ECOLOGY AND BEHAVIOUR OF AN ENDEMIC TREESHREW *TUPAIA NICOBARICA* ZELEBOR 1869 ON GREAT NICOBAR ISLAND, INDIA

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The Nicobar treeshrew *Tupaia nicobarica* is an endemic mammal restricted in its distribution to Great and Little Nicobar islands in the Andaman Sea. This article aims to report basic information on the ecology and behaviour as well as a preliminary population assessment of this species on Great Nicobar Island. Nicobar treeshrews spend more than 60% of the day foraging, followed by resting or sleeping (12%). The proportion of time spent on major activities was significantly different across different time periods, with much of the feeding activity in the mornings and evenings. Nicobar treeshrews were observed largely solitarily or as breeding pairs. Observations on mating, aggression and vocalisation are also reported. Most of the ecological and behavioural traits are shared with one or more species of *Tupaia* in the region. Observations on this species point to its extreme arboreality in comparison to other *Tupaia*. The species also exhibited a high degree of insectivory during the study period. A combination of these two traits makes this species one among a handful of nonvolant foliage gleaning insectivorous small mammals that exist in the world today. The species was observed in moderate numbers both in the littoral forests as well as in the rainforests in the interior of the island. Although formally classified as endangered (on account of its restricted range), the species is common locally. The current status of the species seems to be stable in the Great Nicobar Island which has some of the best preserved forests in India.

Key words: activity pattern, social organisation, arboreality, population assessment, breeding pairs, solitary individuals

INTRODUCTION

Treeshrews (Order Scandentia, Family Tupaiidae) are a group of tropical small mammals found in South and Southeast Asia. Treeshrews have been previously classified under different orders including Primates and Insectivora, and are considered by some to resemble primitive mammals. Currently they are classified under the Order Scandentia (Family Tupaiidae) and includes 19 species distributed among five genera (Anderson and Jones 1984). Molecular evidence supports their clustering as a separate order but places Scandentia along with Lagomorpha (which belongs to the cohort Glires, a sister group of Primates) (Schmitz *et al.* 2000). Treeshrews also belong to one of the four superordinal clades (rodents, primates, flying lemurs and lagomorphs) (Murphy *et al.* 2001). The present classification of treeshrews recognises two subfamilies: Tupaiinae (including the genera *Tupaia*, *Anathana*, *Dendrogale* and *Urogale*), and Ptilocercinae (with the genus *Ptilocercus*) (Luckett 1980; Wilson 1993). Zoogeographic, systematic and behavioural investigations concerning many of the species are ongoing. Although a large number of laboratory studies on captive Treeshrews have been carried out, field observations have been limited to a few studies (D'Souza and Martin 1974; Chorazyna and Kurup 1975; Kawamichi and Kawamichi 1979; Langham 1982; Dans 1993; Emmons 2000; Oommen 2002). Recent studies on the ecology and behaviour of these species have yielded many insights into their ecology including the unique absentee parental care system (Emmons 2000). Many tupaiids survive in tropical forests where human activities are increasing and, therefore, efforts need to be made to understand their status, ecology and behaviour in order to frame management guidelines and strategies for their conservation.

Treeshrews are entirely confined to South and Southeast Asia, and the latter region has the largest number of species. Of the three species found in South Asia, two are confined to the mainland, namely the Madras Treeshrew (*Ananthana ellioti* Waterhouse 1849) in peninsular India and the Northern Treeshrew (*Tupaia belangeri* Wagner 1841) in north-east India extending into Myanmar. The Nicobar Treeshrew *T. nicobarica* is a small tupaiid with a restricted range and is found only on two islands (Little and Great Nicobar islands with an area of 150 sq. km and 995 sq. km respectively) in the Andaman Sea. Two subspecies have been described: *T. nicobarica nicobarica* Zelebor, 1869 (on Great Nicobar

Island) and *T. nicobarica surda* Miller 1902 (on Little Nicobar Island).

The Nicobar Treeshrew (henceforth Treeshrew) has been classified as 'Endangered' in the World Conservation Union – IUCN's Red List of Threatened Species (CBSG CAMP Workshop, India 2000). Here, we present results from the first field study of the Treeshrew, summarising findings on the ecology and behaviour of the species. We also compare the ecology and key behavioural characteristics of this species with other treeshrew species that have been studied elsewhere in the Southeast Asian region. Finally, we present a preliminary population assessment of the species.

