamorta Island, *P. melanotus* pups were observed in December and February. On three occasions pups were found to have been dropped from roosts in three villages on Kamorta Island in February and March. (Changua village, Bada Enak and 8 km village). Pups appeared to be 3-4 months old and it is probable that the mating season was initiated during May or June at the onset of the monsoon. Day roosts of *Pteropus melanotus* located on Tillangchong Island had pups clinging to mothers in April. *P. faunulus* on the other hand roosts in the forests fringing the mangrove creeks and does not roost in large colonies. None of the attempts in the survey by me were successful in locating the day roost of this endemic flying fox in the islands. Radio collaring studies of the species was successful in locating the day roost of 6 individuals of the 11 individuals' radio collared. It usually roosts singly in the day and aggregates in the feeding areas for

5 Based on information obtained about the capture of the pup and estimation.

interaction and mating. The six individual roosts that were located were on Kamorta Island itself. The individuals roosted high up in the canopy and were well concealed when observed from the base of the tree. They appeared to prefer tall trees of about 20-30 m height. The dominant species that appeared in its roost were *Sandoricum koetjape, Fagrea racemosa and Buchnania* sp. Three of the six day roosts located was sited within 2 km of village settlements, while the others were at safer distances. The preference of the species appeared to roost in areas with a number of lianas, climbers and *Calamus* sp in the understory which prevented their easy detection from the ground. The trees the individual was roosting in were either canopy trees located in partial open canopies or gaps.

Cynopterus brachyotis has been well studied across mainland India, but no detailed information exists on its distribution in the Andaman and Nicobar Islands. The species was observed to roost in *Cocos* sp fronds and in the entrances to caves in the Andaman Islands, while in the Nicobar Islands it roosted within either *Cocus* sp or Areca nut fronds on trees located in plantations or in the forest, in groups of 4-5 individuals at each site. These were observed roosting under thatch roofs of houses. The proximity to human settlements did not have any impact on the location of the roosts of this species.

Species	Island	Type of roost	Numbers	Remarks
Pteropus melanotus	Kamorta	Foliage	150-300	Roosts in aggregations in the island. Commonly seen in the mangrove creeks and upper canopy trees throughout Andaman and Nicobar Islands
Pteropus faunulus	Kamorta	Foliage	1-2	Roosts solitarily during daytime, observed to camouflage well into the canopy in the day roost. Roosts located on the mangrove fringes towards the forests on Kamorta Island
Cyanopterus brachyotis	Kamorta	Foliage/thatch roofs	5-6	Roosts in small groups, seen to roost under coconut / areca nut leaf fronds and thatch leaves in houses throughout the Andaman and Nicobar Islands

Table 5: Roost characteristics of the fruit bats on Kamorta Island

4.3.2 Niche separation by foraging time and habits

C. brachyotis generally began feeding at dusk (1800 h) and carried on gregariously till dawn (0330 h) while *P. faunulus* started after dusk, peaking at between 2000 h and 2300 h and then again at ca. 0200 h while *P. melanotus* started at 2300 h and peaked at 0200 h. *C. brachyotis* rarely stayed for a long time in any one fruiting tree, hovered around near the fruit, bit off bits and flew to nearby feeding roosts. *P. faunulus* preferred to feed on fruits by staying at the fruiting tree itself. *P. melanotus* on the other hand would bite off pieces of the fruit, if larger, and fly to nearby feeding roosts and feed on the pieces. If the fruit was smaller, like fruits of the species *Syzigium* spp and *Ficus* spp the individual stayed on the fruiting tree and consumed the fruit there itself. The time for foraging of all the three species in the study area begun at different times but overlapped in between and then ended at separate times. The time of foraging varied for all the three species of fruit bats in the islands (Table 6).

4.3.3 Niche separation by diet

Interviews and visual observation in field confirmed the diet and seasonality of fruits appearing in the diet of the fruit bats in the islands in different months (Appendix. I). Local names have been provided and some species which remain unidentified are mentioned as such A total of 43 species of fruiting plants were encountered in the study area of which 37 species were used by the three species of fruit bats. Most fruits found in a particular season belong to the families Meliaceae, Anacardiaceae, Rubiaceae, Melastomataceae, Sapotaceae and Palmae. The number of plant species consumed by fruit bats is represented in Table 7.

Pteropus spp accounted for 27 of the species (71%) while *Cynopterus brachyotis* accounted for 18 species in its diet (47%). Among the 37 fruit trees recorded only 8 species (~21%) were observed to be consumed by all the three species of pteropodids these included *Ceiba pentandra*, *Mangifera camptosperma*, three *Ficus* spp, two *Syzigium* spp and *Semecarpus anacardium*. *P. melanotus* exclusively fed on two species and *P. faunulus* on another 6 species and *C. brachyotis* exclusively fed on 8 species of fruits not appearing in the diet of the Pteropodids. *P. melanotus* and *P. faunulus* jointly fed on 19 species of fruits not shared by *C. brachyotis*.

Hours →	18.00	19.00	20.00	21.00	22.00	23.00	24.00	01.00	02.0 □	0□.0 0	04.00	05.00
P. melanotus							□	□				
P. faunulus												
C. brachyotis												

Table 6: Foraging time of three species of fruit bats in Kamorta Island (n>20 observation nights)

Note: The shaded areas indicate the foraging activity

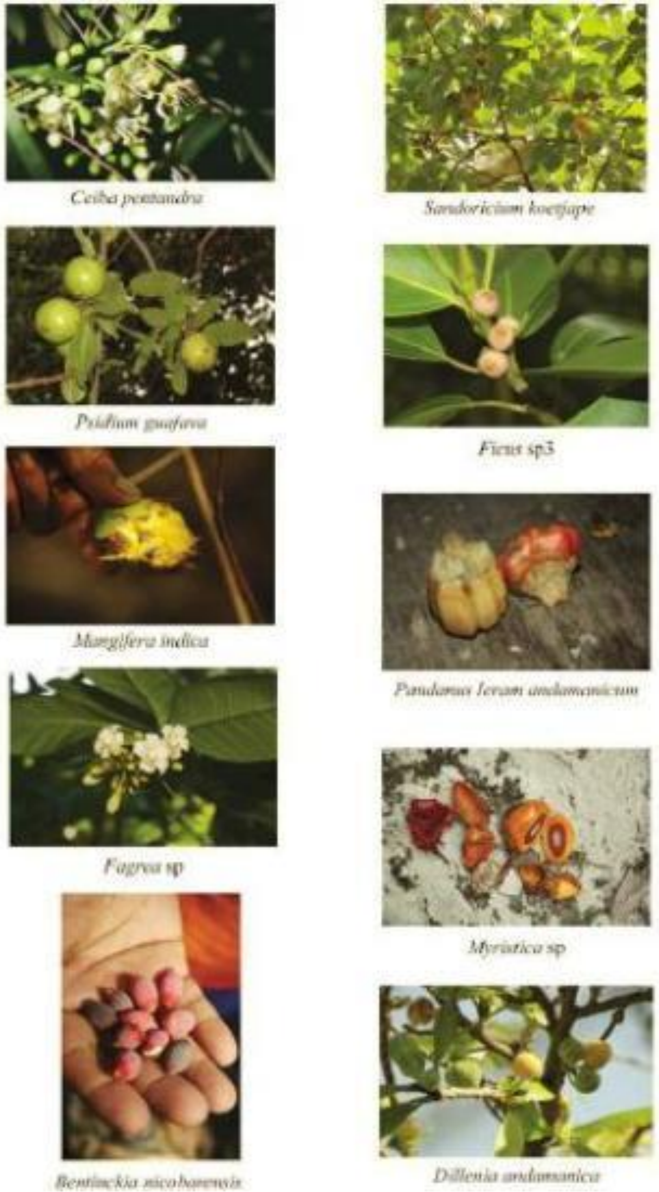


Plate 2(a): Pictorial representation of the diet of the fruit bats in the Central Nicobar Islands

Plate 2(b): Pictorial representation of the diet of the fruit bats in the Central Nicobar Islands

Only three species of planted fruits were found in the diet of the fruit bats in the study area; namely *Musa paradisiaca*, *Psidium guajava* and *Mangifera indica*. *M. paradisiac* was only consumed by *C. brachyotis* and *Psidium guajava* exclusively by *P. faunulus* while *M. indica* was shared by *P. melanotus* and *P. faunulus*. Most of the fruits consumed by the flying foxes were small, oval and pulpy, strongly aromatic and sweet tasting, *P. faunulus* however fed on Taminion (UID sp 4) which was sour tasting.

C. brachyotis is a generalist and voracious feeder, flying in and out of plantations and forested areas in search for fruit. A distinct click-click sound confirms its presence in the foraging areas. *Cynopterus brachyotis* is oblivious to which other species was feeding on the same fruit. The two sympatric species of flying foxes fed on the plant species and individuals which were (1) easily accessible; (2) greater than 15 m in height; (3) strongly aromatic; (4) sweet tasting and smooth textured.

Tree species used (n = 37), general height (seven ordinal categories: <5 m, 5-10 m, 10- 15 m, 15-20 m, 20-25 m, 25-30 m and >30 m) and occurrence within vertical strata (four ordinal categories: gaps, lower storey, middle storey and canopy), fruit colour (green, yellow, purple, red or white) and habitats they were located in (five categories: Inland forests, Plantations, Grasslands, Edges and Coastal-forests) were recorded and analyzed using a Non-metric Multi-dimensional scaling method (PC-ORD version 4.0; McCune and Mefford, 1999), resulting in a 2-dimensional solution that cumulatively accounted for 95.3% of the variance in the original tree bat use matrix (r2 Axis 1=0.221, r2 Axis 2=0.732). This result is presented in Fig 5. Axis 1 is interpreted as a weak gradient representing habitat strata (Kendall's r=-0.319, tau = 0.006) and separating the *P. melanotus* and *P. faunulus* based on *P. faunulus* more prevalent use of trees in canopy gaps. Axis 2 represents a strong gradient of tree height (Kendall's r = 0.622, tau = 0.494) and fruit colour along which the two *Pteropus* sp are separated from the *Cynopterus*.