STUDY AREA

The Andaman and Nicobar islands are situated in the Bay of Bengal between India and Myanmar and run parallel to the coast of Myanmar. Geologically, they are the summits of a submarine mountain range lying on the great tectonic suture zone extending from the eastern Himalaya to the Arakan coast and to Sumatra and the Lesser Sundas. The Nicobars are separated from the Andaman group by the Ten Degree Channel, and the biogeographical characteristics of these islands are an intermixture of the two biogeographic hotspots that border each other in the region. In terms of primary affinities, the flora and fauna of the Andaman Islands are similar to that of the closest biogeographical unit, the Indo-Burma hotspot. The Nicobar Islands form a part of the Sundaland hotspot (Davis *et al.* 1995). However, these affinities are also taxa dependent, as studies on groups such as birds and plants have shown (Elwes 1873; Ripley and Beehler 1989; Davis *et al.* 1995).

The Great Nicobar Island, with an area of 995 sq. km is situated at 6° 45'-7° 15' N, 93° 38'-93° 55' E in the Bay of Bengal. It is the southern most island of the Nicobar Archipelago, and is separated from the rest of the group by the Sombrero Channel. Temperatures in the Nicobar group of islands range from 22 °C to 32 °C, and the mean annual rainfall varies from 300 cm in the south to 380 cm in the northern region. April is the hottest month. The area comes under the influence of the South-west monsoon from late May; January, February and March are comparatively dry. The island is subject to occasional gales and cyclonic storms. Unlike other islands in the archipelago, Great Nicobar has perennial rivers (Alexandria, Dagmar and Galathea).

Although politically a part of India, the geographical proximity of the island is to the South-east Asian region. The biogeographic affinities (primarily floristic affinities) are to a large part to that region. The distance from the southern tip (Indira Point) of Great Nicobar to the mainland of Sumatra is approximately 100 km. The Nicobar islands host a highly diverse flora and fauna, many of which, including the Nicobar Treeshrew, are endemic. Other endemics include a subspecies of Wild Pig and the Crab-eating Macaque. Species level endemism is high, but many genera and families, including those of the Treeshrews are shared with the nearby island of Sumatra and much of Southeast Asia. Recent estimates of natural vegetation cover on Great Nicobar range from 86% to 93.5%, and although only a small percentage of forests has been lost till date, habitat conversion poses potential dangers to the island (Sankaran 1997; Gupta *et al.* 2004).

This study was carried out in areas within and adjacent to the Galathea National Park on Great Nicobar Island. The intensive study area was a small 5 sq. km patch of littoral forest where it was easy to locate and observe the animals. Basic population assessment surveys were also carried out in other areas of the island excluding the northern part. These included sites with both littoral as well as inland evergreen rainforest. Specific localities that were surveyed include Galathea, Indira Point and surrounding areas on the southernmost tip of the island, Kophen Heat and surrounding areas and the East–West Road to Shompen Hut.

The intensive study area was characterised by lower forests of littoral woodland. Mangroves and *Pandanus* vegetation was adjacent to the beach and further away mixed evergreen forests intruded into the patch. Dominant species in these mixed littoral forests included *Pandanus leram* var. *andamanensium, P. odoratissimus, Thespesia populnea, Barringtonia asiatica, Pongamia pinnata, Artocarpus gomeziana, Terminalia cattapa, T. bialata,* and *Lagerstoemia ovalifolia.* The interior evergreen rainforests had a luxuriant canopy with tall evergreen trees including *Calophyllum soulattri, Sterculia macrophylla, Planchonella firma, Palaquim semarum* and *Knema andamanica.*