Table 7: Tabulation of food items used by the three fruit eating bat species in the Central Nicobar Islands based on personal observation, interviews and radio collaring of *P. faunulus*

Plant species	P.m	P.f		Resource	Source of information	Degree of certainty	Vernacular name
Artocarpus lakoocha	X	x		Fruit	1,2	C	Lea/ Thompeing
Musa paradisiacal	-	-	x	Fruit	1,2	C	Hipu
Bentinckia nicobarensis	-	x	-	Fruit	1,2	UC	Jungli supari
Bentinckia sp1	-	x	-	Fruit	2	UC	Huksuak /Jungli supari
Buchnania sp	X	x	-	Fruit	1,2	C	Kanap
Calamus andamanicus	-	-	x	Fruit	1,2	UC	Moota beth
C. palustris	-	-	x	Fruit	1,2	C	Chotta beth
Ceiba pentandra	X	x	x	Nectar	1,2,3	C	Didu
Dillenia andamanica	X	x	-	Fruit	1,2	C	Luinch
Diospyros sp	X	x	-	Fruit	1,2	C	Hinlanch
Elaeocarpus macrocerus	-	x	-	Fruit	1,2	C	Kumlang
Fagrea sp	-	-	x	Flower/Fruit	1,2	C	Mallock
Ficus glomerata	-	-	x	Fruit	1,2	C	Ficus sp7
Ficus sp1	-	-	x	Fruit	1,2	C	Ficus sp1
Ficus sp2	-	-	x	Fruit	1,2	C	Ficus sp2
Ficus pendula	-	-	x	Fruit	1,2	C	Ficus sp3
Ficus sp4	X	x	-	Fruit	1,2,3	C	Pong
Ficus sp5	X	x	x	Fruit	1,2,3	C	Lanup
Ficus sp6	X	x	x	Fruit	1,2	C	Pong yaniaak
Ficus sp7	X	x	x	Fruit	1,2	C	Lanup (big tree)
Mangifera camptosperma	X	x	x	Fruit	2	UC	Flat mango
Myristica sp	-	x	-	Fruit	1,2	C	Aukceya
P. leram andamanicum	x	x	-	Fruit	2	UC	Big pandanus
Pandanus odoratissmus	x	-	-	Fruit	2	UC	Hikai
Psidium guajava	-	x	-	Fruit	1,2,3	C	Planted guava
Semecarpus anacardium	x	x	x	Fruit	2	UC	Planted cashew
Mangifera indica	x	x	-	Fruit	1,2	C	Manga
Sandoricum koetjape	x	x	-	Fruit	1,2	C	Khutta Phal
Semecarpus kurzii	-	-	x	Fruit	1,2	C	Jungli Kaju
Syzigium sp1	x	-	-	Fruit	1,2	C	Matmuang
Syzigium sp2	x	x	x	Fruit	1,2	UC	Epoh
Syzigium sp3	x	x	x	Fruit	1,2	UC	Epoh tahane
UID sp1	-	-	-	Fruit	1,2	C	Jipach
UID sp2	-	x	x	Fruit	2	UC	Amai
UID sp3	-	-	x	Fruit	1,2	C	Cynopterus b spp (trinket)
UID sp4	x	x	-	Fruit	1,2	C	Taminion
UID sp5	x	x	-	Fruit	2	UC	Mitai/Coastal Badam
UID sp6	x	x	-	Fruit	2	UC	Hihiluia/Kumpa

Note: 1 visual observation; 2: interviews and secondary information; 3: Radio collaring studies; C: reasonable certainty; UC: reasonable uncertainty; UID: Un-identified species; x denotes consumed or fed upon. P. m: *Pteropus melanotus*, P. f: *Pteropus faunulus*, C. b: *Cynopterus brachyotis*.

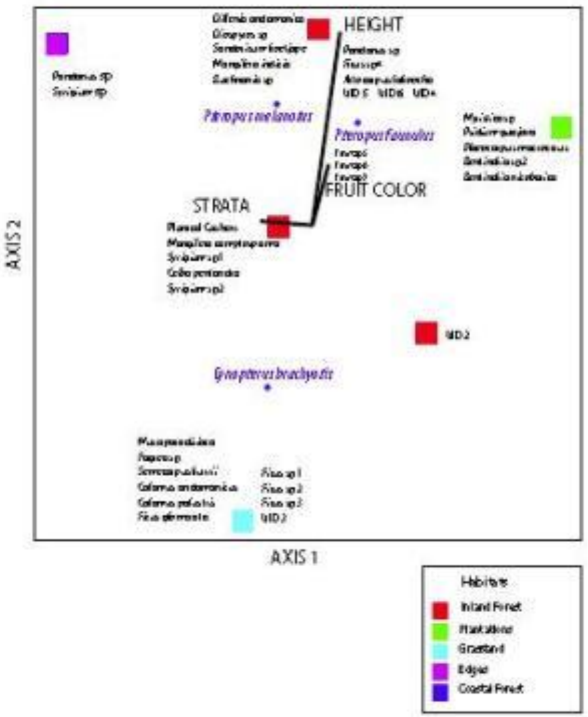


Fig 5: Fruit trees in bat ordinal space, grouped by habitat types

4.4 Fruit size and colour preference by the fruit bats

Fruit size did not appear to be a determining factor for a plant species to be a preferred food item for the flying foxes as a majority of the fruits consumed by the flying foxes range in size from 12.3 to 15.5mm in length , with the exception of the *Psidium guajava* which was about 40-45 mm in length. *Psidium guajava* is a planted species and is preferred by *P. faunulus* and *C. brachyotis* and not by *P. melanotus*. In terms of fruit colour, *C. brachyotis* appears to favour lighter coloured fruits than either of the two *Pteropus sp*, among which fruit choice is more evenly distributed by colour (see Fig 6).

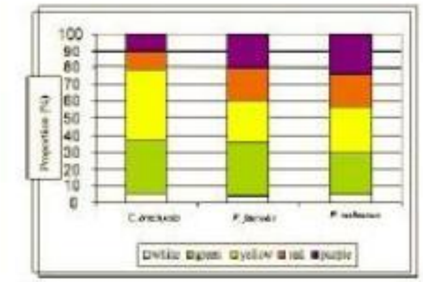


Fig 6: Proportion of fruits* of different colour in the diets of *P. melanotus*, *P. faunulus* **and** *C. brachyotis*

*Note: White refers to flowers of *Ceiba pentandra*, from which nectar is extracted by all three bats.

6 The unconsumed fruit was measured for determining its length by dial vernier callipers. This was an estimation of the size of the fruit consumed by fruit bats.

4.5 Vertical differentiation – height and strata used by the fruit bats

The pteropodids were not seen to feed on the species that constituted the middle strata of the forest and even if it was a species that occurred in the diet of the flying foxes: heights of fruiting trees appear to be a critical element in determining whether a tree is exploited. *Cynopterus* however seen to feed on the *Ficus* sp which were in the middle strata with a height of 10 m or less as well as on individuals which were not easily accessible.

Though there was an overlap in the species consumed by the two sympatric flying fox species, while feeding on the fruit species *Pteropus melanotus* fed on the same species in different areas and at different heights (> 20 m) while *P. faunulus* fed at a height between 15-20 m, *C. brachyotis* on the other hand fed at lower heights (Fig. 7 A and Fig. 7 B). *P faunulus* was also observed to use fruiting trees in canopy gaps more than *P. melanotus*.

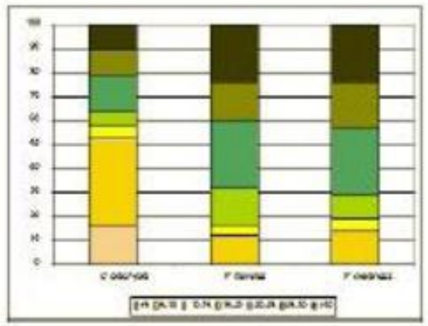


Fig 7: (A) Proportion of fruit trees foraged on by the three bats, categorized by height

C.b, *Cynopterus brachyotis*, P.f, *Pteropus faunulus*, P.m, *Pteropus melanotus*

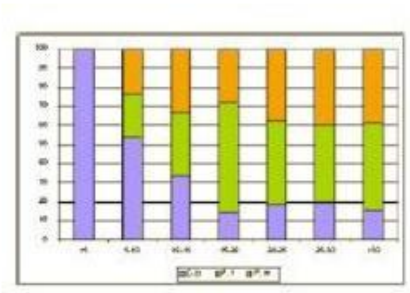


Fig 7: (B) Proportion of trees at different heights exploited by the three fruit bats

C.b, *Cynopterus brachyotis*, P.f, *Pteropus faunulus*, P.m, *Pteropus melanotus*

4.6 Discussion

Radio-tracking is an important, commonly used technique for research on bats. 17 studies published in the Journal of Mammalogy over the past decade applied radio collars to bats involving 338 individuals of 15 species, most of which were insectivorous bats (Neubaum et al. 2005). The American societies of Mammologists (1998) recommend that in such studies, the mass of radio transmitters should not exceed 5% of the body mass of the tagged bat. This recommendation is based on the findings of Aldridge and Brigham (1988).