METHODS

The field study was carried out in the Galathea National Park of Great Nicobar Biosphere Reserve between October 2001 and February 2002. The Treeshrews were common in closed canopy forests and were easily located by their loud piercing calls. Space utilisation and behavioural observations were made mostly by instantaneous scans covering a period of 25 hours. A minimum target for each 3 hour time period of the day (0500-0800 hrs, 0800-1100 hrs, 1100-1400 hrs, 1400-1700 hrs) was 60 scans. Sunrise and sunset were at approximately 0500 hrs and 1700 hrs respectively (Great Nicobar Island follows Indian Standard Time). During each sampling period, the activity of the animal/ animals was noted at 3 or 5 minute intervals, picked randomly. These data were

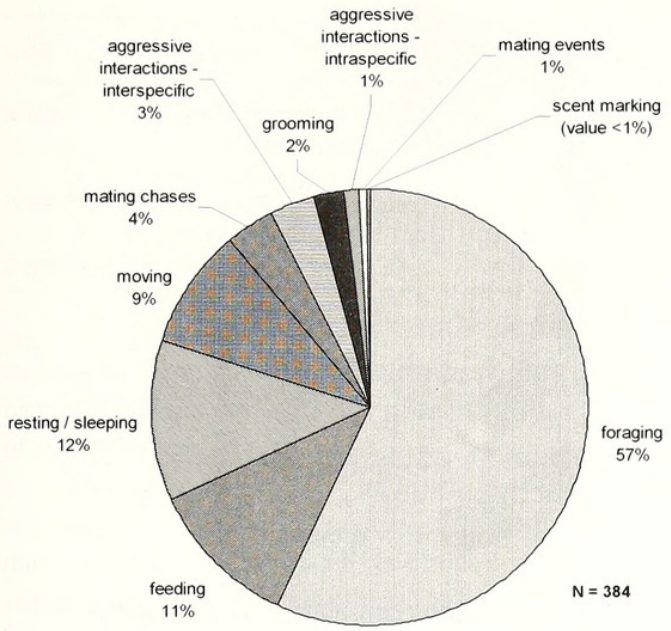

Fig. 1: Overall activity budget of the Nicobar Treeshrew

utilised to determine the proportion of time the animals spent in general activities such as foraging, resting and moving. Instantaneous scan periods covered 25 hours, and the activity was recorded for approximately 360 scans (28 sessions). Focal animal sampling was also carried out to accurately record rare events, and to identify behavioural traits that were difficult to detect during instantaneous scans. These included recording actual feeding successes, mating, grooming, scent marking and interactions with same or different species. Focal animal sampling data were collected for a total of 6 hours 24 minutes.

Population assessment was carried out in selected sites on the island. Distance constrained sampling was carried out in six sites, (three in the southern part, two in the western part, and one in the east central part of the island). Transects were walked in the morning on good weather days along existing roads and trails. The total distance covered was 21.3 km. Locating animals in both the dense canopy rainforest as well as the coastal forests was easy as Treeshrews call frequently, and their presence is also indicated by that of Greater Racket-tailed Drongo (these birds also call characteristically), which exhibit commensal feeding. All calls and sightings were recorded along with sighting angles and perpendicular distances. Initial population estimates are represented as encounter rates based on call counts.

Body measurements were available only from a single dead individual. Body measurements included head and body length (HB), measured as the length from the tip of the nose to the anus, tail length (T) measured from anus to tip of tail excluding protruding tail hairs and hind foot length (HF) or length from heel to longest toe excluding claws.

RESULTS

Morphology

Treeshrews resemble squirrels in general appearance but have different distinguishing features, the most distinct being their long snouts with an absence of vibrissae and typical dentition (the dental formula is i2/3, c1/1, pm3/3, m3/3 * 2 = 38). *T. nicobarica* resembles *T. glis* in appearance. The dorsal portion from the nape to tail tip is uniformly dark brown to russet in colour, there are no prominent facial or shoulder markings, the region from the nape to snout is lighter brown, and so are the limbs. The underside is much paler in comparison to the dorsal portion. Measurements of a single adult male were obtained: HB = 135 mm; T = 180 mm; HF = 28 mm; weight = approx. 80 g. The skull and jaws of the specimen which we found were crushed and too disfigured to take exact measurements. *T. nicobarica* is likely to be the smallest among the three South Asian Treeshrews and also likely to be among the smallest tupaiids.