A number of factors potentially influence variation in home-range size of individuals within a population. Each individual adjusts its use to best suit its own survival and reproductive strategies. By analyzing movement distances of all individuals in the population, evaluation of impact of individual responses on overall home range size can be determined (Getz et al. 2005). A number of studies on rodents to determine the effect of population density on home ranges concluded that population densities should have a negative influence on home range size (Gaines and Johnson 1982; Rodd and Boonstra 1984). In tropical forests, the home ranges of frugivorous and nectarivorous bats that roost singly or in groups of <20 individuals are usually smaller than 15 ha. This has been demonstrated in pteropodid bats in Papua New Guinea, including *Syconycteris australis* (Winkelmann et al. 2000), *Dobsonia minor* (Bonaccorso et al. 2002), and *Macroglossus minimus* (Winkelmann et al. 2003).

Small home ranges in bats living in topical forests select the high production of fruits and flowers throughout the annual cycle (Smythe 1970; Bonaccorso 1979). In the radio tracking of *P. faunulus* we observed that the roost sites were distinct from foraging areas, separated by a maximum distance of 12.35 km (mean: 7.05 km; min: 2.11 km). Males appear to roost closer to foraging areas (range: 2.11 to 12.35 km; mean: 6.20 km; median: 5.92 km) than females (7.49 and 10.82 km; mean: 9.16 km). Despite the marked separation between day roosts and foraging areas of the radio collared *P. faunulus*, the 50% kernel for all individuals was calculated at only 97.85 ha, concentrated towards the southern end of Kamorta, between the jetty area and the local veterinary hospital.

The observed activity patterns are most likely related to the cluster of *Ceiba pentandra*, *Psidium guajava* and *Ficus* sp5, all of which were in fruit/bloom in this area during the study interval. A compact home range often is accompanied by small intra-specific overlap in core-use area used for feeding. However, significant overlap in home ranges within and between bat species often occurs if shared food species produce large crops that are highly clumped (Bonaccorso et al. 2005). The black bellied fruit bat, *Melonycteris melanops*, is the largest obligate nectarivore (45-55g) of the family Pteropodidae in the South Pacific region (Bonaccorso 1998). Bonaccorso et al. (2005) in an attempt to determine the home range of *Melonycteris melanops* radio collard 15 individuals and observed that the movement of individual black-bellied fruit bats was not random, but highly clumped within small home ranges that varied from 0.5 to 9.2 ha. Small home ranges are characteristic to solitary foliage-roosting pteropodids.

P. samoensis, is an endemic species to the Samoan and Fijian archipelago exists along with *P. tonganus* on Tutuilla Island, American Samoa. The Samoan population was believed to be near extinct as a result of habitat loss and extensive commercial hunting. *P. samoensis* is a solitary roosting species with the males roosting on dead branches that jutted out of the canopy while the females and dependent young roosted below the canopy, hidden within vegetation. Adult male-female pairs were seen together only in the mating season (Brooke 2001). The Nicobar flying fox *Pteropus faunulus* is a solitary roosting species, and this was confirmed by radio collaring.

This could also explain its small foraging ranges as compared to *Pteropus melanotus*. Through the period of telemetric observations, no individual was recorded moving between islands: telemetric fixes for eight individuals were concentrated in an area under 100 ha across three months (January-March). This however doesn't confirm the absence of inter island migration and may only reflect the seasonal nature of these observations and the fact that *P. faunulus* may aggregate within small patches of fruiting/flowering trees. Day roosts were separate from centres of foraging activity, and some evidence was found of greater loyalty to roost site by females, that appear to use larger, more distributed foraging areas located at a greater distance from day roosts than males. Anderson (1986) and Desy et al. (1990) found that home ranges of some species of aricoline rodents to be smaller in sites where the risk of predation was higher (i.e. habitats with sparse cover), suggesting predation risk may also influence home-range size.

After foraging the radio collared *P. faunulus* flew close over the canopy heading straight to their day roost whereas *P. melanotus* was observed to take a high flight over the canopy probably towards their roost. Wiles et al. (1997) reported while studying the feeding ecology of the bats in Palau islands that bats making short flights in the early evening indicated that foraging often occurred within 1-2 km of the day roosts and bats regularly seen at dusk flying in relatively straight paths above the landscape, suggested that some animals travelled greater distances to reach foraging sites.

Foraging habitat is one of the most fundamental limiting resources for wildlife, and management of foraging habitat often creates the largest response of changes in wildlife populations (Leopold 1933). The importance of foraging habitat for bats has particular relevance in the case of large flying foxes, a threatened group of species generally suffering from habitat loss (Mickleburgh et al. 2002). Many dietary studies on flying foxes provide only tabulations of diet items used with no quantification of that used (Marshall 1983; Richards 1990). These studies are however used little in designing focused restoration projects. *Pteropus sp*ecies feed on a wide variety of fruits, flowers and leaves (Pierson and Rainey 1992) and individuals show a preference for certain foods on a seasonal basis and can be regarded as 'sequential specialists' (Marshall 1985).

In the present study the effort has been to gather base line information and assess the separation of the two sympatric flying foxes on Kamorta Island. In the absence of any such information in the past it was vital to determine the foraging habitat for the flying foxes in the islands. Amongst the two *Pteropus sp*p, *P. faunulus* appears to use a distinct niche compared to the two other species of fruit bats found within the study area (*Pteropus melanotus* and *Cynopterus brachyotis*). Of 37 species of trees exploited by the three fruit bats in the Central Nicobar Group, a 21% overlap was observed (including one species exploited for nectar) between all three bats, but fruit colour preferred, vertical and temporal foraging pattern distinctly separated the two *Pteropus sp* from the *Cynopterus*. In terms of fruit colour, *C. brachyotis* appears to favour lighter coloured fruits than either of the two *Pteropus* spp, among which fruit choice is more evenly distributed by colour (Fig.15). Among vertebrate frugivores, fruit colour, display and odour have been of particular interest. It has been demonstrated in studies that birds preferred small, dark coloured fruits that are displayed for either perching or reaching birds (Wheelwright and Janson 1985; Moermond et al. 1986; Willson et al. 1989).

The classical view of bat fruits is that they are drab or light in colour, displayed openly by plants and have a distinct odour (van der Pijl 1957). Bollen and Elsacker (2002) studied the feeding ecology of *Pteropus rufus* in Madagascar and concluded that odour was the feature of most (65%) of the fruits available in the forest. In our results the two *Pteropus* spp did not show any particular affinity to the colour of the fruit but the odour of the fruits consumed by them might have been a significant factor in choosing the resource as all the fruits consumed in the diet of the fruit bats in the study were strongly aromatic. This has been proved that fruit bats use olfactory cues to locate fruits (Marshall 1983; Laska 1990; Oldfield et al. 1993; Kalko et al. 1996; Bloss 1999). *C.* sp has been known to be a common species in most parts of India. This bat visits fruit bearing plants that have both 'steady-state' and 'big-bang' phonological patterns (Elangovan et al. 1999; 2000).

At the time of two fruit-bearing species *Ficus* sp which is a 'steady-state' species producing fruits over an extended period of time and *Ceiba pentandra* a 'big-bang' species producing a large number of blossom over a short time *P. faunulus* went in for the fruit-bearing species which represented the 'big-bang' phonological characteristics. *P. melanotus* showed more territorial behaviour than *P. faunulus*, which did not show any territorial behaviour in a shared resource. Trewhella et al. (2001) observed resource defence behaviour of *P. livingstonii* on the kapok flowers to be common in large pteropodids feeding on patchy resources. Elmqvist et al. (1992) observed similar behaviour when *P. tonganus* was feeding on kapok trees in Samoa. In studies of sympatric species of *Pteropus samoensis* and *P. tonganus* it was determined that *P. tonganus* and *P. samoensis* both foraged on fruits, flower resources and leaves in varying amounts. *P. samoensis* and *P. tonganus* fed on 36 and 42 plants respectively with 22 overlapping species (Banack 1998).

The differentiation between the resources used by the two *Pteropus spp* was not easily accomplished. The differences were in the way the two *Pteropus* used the resources in the secondary forests. There was an overlap in the diet between the two species, *P. tonganus* foraged more often in the agroforest than the *P. samoensis* (Banack 1998). *P. tonganus* was also observed to feed more on the cultivated species than *P. samoensis*. Our observations of the two sympatric flying fox species in the Nicobar showed that *P. faunulus* was more commonly seen in agro or secondary forest whereas, *P. melanotus* preferred canopy trees in primary forests. Cultivated fruits like *Mangifera indica*, *Psidium guajava* and *Ceiba pentandra* were more common in the diet of *P. faunulus*. A total of 37 plants were identified of which 19 were shared by the two *Pteropus sp* in the island. Our results were consistent with predictions of Flemings (1986) for frugivorous bats, *Pteropus* spp eat a non random subset of fruits.