Activity patterns

Instantaneous scan data were analysed to construct a behavioural repertoire of the species. Treeshrews spend more than 60% of the day foraging (feeding or searching for food) followed by resting or sleeping (12%), but it is important to note here that for a 12 hour span, this amounts to 10 hours 34 minutes of activity and only 1 hour 26 minutes of actual resting time (Table 1). Focal animal sampling provided information on other activities such as actual feeding events, mating, grooming, scent marking and interspecific interactions. The activity patterns of breeding pairs were on the whole similar to those of solitary individuals; pairs rested more often than solitary individuals and mostly after mating

Table 1: Activity patterns during different sampling periods

Activity	0500-0800 hrs (73 Scans)	0800 1100 hrs (75 Scans)	1100-1400 hrs (158 Scans)	1400-1700 hrs (78 Scans)
Foraging	71.2	49.3	47.5	70.5
Feed	11.0	17.3	8.9	9.0
Rest / sleep	1.4	8.0	24.7	-
Groom	2.7	2.7	2.5	1.3
Scent mark	-	-	-	1.3
Move	4.1	10.7	7.6	14.1
Mating chases	-	4.0	7.0	-
Mating	-	-	1.3	-
Aggression - intraspecific	5.5	-	-	-
Aggression - interspecific	4.1	8.0	0.6	3.8

(Table 2, Fig. 1). Resting activity of solitary individuals was mostly during rains. The number of actual recorded feeding events was also lower for pairs as they devoted attention to mating and associated activities.

The proportion of time spent under major activities (foraging, feeding, resting, moving and mating activities) was significantly different across different time periods ($\chi^2 = 76.20$, $p < 0.05$, $df = 15$). As expected, foraging activity was more during morning and evening scans, i.e. soon after the animals came out or just before they retired. Resting or sleeping was recorded almost entirely in the late morning or afternoon scans. Bad weather affected foraging activities adversely; the animals were less active during rain than in sunny weather ($\chi^2 = 28.28$, $p < 0.05$., $df = 6$). There was an increase in resting activity and decrease in combined foraging and feeding activities during rainy weather (N=384) (Fig. 2).

Resting during daylight hours could be classified into two types: the animals pausing while foraging, usually sitting still on branches (average duration = 25 seconds, n=5); and longer resting periods involving solitary individuals or breeding pairs curling up on branches and sleeping for longer periods of time (average duration 13 minutes). Breeding pairs rested more often, and soon after mating. The average diurnal resting time (for long periods of rest) calculated for the study period was 1 hour 26 minutes for all individuals put together, 1 hour 12 minutes for solitary animals and 1 hour and 48 minutes for breeding pairs. These values incorporate resting periods for the rainy days that occurred during the study also. The animals rested comfortably on branches below vine-covered canopies or subcanopies with their tails curled around the body, staying motionless and evidently sleeping. Some daytime resting sites were used repeatedly by the Treeshrews. Sleeping animals were extremely well camouflaged

Table 2: Activity patterns of solitary individuals and breeding pairs

Activity	Activity budget (%)	
	breeding pairs (212 scans)	solitary animals (172 scans)
Foraging	56	58
Resting/Sleeping	15	10
Feeding	8	15
Moving	8	10
Mating chases	7	0
Aggressive interactions-interspecific	3	3
Aggressive interactions-intraspecific	0	2
Grooming	2	2
Mating	1	0
Scent marking	0	0