In terms of vertical stratification the *Pteropus sp* did not favour middle and lower strata trees as against the *Cynopterus*, which was a dominant frugivore in the lower and middle strata. Though there was an overlap in the species consumed by the two sympatric flying fox species*,* while feeding on the same fruit species *Pteropus melanotus* fed on the same species in different areas and at different heights (> 20 m) while *P. faunulus* fed at a height between 15-20 m. In a study on the nectar-feeding activity of three species of fruit bats, the larger *P. giganteus* foraged at a height of about 25 m of the *Ceiba pentandra* tree. The medium sized bat *Rousettus leshenaulti* foraged at a height of about 15 m, whereas the smaller bat *Cynopterus sphinx* foraged at a height of about 10 m (Singaravelan and Marimuthu 2004). It appears that larger the size of bats greater the heights of their foraging. In another study of the dietary habits of *Acerodon jubatus* and *P. vampyrus lanensis* it was concluded that *Acerodon jubatus* was a forest obligate foraging on fruits and leaves of plant species restricted to lowland, mature natural forests in contrast to *P. vampyrus lanensis* which had a broader diet, including fruits, leaves and flowers and foraged in both natural and agro forests (Stier and Mildenstein 2005).

Though there was a preference for certain fruits which were cultivated there was no apparent preference of the *Pteropus* spp in our study to limit feeding in only a specified area. Since the spatial distribution of the fruit trees is not uniform it is possible that the species is driven more by the fruit-bearing species rather than location in the primary forest. Though the *Pteropus* spp revealed a much stronger niche overlap *P. faunulus* appeared to favour gaps and fruits at lower heights on the shared tree. Studies on the feeding ecology of *P. rufus* also revealed that it did not prefer to feed only on large trees and 40% of its diet consisted of the smaller trees and shrubs.

While more detailed studies will need to be conducted in order to confirm this finding, there was also some evidence of niche differentiation by season selected for breeding and rearing between the two *Pteropus* sp. A more intensive collaring effort is required spreading across different seasons to state the foraging habitat of the pteropodids in the islands. It will also then be able to depict habitat utilization by this species more comprehensively.

5. Implications for conservation of the Nicobar Islands – Threat Assessment and Awareness campaigns

A total of 11 villages from the three islands were surveyed in the three islands and 4 randomly chosen or previously reported hunters in the villages were assessed via questionnaires and informal discussions. Questionnaires and discussions revealed that the preference for either of the *Pteropus* spp in the diet was non-existent and it was depended solely on the species easier to hunt or readily spotted. Hunting was seasonal restricted to the foraging areas only. Only in 4 interviews did hunters claim to have shot *P. faunulus* and *P. melanotus* in the day roost. Ceiba pentandra or Kapok trees are planted in all the villages on Kamorta and Nancowrie. Trinket villages were inundated in tsunami and C. pentandra is no longer found on it. Hunters used airguns and catapults to hunt the *Pteropus* sp. The dependency on bat meat for food was not established and it was seen that hunting was conducted only for game. Apart from 2 hunters interviewed, none of the others were aware of the day roosts of the *P. faunulus*. Commercial hunting was not recorded in the Nicobar Islands during the study period.

The present project chose the Nicobar flying fox *Pteropus faunulus* as the key or "flagship" species in the Central Nicobar Islands. Being a shy and solitary roosting species and lack of background information available on the species, secondary source information and bat hunter interviews with the local inhabitants were done to access the hunting pressure on the endemic Nicobar flying fox in the Central group of islands.

5.1 Hunting of flying foxes in the islands

Day time hunting of the Nicobar flying fox (*Pteropus faunulus*) was opportunistic, whereas the Island Flying fox (*Pteropus melanotus*) is hunted deliberately in the day roosts, especially during rainy season when large aggregation of *P. melanotus* occurred in the mangroves. Night hunting was deliberate and not species specific. In a single night during the fruiting of Ceiba pentandra, approximately 40 bats (*Pteropus melanotus* and *P. faunulus*) were sighted on a single tree. Ceiba pentandra or kapok trees are in full bloom in the months is January – March and are usually planted for extraction of the cotton by the local inhabitants. *P. faunulus* and *P. melanotus* consume the nectar of the kapok blossoms and the local inhabitants hunt these bats during foraging. Air guns, catapults and old fishing nets were seen to be used for hunting the bats in the villages. On an average in a single night two bats were killed per person. At a single time we have observed 5-10 hunters during the night. The hunters were seen to hunt in pairs as one aims the torchlight to the individual being hunted while the other shoots the air-gun. A single bullet sometimes wasn't too well aimed and would either leave the bat injured or even if it was killed in one shot the Pteropus would cling on to the branches of the tree. Among the two flying foxes the heaviest impact was on the Nicobar flying fox being a medium height (<20 m) forager it foraged at a height that was relatively closer to the hunters aim thus increasing the chances of getting shot with greater ease. Also the time of arrival in the foraging area was earlier for the Nicobar flying fox (2000 h) as compared to the Island flying fox (after 2200 h). The onset of modern amenities like electricity in some of the new villages established post-Tsunami have proved fatal for the *Pteropus sp*, particularly *P. melanotus* which were seen electrocuted on these high volt cables (n = 10 in 3 months). A well-designed conservation education coupled with community participation and further studies on the species population estimates, breeding ecology and habitats use is essential to mitigate the effect of over hunting coupled with the increasing habitat loss in the islands.

5.2 Conservation measures – solution to the existing problem

5.2.1 Education and awareness – present and future

Of the 11 villages identified in Kamorta Island, slide shows and informal talks with the village heads or "captains", hunters and the general public were conducted using side projectors as well as games to illustrate the importance of flying foxes in the islands as well the effect of unsustainable hunting in the islands. The slide shows were given in Hindi as well in the locally spoken language by the team members. It was observed during the course of this activity that the acceptance of such talks was wider when delivered in the local language. The games introduced in the programme were simple games which involved the entire community in finding out about the equipment we use and the behaviour of the flying foxes in the islands. The participants would be divided into two groups where one was an observer and the other was a bat with a radio collar. The group with the radio collar would hide and the other group would try and locate them in the forest. The ecological role of the species was related to the conditions prevalent in the islands as indirect effects or ecological roles often go unnoticed.

5.2.1 Target Groups

In our previous survey in the year 2002-2003 the team identified the stakeholders in the islands namely the Nicobarese and the threats caused by them on the flying foxes in particular the Nicobar Flying fox. The special hunting rights given to the indigenous tribes in the Nicobar Islands under the Indian Wildlife (Protection) Act, 1972 coupled with an unsustainable forest and wildlife use was threatening the bats in the wildlife. The past survey identified three main target groups – The Nicobarese, The Forest department and other officials and the school children as well as the educationists. During the follow up project our team worked closely with two groups during the study namely the hunters and the village heads. Group I included the "hunters" in the Nicobar Islands. The hunters in the Nicobars are the local community members who hunt the fruit bats for meat. The hunting communities were critical as they have the most extensive information on the location of day roost of flying foxes as well as caves in the islands. The second group was the village heads and communities who are the authorities and it is critical that they are sensitized about the wildlife problems in the Islands and are also crucial in implementing a no-hunting season in their islands. In the follow up study the necessity was to curb the hunting and introduce a "No hunting season" rather than establish legal impositions on the local inhabitants. The hunters were aged from 17-30 yrs and schools were not included in the education programmes as the education camps in the villages covered all the age groups and were more wide spread in their acceptance.

5.2.1.1 Group 1 – hunters

This group is our focus group as they are the cause of the present plight of the Nicobar flying fox. In an attempt to minimize the hunting pressure on the flying fox and other fauna in the islands our team worked closely with this group. Hunters from various villages and settlements were included in the team and encouraged to share information as well as question the aims of the project. A landmark achievement was the involvement of Martin in the project who was an ace hunter in Munack, a village in Kamorta Island. After having been involved in the research project, Martin is the sole custodian for 5 villages under him where hunting has reduced dramatically and we have a network of bat observers as well as roost protectors in Kamorta Island. People like Martin were encouraged to give a talk to the others regarding the Nicobar Flying fox and its ecological importance in their islands. Talks by the local inhabitants in their vernacular language were very popular and aroused a lot of interest in the team's endeavour in the islands.

5.2.1.2 Group 2 – Village heads

Our second target group for bats awareness in the islands was the village captains. These are the heads of villages and are elected by the people. Discussion with them and the people was effective in raising an awareness of the research activities and the loss to the islands due to the current unsustainable trends of forest use. The village heads can decide whether a certain act was to be implemented in the village or not and they are the key element in case we needed to initiate a "closed season" for hunting. During our radio collaring efforts, an unfortunate incident occurred where one of the bats (FREQ 82) was hunted. On tracking the signal we recovered the tag from a hunter's home in Kamorta. Since we had been informing the people and villages of our activities, occurrence of such an incident spread in the entire island and the sensitization of people of their activities was much more than what we expected, to the maximum that in Kamorta Island at present, the village captains have instructed hunting to be minimized in the villages.

5.3 Threats to fruit bats and other fauna in the islands

Past surveys by the team as well the present follow up study was critical in determining the threats to the flying fox populations as well other faunal groups in the islands. A summary of the information gathered is compiled and discussed in the following paragraphs. Threats were classified as (1) Direct; when they were directly committed on the species, and (2) Indirect; when the impact was due activities not directly aimed at the species.

5.3.1 Direct threats

5.3.1.1 Hunting in the islands

Hunting appears to be the major threat for the islands' fruit bats affecting both the species of fruit bats, *Pteropus melanotus* and *P. faunulus*. The advent of air guns from Port Blair and mainland India brings a quicker and more effective way to hunt bats and birds. This is in contrast to the primitive crossbows that were used for hunting prior to the air guns use. Most of the hunting is carried out in the foraging sites and few in the roosting areas. The seasons of the flowering of the silk cotton tree (*Ceiba pentandra*) and a number of preferred fruit trees (e.g. *Psidium guajava*, *Artocarpous lakoocha*) coincide with the reproductive time of the fruit bats. The hunters shoot down these bats and adopt the orphaned babies. To prevent the bats from escaping, the forearm is removed and the wings are clipped in some instances. On some occasions we were able to see the locals rear the babies belonging to *P. melanotus* (4 occasions) and *P. faunulus* (2 occasions) in the Nicobar Islands (Aul and Vijayakumar 2003). The bats are eaten for their meat and for the belief that it is for asthma cure and provides strength.