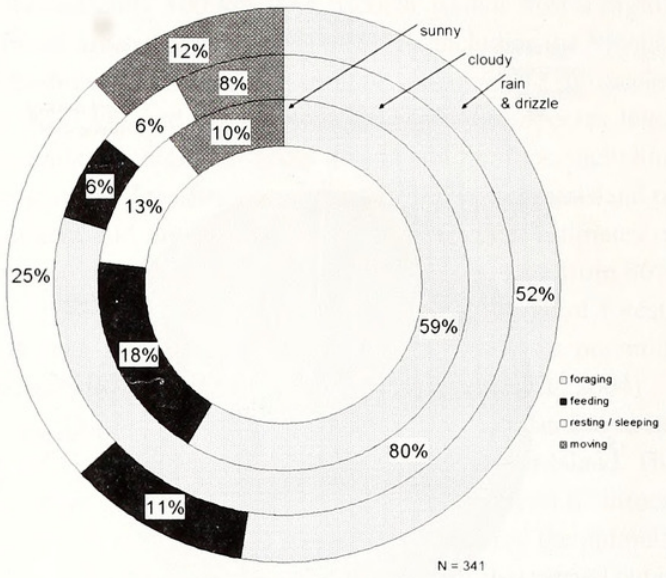

Fig. 2: Activity patterns of the Nicobar Treeshrew in relation to weather

and could only be spotted when they moved or while grooming. On two occasions, after copulation, the male was observed on top of the female (in the same position) for more than 10 minutes. Breeding pairs rested more often. Single resting sessions of animals lasted for up to 39 minutes. Some of the resting sites were exposed branches. However, it is suspected that these animals spent the nights in the thick foliage of *Pandanus* species that are found in abundance in the littoral forests of the island. No nest sites were discovered during the study, and there is no available information about the nesting of *T. nicobarica.*

Social organisation and other behavioural observations

It was observed that *T. nicobarica* moved solitarily or in pairs. Out of 311 instantaneous scans, 138 were of breeding pairs, 168 of solitary individuals and four were of two individuals of the same sex. Breeding pairs interacted often and it is suspected that they are monogamous. Individuals rested very close to each other, either with the nose of one individual touching the base of the tail of the other, or one on top of the other. It was not discovered if pairs spent the night at the same or nearby roost sites. However, it was noticed that before retiring for the night mating individuals called repeatedly to each other and moved away together in the same general direction.

Six mating events were recorded during scans (three more were recorded out of scan periods). The average duration of mating was approximately 16 seconds. Breeding pairs could be easily identified as males usually chased females while foraging and tried to mount them. The pairs seemed to be monogamous, and during one scan period the pair mated thrice within 5 minutes. Females showed aggression during

Table 3: Encounter rates from different parts of Great Nicobar Island

Area	Location	Distance (km)	Encounters	Encounter rate (per km)	Forest type
South	Indira Point to Chingen village	4	17	4.25	Littoral
	South Bay to Chingen village	4	14	3.5	Littoral
	South Bay to 36 km point	4	8, 17	2, 4.25	Littoral
West Coast	Kopen Heat-Shompen Hut road	3.5	9	2.57	Rainforest
	Alexandria beach to Kopen Heat	1.8	8	4.44	Littoral
Central	Shompen Hut road (13 to 17 km)	4	25	6.25	Rainforest

mating. Both the male and female occasionally clambered over each other immediately after mating. Pairs usually rested or slept after mating.

One set of aggressive interactions was observed between two males. An approaching male disturbed a male that was feeding on insects on cane buds and the latter was chased away. The intruder was chased a long way (more than 20 m) after both animals confronted each other in close contact, screaming loudly. This interaction was bloodless and was repeated a couple of times before the intruder retreated. Females sometimes showed aggressive behaviour during mating. After copulation, some females tried to push the male away and scolded loudly. Aggression with other species was demonstrated only with bird species in the feeding association. Feeding individuals sometimes screamed, scolded and chased both drongos and sparrow-hawks that infringed on prey that was flushed.

Scent marking was a frequently observed behaviour. They frequently rubbed their ano-genital region on branches. Chest and chin marking was observed once during scans. Scent marking was observed 15 times for a total scan period of two hours. The male was also seen urinating on the female on one occasion following mating. Pairs usually rubbed against each other, especially with the chest and chin.

T. nicobarica was observed to call frequently and to make different types of vocalisations. These included single noted squeals while solitary animals were foraging and moving from place to place, continuous alarm calls in the form of squeaks in the presence of predators, loud two or three noted shrieks of protest while feeding with birds or other individuals and calls of contact between individuals of a breeding pair.

Population Assessment

Encounter rates were recorded along transects in some accessible parts of the island (Table 3). Ninety-eight individuals were recorded over a distance of 21.3 km. The majority of individuals were located by their calls. Only 2% of the records are sightings where the animals were spotted before being heard. Therefore, absolute encounter rates are likely to be underestimates, but will serve for a broad level relative comparison between localities. The largest number of individuals were recorded in the rainforests in the central part of the island (6.25/km). The littoral forests in the southern part of the island had lower encounter rates.