Hunting in the islands was not restricted to bats alone (Table 8). During the study the other fauna that often appeared in local menus were birds (*Caloenas nicobarica nicobarica, Ducula aenea* and *Megapodius nicobarensis*), reptiles (*Chelonia mydas*, *Python reticulatus*, *Varanus salvator* and *Crocodylus porosus*), crabs (*Birgus latro*) and *Dugong dugon*. Among these *Dugong dugon, Crocodylus porosus*, *Chelonia mydas, Python reticulates* and *Megapodius nicobarensis* are Schedule I species in the Indian Wildlife (Protection) Act, 1972. The establishment of a sanctuary or protected areas for the same might not be an effective remedy for the same as the aborigines of Nicobar Islands are given a special hunting right. Establishment of a protected area might only deter any research on the species in the event of permit requirements.

5.3.1.2 Habitat loss

Forest fragmentation increases the area of forest edge habitats, the most altered zone of a fragment (Murcia 1995). Forest fragment may control the influx of organisms between forest and non forest fragments. Edges are the point of entry of external influences such as exotics and the invasion of exotic species including pathogens to the remaining forests (Janzen 1983; Gelbard and Belnap 2003). The biodiversity of the Andaman and Nicobar Islands is experiencing a rapid transformation. Since the time when the land was "clothed from the coast to the summit by virgin forest and the natives seem to amuse themselves by taming pigeons, doves, and parrots and bats. At that time, the Nicobaries co-existed harmoniously with the natural environment, which met all of their needs.

Group	Species	Distribution	Purpose	Belief
Fruit Bats	Flying foxes	Pteropus melanotus throughout the ANI, P. faunulus restricted to CNI.	Meat and medicinal purposes	Believe that bat meat gives strength and cures asthma.
Insect Bats	All species	Andaman and Nicobar Islands	Indirect threat due to disturbance by humans entering the caves	None
Birds	Nicobar Pigeon Caloenas nicobarica nicobarica, Ducula aenea and Megapod Megapodius nicobarensis	Pigeons throughout ANI, Megapod is endemic to the Nicobar Islands	Meat	None
Reptiles	Salt water crocodile Crocodylus porosus	Throughout ANI	Skin , meat, claws & teeth	None
Lizards	Water monitor Lizard, Varanus salvator	Throughout ANI	Meat	None
Turtles	Green sea turtle Chelonia mydas	Throughout ANI	Meat & eggs	None
Snakes	Reticulate python Python reticulatus	Endemic to the Nicobar Islands	Meat	None
Crustaceans	Giant coconut crab Birgus latro	Found in South sentinel Island in Andaman only and in the South and central Nicobar Group of Islands	Meat	Medicinal use in some islands in CNI
Sea mammals	Dugong Dugong dugon	Nancowrie harbour	Meat	None
Sharks	Hammer head and other species	Ritche's Archipelago	Meat and Fins	Fins are used for medicinal purposes as an aphrodisiac

Table 8: Wildlife threatened and hunted in the Andaman and Nicobar Islands

The trees provided housing and utensils, the soil provided for cultivation and the wildlife provided food . The demands of a modern society have rapidly changed the environment, particularly over the last three decades, and resources have been increasingly exploited in an unsustainable manner. Forest clearance for agriculture, commercial development programmes have virtually and collectively contributed to environmental degradation. Very little lowland forest remains and pressure on the mid-slopes and upland areas is now increasing. Anti-encroachment drives in the Andaman Islands was successful in putting a brake on the extensive logging activities as well as forest clearing activities in the islands, but the Nicobar Island still remains protected from legal interference. Tsunami occurred on 26th December 2004 but the after effects are still visible as unplanned activities and forest clearances for settlements are leading to a strain on the already shrinking habitats in the Nicobar Islands. Conversion of grasslands and other unique habitats for agriculture activities are planned and these were witnessed in the settlements in all the villages, New Laful (Trinket Island, inhabitants), Tapong village (Nancowrie Island), Bada Enak (Safeed Ballu, Trinket Island). Vegetables and coconut plantations were being planned out and are awaiting execution.

5.3.2 Indirect threats

5.3.2.1 Disturbance of caves -- bat habitat under pressure

The insectivorous bats in the islands are poorly described in past literature of the islands (Hill 1967; Abdulali 1976a, b). Due to their patchiness in space caves are more prone to disturbances, both natural and manmade. Human intrusion in the caves has been documented to have adverse impact on the bat populations (Culver 1986). The caves in the Andaman and Nicobar Islands are of economic value to the owners as they harvest the nest of the edible nest swiftlet (*Collocalia fuciphaga*). The nests are an important item in the Chinese cuisine and pharmacy. The medicinal properties of the nest have made them extremely valuable and at the same time they have been exploited throughout the swiftlets range (Sankaran 1998). In the Andaman and Nicobars the edible nest swiftlets roost only in the caves. This is a serious problems faced by bats, including some endemic species and sub species (*Rhinolophus cognatus*, *Hipposideros diadema nicobarensis*, *Myotis dryas horsfieldii* and *Pipistrellus coromandra*) were also observed to cohabit the day-roost with the birds. Some of these caves are privately owned i.e. the caves are located in the plantation and the person owning the plantation by default owns the caves. Private ownership has in some cases restricted the access to outsiders, thus reducing the visitation rate. But the trend is changing as evidenced in some islands. Guided by the local people, settlers at some islands like Katchal have been reported to regularly visit caves for swiftlet nest collection. Another fact for consideration is the accessibility to the caves. Many caves are located on the coast making them easily accessible by locals as well as settlers. Monitoring of bat populations in some of the caves is needed to assess the magnitude and intensity of these anthropogenic activities.

5.3.2.2 Introduced species

Species not native to a place thrive better than native species in the absence of competition and may even drive out the native populations to extinction. The menace caused by the introduced species is phenomenal with direct impact on the endemic flora and fauna. The mammalian fauna of the Andaman and Nicobar Islands comprises of a rich assemblage of largely rodents and bats, besides the only three large species, the Andaman wild pig *Sus Scrofa andamanensis*, the civet cat *Paguma larvata tytlerii*, the Nicobar crab eating Macaque *Macaca fascicularis umbrosa* (Miller 1902; Hill 1967; Saha 1980; Pande et al. 1991; Tiwari and Biswas 1969). The other mammalian fauna represented are the spotted deer, Asian elephant, goats, cows, dogs, and cats all of which have been introduced in the islands. Spotted deer (*Axis axis*) are now widespread throughout the Andamans, as is the African giant snail (*Achatina fulica*). Elephants (*Elephas maximus*) have been introduced to Interview Island and North Andaman (Aul 2002b; Andrews and Sankaran 2002). A recent of introduction of horses on Kamorta Island for load bearing was brought to our notice, two of which died enroute .

5.3.2.3 Legislative imperfections

Legal protection of bats in India has long been ignored. Bats are nocturnal and habitat specific and are considered difficult to locate and study. The fruit bats are listed in Schedule V of the Wildlife (Protection) Act, 1972, which classifies them as vermin, the amendment in 2002 maintains the status of the fruit bats as vermin. IUCN and the Red Data Book classified them as not assessed and vulnerable. Most of the species are poorly known and very little information is present on their status, ecology, behaviour and distribution (Anon 1994). While the fruit bats do not enjoy protection under the Wildlife (Protection) Act, 1972 in India they are especially more vulnerable to over exploitation even in the islands. Another important fact to note in the Indian Wildlife (Protection) Act, 1972 is the inclusion of the whole group in an otherwise species specific listing in the Schedules of the Act. There is no provision for the fact that a species might not be a vermin in a certain area. For example in the Andaman and Nicobar Islands, the flying foxes may play a major role in pollination and dispersal of important fruit trees. Since they do not enjoy any protection under the Wildlife Act indiscriminate hunting is affecting its numbers in the islands. The absence of orchards and orchard damage in the islands suggests that they are not vermin in the islands. An area wise specific schedules and conservation practices might lessen the impact of hunting on some species all across India. Lack of adequate information and quantitative data on the species is another deterrent to conservation practices in India. More extensive field surveys need to be conducted to obtain an area wise species distribution list. As reported from the previous section on hunting, it is evident that the hunting of species by people is irrespective of the schedule they are placed. The credibility of the Act could be questioned as to who these Schedules are actually formulated for.

5.4 Discussion

Wildlife conservation in tropical forests has become a challenge recently. Hunting is one of the serious factors that currently threaten almost all the medium and large vertebrates. Several neotropical studies have shown that hunting activities have a detrimental effect on wildlife populations by reducing their abundance (Reya-Hurtado and Tanner 2005). Subsistence and commercial hunting have a profound effect on the forest and wildlife populations, while leaving the physical structure of the forest unaltered (Peres 1990). Although a number of studies have documented the hunting of wildlife, there are few data on the sustainability of hunting activities. Large flying fox fruit bats are indigenous to the Pacific and Indian Oceans, Australia and South East Asia (Rainey and Pierson 1992). Fruit bats *Pteropus* spp are eaten by humans throughout the geographic range of the genus (Wodzicki and Felton 1975; Lekagul and McNeely 1977; Racey 1979; Prater 1980; Cheke and Dahl 1981; Cox 1983; Tideman 1985).

Hunting of bats was a common occurrence in the islands and hunting was primarily carried out in the foraging areas in the Nicobar Islands. Observation and interviews with bat hunters revealed that hunting was not for food supplement and it was seasonal coinciding with the blossoming of *Ceiba pentandra* which was a species restricted to the presence of settlements, some also claimed that the elders in the villages used flying fox bones as a traditional medicine for asthma. *P. faunulus* and *P. melanotus* exploit the species for nectar. On small isolated islands with low biodiversity, flying fox population may have a cascading effect on native forest ecosystems (Cox et al. 1991; Rainey et al. 1995). Many pteropodids face severe threats from unregulated hunting around the world. In many areas, flying foxes have been an important source of folk medicine and food for local people (Rainey 1990; Mohd- Azlam et al. 2001). In South East Asia P. vampyrus is valued as a remedy for asthma, kidney ailments and fatigue, especially among people of Chinese origin (Fujita and Tuttle 1991). Among aborigines of the Australia, Papua New Guinea and Indonesia, flying foxes are harvested for curing respiratory ailments (Hall and Richards 2000). In most of the places intensive hunting is reported to occur during the reproductive season, or the 'batseason' that coincides with the peak fruiting and flowering periods (Fujita and Tuttle 1991). The fact that the endemic Nicobar flying fox is already locally extinct from its type locality raises a lot many questions on our conservation priorities and methods. Wiles (1987) estimated the status of the fruit bats in Guam and counted only 425-500 individuals in 1984. He concluded that over-hunting and forest clearing may be the contributing factors. *P. tokudae*, a smaller species known to be rare was not found in the study and is thought to be extinct. The Nicobar flying fox is a good example for the same, it is restricted to the Central Nicobar Islands and none of the islands it is recorded from is a protected area. The lack of previous information on the same prevented any immediate assessments for its ecological needs. Similar declines have occurred in the southern, inhabited portion of the Mariana Islands where two species of Pteropus occur, the *P. m. mariannus* and *P. tokudae* (Wheeler and Aguon 1978). The day roosts of *P. melanotus* located in areas like Barren Island (Middle Andaman Group), Dugoung creek (Little Andaman Island); Tillangchong Island (Central Nicobar Group) were the largest. No hunting is carried out by the Onge's who inhabit Dugoung creek in Little Andaman while Tillangchong is an uninhabited island in the Central Nicobar group and is considered a sacred island by the Nicobarese and no hunting is carried out by the local inhabitants from the surrounding islands. Krueger and Donna (1999) in a study on the Mariana Fruit bats in Tinian observed that the densities of Marianna fruit bats was the highest on islands where few people live and there is little hunting. Excessive hunting has been a primary factor in significant declines of fruit bats on many Pacific Islands (Wodzicki and Felton 1975, 1980; Wiles and Payne 1986; Wiles 1987; Wiles et al. 1989; Rainey 1990; Pierson and Rainey 1992; Craig et al. 1994). The local involvement in the Nicobars is critical for determining zones of no-use and no logging. Seasons for non hunting especially in the breeding time of most of the faunal groups is needed to be observed. It was concluded that detailed studied are required to determine the community patterns as well as the interaction and interdependence between different faunal groups in the islands. This is to say that conservation in the Andaman Islands like in the Nicobar Islands will have to be a community study instead of single species or isolated habitat protection. Wiles et al. (1997) studied the abundance, biology and human exploitation of bats in the Palau Islands and observed that Palauns were hunting *Pteropus mariannus pelewensis* extensively for commercial and personal use. About 10, 000 – 16, 500 bats were shipped to Guam and the Commonwealth of Northern Marianna Islands annually and another 2,000 to 5,000 animals were estimated to be taken per year for local consumption. The study also suggests that consideration should be given to the establishment of several reserves or non hunting areas to safe guard the population further. Andaman and Nicobar Islands too have several protected areas encompassing many islands but no consideration is given to the species inhabiting these protected areas. A number of islands are present, which are home to endemic species of birds and other fauna but are currently not in the protected area network. It is essential to design a network of protected areas in the Andaman Islands instead of isolated single island sanctuaries or national park. A network would ensure the protection of corridors protection for the safe movement of certain fauna in the Islands. Currently there is no provision to protect such corridors (Sankaran 1997).

Electrocuted *P. melanotus*

Local inhabitants with freshly shot *P. melanotus*

Local inhabitants adopt orphaned pups as pets

Awareness programs amongst the locals

Plate 3: Threats to bats in the Central Nicobar Islands

Demonstration of techniques used by the team

The first *Pteropus* sampled by the team

Slide shows and discussion with villagers - Malacca Village

Children caught a fancy for the slides of their islands

Plate 4: Education programmes and local involvement of the inhabitants

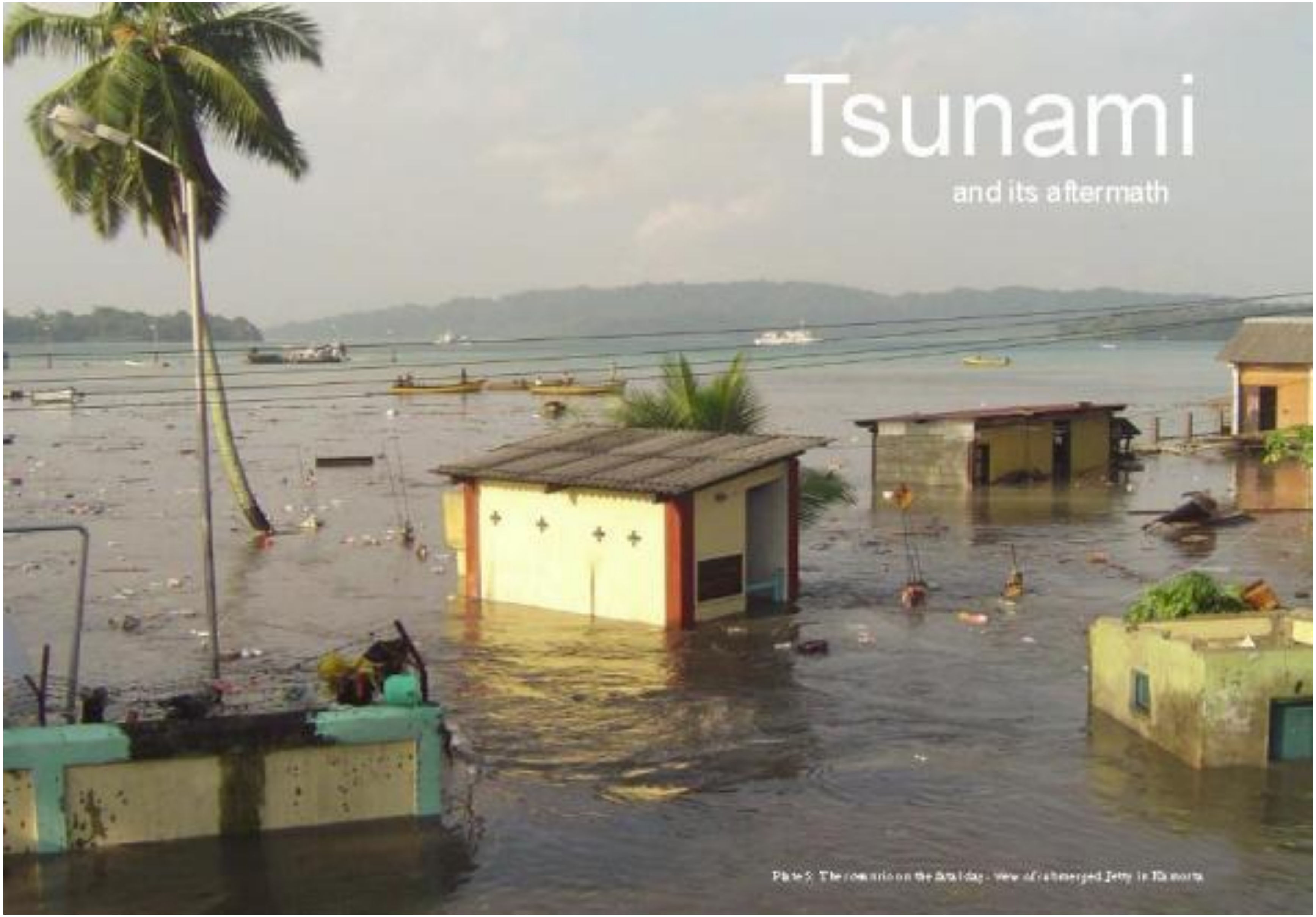


Plate 5: The sceanrio on the fatal day- view of submerged Jetty in Kamorta

“Nicobaren”

was how the Danish referred to the friendly people who live in the remote Islands of Nicobar archipelago. A group of 23 Islands & few rocky outcrops lie scattered on the Bay of Bengal Sea: the southern tip less than 100 kms north of the Island of Sumatra. Travelling downwards from North to South, the first Island encountered is the Car Nicobar; the most developed also the most disturbed of the lot. Car Nicobar Is and Battimalv, a small uninhabited Island located further south of Car Nicobar forms the Northern cluster. Further south we would encounter a group of 10 Islands scattered from North to South and East to west. They are known as Nancowrie group of islands and form the Central cluster. Further around 50 Km south, after sailing through a deep Sombrero channel we would reach the Southern cluster. The southern cluster is a group of more than 10 Islands and islets which includes the largest Island in the Nicobar, Great Nicobar Island and the smallest inhabited island namely Pulo Milo.

6.1 Diary of Events

It was the same time every year when celebration was in the air, the music of carol singing had commenced long before we got into field and festivity marked every village and household in the islands. M. V. Chowra set sail from Port Blair on 15th December 2004 and began its usual journey. Our team (Martin, Thope, Jonathan and Joel) and I were heading to Nancowrie with new objectives and the hope of finding the elusive Nicobar Flying fox.

Plate 6: The mangrove habitat converted into swamps of debris- Galathea Bay

The cast off was at 600 hr and we reached Little Andaman at 1630 hr where there was a 7-8 hr halt where we all got down to explore the local restaurants and discussed about how the following field work might turn out. The tempo was high and all believed that we will definitely get what we had so firmly set out for. A team like this where so much of enthusiasm is abundant is highly contagious and there is no scope of thinking of failure. There was no indication that within a couple of days our lives would change so drastically and we would witness something so devastating that it would bind us to the people and islands more firmly. We saw the island of Little Andaman fading out as the ship headed away from the Andaman’s and closer to our destination, it was 2230 h and we were crossing the 10 degree channel that separates the Andaman Group of Islands from the Nicobar Group of Islands. Early noon we were safely across the channel and a flat island of Car Nicobar, the northernmost island in the Nicobar Group. The halt here would be for 8- 10 hrs and the ship would sail at night for Katchal just 45 min away from our destination. Towards the end of the journey everyone was just waiting to get off the ship and head to the field base. It had been two and a half days by the time we reached Kamorta jetty where we were to get off. The ship came alongside the jetty and we were welcomed with same familiar faces and expectant look when a ship comes into these remote islands. It is quite an event when the ships come to such remote islands.

Ships are a life line for the islands as they carry messages from near and dear ones, provisions for the shops and people and also some researchers like us who have found a home so away from home!

With all the team and fellow passengers we stepped off from the ship and as usual got stopped by the S.H.O for our tribal area permits, a permit issued by the District Commissioner, Nicobar Islands. Entry into the Nicobar Group of Islands is limited primarily to the people who often carry tribal passes. Our team visits the islands so regularly but somehow we are always checked by the ever watchful S.H.O.

Anyways the thrill to step foot on ground after almost 50 hrs of ship journey our spirits were not dampened. It was late in the evening by the time we settled down into our newly hired field base. The next few days were busy in getting organized and setting up an agenda for the next phase of the field work. It was a bit strange that there were a few things we did away from our normal routine, for example we bought all our provisions from Port Blair unlike the usual where we came to Kamorta and then made all the purchases for the essentials. A thought had crossed my mind that we might not get provisions in Kamorta when we reach so we catered for a month in advance and also since we had shipped all our equipment in advance by the cargo ships, I had enquired from our liaison in Kamorta as to where he had kept all out luggage and he said it was close to the jetty in Kamorta, upon which I requested him to keep it away from the water in higher ground. In retrospect it seems like we all had an intuition of some event occurring but could not really place what the event was. Christmas celebrations were in full swing and the villages were preparing for a night of a festivity in Champin village, where the church was located and a common ground for most of the main celebrations in the Nancowrie Group of Islands. We were also invited to the village for the celebrations, but little did we to know that those celebration and that day would be one night to remember as a last happy occasion for a long time in the near future and the next day would change the lives of the local inhabitations so drastically that we would not recognize the villages we were so at home for so many years. The evening was splendid but had such stillness about it that it was unnerving to be back alone in the base as not a single sound could be heard in the forest it was if the silence was forewarning us about the danger awaiting. The night passed but it was one of the most uncomfortable nights in field and the stillness around was unnerving. No bats, no sound of insects and not even the people around seemed to be talking. A silence had engulfed the islands and it reminded us of the storm that usually followed such a silence.

On the 26th December 2004 at 0630 hr, there was a strange rumbling noise we heard as we slept on the floor of our base and then the first shake came which caused everyone to scuttle out of their homes and the earthquake of the intensity 9 on the Richter scale followed which shook the islands for 6 minutes was felt. No one was able to remain standing and was forced to sit on the ground. Everything around was swaying to 45° either ways. Though it was 6 minutes by the watch it seemed like forever and once it got over we all strolled down till the jetty and it was within 15 min from the earthquake when people started rushing back from the jetty screaming, "Tide's rising!!" which was strange as the high tide time was not coinciding with the phenomenon and then it struck us that it a tidal wave and we are witnessing what we had only read and heard about, we urged the people to find a place in higher ground and to get away from the water edges. It is worth mentioning Ramana, a boat operator and his friend who took the risk and went to get the boats to safer waters. If it had not been for these two we would not have had the chance to travel to the nearby village and rescue the stranded people there the same day. The water came and went and the height of the waves was more than 6 ft when it first stuck. The media reports that only three waves struck were not entirely true for the Central Nicobar and the water kept rising and receding every half an hour till mid-day (1200 hr). Only after the water level stabilized were we able to move from Kamorta to Champin Village where there were some 250 people stranded and fortunately there were minimal causalities as the people had all rushed up to higher ground. The relief camp in Champin was established in Mark Paul's house which was on elevated ground and had some open space to accommodate people in the ground. That's when the first survivor from Trinket, a local resident named Nepus swam in to Nancowrie. Trinket was the most severely affected island amongst the three namely Kamorta, Nancowrie and Trinket. The first survivor from Trinket to reach Kamorta was a 4 yr old girl named Nisha who clung onto a floating log and was picked up by the out boats searching for survivors in the bay. The first 161 survivors from Trinket swam into Kamorta and Nancowrie islands and were picked up by the country boats moving within the bay. Since the debris was so much the bigger ships could not enter the bay and even the smaller boats were facing the risk of being struck by hidden logs in the water under the debris. The debris was so thick that one could easily walk on it without sinking. A disaster of such magnitude left all of us worried as to what the situation would be in the other parts of the islands and also whether we would be able to reach those in need for immediate attention well within time? The boat crew of M.V Ramakrishna, an inter island ferry boat not suitable for traversing in high seas, took the risk and we were able to get more than 500 people to safe ground from Changua, Derring, Bunder Khari, Pilpillo villages in Kamorta Island along with the assistance from M.V. Rangat in the next two days. In the absence of communication and supplies there was a constant effort by the Junior Engineers and Public work department officials to get at least communication and electricity working within the islands. It was remarkable that they worked 24X7 and we had electricity, phone and water supplies up by the same evening. Communication to the outside world was totally cut out for a week and it is only after the first ship M.V. Kalighat sailed into Nancowrie harbour that the first communication of the outside world and message of well being could be sent home. The Defence forces Commander and Chief had flown into Kamorta 3 days after the event and he carried the message from home to us and about our well being to our homes. Since most of the team members were local inhabitants and we were awaiting the message of their and their families well being it was inappropriate for us to head home, and thus the decision to stay and ensure that the team and their villages were not deprived of their rightful claim encouraged us to abandon our research and participate in the relief operations in the islands for the following few months. Having worked in the islands for so long and seeing the people who had made us feel so at home within their villages made us work for their well being. It was a tricky situation as we had to deal with an over confident set up who thought they could decide everything for the people without considering the relevance of their actions and had to face a lot of opposition. Media came in to the Central Nicobar Group only by the second month and all the news of the disaster was limited to Car Nicobar Island, in the Nicobar Group and to Port Blair in the Andaman group. Our team participated in relief operation for the next two months and this extended from Tressa Island to Great Nicobar Islands in the Southern Group. A team of doctors from St John's Hospital, Banglore were brought in on the 29th December and we decided to help them with the local information and assistance. In the southern group Suresh, I and our team in the islands were the first to do a land search in the west coast of Great Nicobar Islands after 36 days of the disaster. Our suspicions were well in place as we found signs of 9 survivors from PuloBhabi, one of the populated villages on the west coast of Great Nicobar Island. This was critical in making the administration pull up their socks and begin a thorough search of the west coast in

Great Nicobar Islands. Previously attempts of aerial searches did not really serve any purpose as the canopy cover was too thick for sightings from sir. While searching the west coast we never thought that we would see the villages we saw so full of life nothing but masses of dead wood and debris and a few lone coconut trees partially submerged. The setting sun added to the eerie feeling that we were walking in ghost villages. Megapode Island, a wildlife sanctuary located in the Southern Nicobar Group on the west coast is now totally submerged under water. The coastal dwellers were now forced to move inland and a fear for the sea had crept in, no one wanted to venture into the sea and fish seemed to be a taboo. It was a phase and we were glad that it has now worn out, life is returning to normal in some villages and some are modified beyond recognition. As the weeks passed and an influx of NGO's and social missioners was observed an incoming ship was no longer looked at with expectation, each worker and the each NGO's came with the agenda of doing good to the society without any foresight and without any consideration as to what was it that the people really wanted. It appeared to us that it was only a gimmick to mark their presence in a disaster struck zone. Each one competed and tried to outdo the other and in the bargain the main purpose of being in an area like this and helping the affected was defeated. Unplanned and uncoordinated relief articles cluttered the store houses and jetties, material like woollen blankets, small utensils and things catering enough for a small family came in as relief material and no consideration was given to the fact that the communities followed a joint family system with the minimum in each family being 15 members.

Our presence in the islands was an opportunity for us to learn how to cope with such a disaster and the actions taken were enough to safely known what not to do next time such an event were to happen. Socially they islands have faced a huge transformation and it might be the beginning of a whole new system in the villages, joint families have split and kitchens are no longer one for a family. Money has been looked at with power to buy things and actions that would not be ideal for the place. The togetherness that used to exist in the people is slowly diminishing and the feature of comradeship that set apart these islands and their people is now on the decline. The traditional houses of wood and leaves also known as "Ngyo-pul" or round huts are replaced with asbestos sheets and the cultural shift from a joint family to nuclear families is evident. The temporary shelters that came up were built and are so inappropriate for the climate and area but the decision for such homes was not with the people and now after almost three years permanent shelters are coming up which are semi wooden but nothing which will remind us of the villages and traditional architecture that used to exist.

My team comprising of a senior colleague Suresh Babu and two assistants Amber and Raphel, contacted the village heads or "captains" they are popularly called in the islands. These Captains are in full power to decide for the villages and based on our inputs about the amount of material that had come from a division of the Indian Army located all the way in the North of India. The Captains decided which village needed what item and how the material should be distributed. We selected two villages for the household items which included cooking utensils, plates, glasses and serving platters. Apart from this the material included clothes for children, ladies and gentlemen and some stationary articles including copies, pencils, erasers, sharpeners, colour pencils and pens. There was also some general material which was sent which we distributed to families we knew as well as some families who had not been able to get anything from the administration on the pretext that they were employed or that they were non natives to the islands. I also have to mention that I did not expect such a warm response in terms of the amount of material that was sent and that also so promptly. The village captains of Trinket and Daring decided to separate the material into sets for each family; this helped us avoid the problems of giving to one and not giving to another. The first priority was given to Trinket and the village captain, Amber did the needful of sorting the items into sets to be distributed to each family. Apart from this we distributed the schools books, notebooks, pencils and other stationary to schools set up in remote islands like Aleurong village on the west coast of Tressa Island and incidentally they were the first to begin classes under tent age just four days after the December 26th 2004 tragedy. The distribution of material to such villages also served as an encouragement and motivation for the other to follow suit. Some mats were distributed to the first camp that was re established on Chowra Island, these people were relocated on Tressa Island but chose to go back to their own island. Villages like Munack in the eastern bay of Kamorta island are model villages where one can see team spirit and togetherness and so was chosen to distribute some children's clothes and stationary articles as well as towels that had been sent. Though Munack was not affected by Tsunami, it is hosting the neighbouring affected smaller villages. Thanks to the pretext of distribution of relief material which was done by the captain's husband and brothers in the most organized manner we ever witnessed in the islands, we were also treated to the most scrumptious meal we had had in quite some time.

Some individuals worked very dedicatedly for others all through the tough times and deserve special mention in spite of having lost their families. These people were Sunil, a mechanic by profession but now has no shop and profession left but if helping organizing things in the administration; Elango, a forest department labourer who has lost his children in tsunami in Campbell bay, Great Nicobar Island – the southernmost island in the Nicobar Group; Amber, the Second captain of Trinket Island has lost all his family except his three year old son Yash. A lot many more unsung heroes are still working for others in the island and we all wish we could do something special for them when they would really want us too.

From an ecologists point of view the impact of tsunami was particularly evident in the coasts where the mangrove forest are now totally destroyed and in the Central Nicobar Group alone the islands have lost 3-4 km of land all along the coasts in the islands apart from the damage to property and life. Mangrove habitats are a critical ecotone between the terrestrial and marine ecosystems was completely destroyed. Mangrove habitat was critical for our study as they were a potential day roost for the *Pteropus melanotus* in the islands. *P. melanotus* also used *Nypa fruticans* swamps, which were completely destroyed in the incident. Even after 2 years the regeneration of mangrove was observed only in a few places on the coasts of Kamorta and Nancowrie. *Nypa fruticans* have re-generated and bats were seen to return to their old roosts in Tillangchong Island (Pers. obs). This however will be a deterrent for the bats in the present scenario as these palms are used as thatch and due to construction activities and increased demand for thatch these roosts will be continuously disturbed by the local inhabitants.

7 *Nypa fruticans* is used by the local inhabitants as thatch for their homes in the Nicobar Group of islands.

Large scale clearing in some areas on Kamorta Island for settlement has expedited the already shrinking forest resource in the same. Hunting activities has not reduced and species like pigeons, wild boar, turtles, crocodiles and bats still find their way into the kitchen in a number of villages.

Plate 7: Team's participation in Tsunami relief work

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Appendix I:

Species consumed by fruit bats and their fruiting/ flowering months

Species	Vernacular Name	Islands	Month
Artocarpus lakoocha	Thompeing	K, N, T	Feb-April; Sept-Nov
Bentinckia nicobarensis	Jiphack	K, N, T	May-June
Bentinckia sp1	Huksuak	K, N,T	Oct -Dec; April-May
Buchnania sp	Kanap	K, N,T	Fruits April-May;
Calamus andamanicus	Moota beeth	K, N	April-May
Calamus palustris	Pintang	K, N	April-May
Ceiba pentandra	Didu	K, N	Nov-Feb
Dillenia andamanica	Luinch	K, N, T	Fruits April-June
Diospyros sp*	Hinlaien	K	April-May
Elaeocarpus macrocerus	Kumlang	K, T	April-June
Fagrea sp	Mallock	K,T	May-June; Oct-Feb
Ficus glomerata	Pong sp3	K, N	All year round
Ficus pendula	Tuanth	K, N, T	Oct-Dec; May-June
Ficus sp4	Lanup (big tree)	K, N	July-Nov
Ficus sp1	Tuanth	K, N, T	Oct-Dec; May-June
Ficus sp2	Tuanth	K, T	April-May; Oct-Dec
Ficus sp3	Pong	K	Jan-Feb; April-May
Ficus sp5	Pong sp2	K, N, T	May-June;
Ficus sp6	Lanup	K, N	Jan-Feb; June-July
Ficus sp7	Lanup sp2	K, N	All year round
Mangifera camptosperma	Flat mango	K	April-May
Mangifera indica♦	Manga	K	Sept-Nov
Musa paradisiaca♦	Banana	K, N	Year round
Myristica sp	Aukceya	K, N, T	Jan-Feb; April-May
Pandanus odoratissmus	Hikai	K, N, T	Jan-Feb; April-May
P. leram andamanicum	Big pandanus	K, T	Dec-Feb
Psidium guajava♦	Guava	K	Oct-Feb
Sandoricum koetjape	Hinsai	K, N	May-June
Semecarpus anacardium	Planted cashew	K	Flowering, Nov; Fruits April
Syzigium sp1	Mat mu-ang	K, N, T	Fruits April-May
Syzigium sp2	Epoh	K, N, T	April-May
Syzigium sp3	Epoh tahanane	K, N, T	April-May
UID sp1	Jafat	K, T	Jan-Feb; May-June
UID sp2	Kindrial	K	Unripe fruit May-June
UID sp3	sp (trinket)	T	Oct-Feb
UID sp4	Taminion	K	July-Aug
UID sp5	Mitai	K	May-June
UID sp6	Hihiluia/ Kumpa	K, N, T	Feb-April

*species was recorded only from one site in Munack, Kamorta Island. ♦ planted species; K: Kamorta Island; N: Nancowrie Island; T: Trinket Island. UID: Un-identifies species

(Footnotes)

1 Positive fixes are referred to as the points the tracked animals was located and the point which is used for the calculation of the range of the animal.

2 Insect Bats cohabit the day roosts with the edible nest swiftlet, the nest of this is used in traditional medicine and is exported out of India (Sankaran 1998).

3 Crocodiles in the Nicobar group are not hunted for skin. The value of the skin is unknown to them till date. Commercial hunting in the Andaman might be taking place.

4 T he distribution of *Dugong dugon* is not known as no studies have been carried out for ascertaining its population or distribution. The sighting here is pers. obs.

5 The meat of *Dugong dugon* is sold for Rs 50/kg. This was observed in Nancowrie Island when fisherman (non-tribal) brought it in to sell to the local inhabitants.

6 Shark fishing was observed during the survey on Outram Island, where fisherman had camped to fish.

Action Tayam-peh is a community based conservation project in the Nicobar Group of Islands which aimed to determine the ecology and threats to the Nicobar flying fox, an endemic species restricted to the North and Central Nicobar Group of Islands. In a survey funded by BPCP in 2003, The Nicobar flying fox was rediscovered after almost a century. The survey also confirmed that the species was locally extinct from its type locality (Car Nicobar Island).

As a follow-up to the survey eleven individuals were radio collared on Kamorta Island in the Central Nicobars. The Nicobar flying fox, unlike other flying foxes, is a solitary rooster selecting roosts among well camouflaged trees in the canopy. Day roosts of were located for the first time during this study and approximately 25 fruit species were recorded in its diet. Seasonally occurring fruits were preferred to more easily available perennial fruiting species like Ficus.

There are three species of fruit bats in the Central Nicobars, Niche separation between them was also recorded. Of the 37 species of food plants used, a 21% overlap was observed among the three bats. Roost location and fruit colour preference along with vertical and temporal foraging patterns distinctly separated the two *Ptreopus* spp from the *Cynopterus* sp. The two *Pteropus* spp revealed much stronger dietary overlap (76% shared species) but *P. faunulus* favoured gaps and trees at lower heights than *P. melanotus*.

Direct threats due to hunting and habitat loss and indirect threats due to poor legislative measures and human intrusion in cave for nest collection attributed to the declining populations of bats in the islands. Most of the hunting of fruit bats is carried out in the foraging sites and few in the day roosts. Hunting of other fauna was also recorded most of which were schedule I species. Education programmes in the local language were carried out in 11 villages in the Central Nicobar Islands in three islands (Nancowrie, Kamorta and Katchal Islands). Target groups included hunters and villagers living close to the roost sites. The education programme addressed the need to minimise hunting and disturbance to the bats in the area.