DISCUSSION

Activity patterns

Emmons (2000) reports that the *Tupaia* species rested sporadically after being completely active during the first two hours of the morning and the same could be said of *T. nicobarica* as well.

The time of the day had an effect on the activities of the animals, as did bad weather. On days when there was heavy rain early in the morning, the Treeshrews delayed their foraging activities. A light drizzle, however, did not prevent them from foraging in the morning hours, probably because they could not afford to rest without feeding following a long night's fast. Treeshrews in Borneo are also known to respond in a similar manner during adverse weather conditions (Emmons 2000).

Tupaia are known to be active only during the day, and this was true of *T. nicobarica* also. The individuals in the study area were observed to be active from dawn to dusk (0507 hrs to 1730 hrs) (Table 1). It may be noted that the approximate sunrise and sunset times were 0500 and 1700 hrs respectively (Great Nicobar although considerably east of the mainland India follows Indian Standard Time). On some days initial calls were heard only well after the sun had risen but on most occasions the animals foraged frantically at dusk well after 1700 hrs. The emergence time in the morning was delayed if there was heavy rain. *Tupaia* in Borneo are known to leave their nests at dawn, but evening return times varied with feeding periods and weather conditions (Emmons 2000). For *T. minor* in West Malaysia, D'Souza and Martin (1974) report different results with late emergence times, except for days after heavy rainfall, when they emerged very early to forage.

Reproductive Behaviour

No information on the reproductive activity other than observations of mating could be obtained during the study period. Treeshrews are known to exhibit the 'absentee' maternal care system, which was first observed for captive *T. belangeri* (Martin 1968) and later for captive *T. minor* and *T. tana* (D'Souza and Martin 1974). This practice was also recorded among wild *T. tana* in Borneo (Emmons 2000). The significant feature of this system is the mother gives birth to her young ones in a separate nest and visits them only for a few seconds every other day to nurse. The young ones huddle and lie motionless and noiselessly in the nest to preserve body heat. They feed hysterically (almost 1/3 rd their body weight in milk) when the mother discreetly returns for a few seconds. The young ones also groom themselves from time to time as the mother does not spend any effort in cleaning or looking after them. The nests are clean and are known not to have any particular odour that might attract predators, and the mother is also known to return to the nest cautiously and using different pathways usually in the early hours of the morning, when few predators are about. The young grow rapidly owing to the highly nutritious nature of Treeshrew milk (which is known to be second only to seals' milk in terms of fat content). They are weaned and leave the nest in 25 to 33 days, after which the mother spends time with them grooming them and providing them with food. The nesting and post-partum behaviour of this species seem to be directed at predator avoidance. Emmons (2000) describes this pattern in detail.

It is likely that *T. nicobarica* also follows such an 'absentee' system, but no information is available. The litter size of a single *T. nicobarica* individual has been reported to be one (Lyon 1913). Although mating events were recorded between November and February, it is not clear if this reflects a more seasonal pattern. *Tupaia* species in Borneo had a broad breeding season from August to November and a second one from March to May and breeding is reported to be highly related to availability of fruit and invertebrate prey (Emmons 2000). In contrast to captive situations, wild treeshrews show low overall reproduction rates, probably due to nutritional limitations (Langham 1982; Emmons 2000).

It may be suggested here that *T. nicobarica* also possibly exhibits the 'solitary ranging pair' system reported by Kawamichi and Kawamichi (1979) for *T. glis* (= *belangeri*) and probably the Bornean Treeshrews. This refers to a social system where solitary animals that form a monogamous pair form a territory and defend it against other individuals of its own gender (the Type I or facultative monogamy described by Kleinman 1977. This pattern has been reported among a number of mammals including nocturnal prosimians, pikas, elephant shrews and Maned Wolf (Emmons 2000). Like *T. minor, T. nicobarica* pairs also sometimes spent the whole day foraging and resting together. This is unlike other *Tupaia* species that interact briefly. The pairs rested together during the day, but unlike *T. minor* that rested far apart on the same trees, *T. nicobarica* seem to be strongly pair-bonded and rested close together.

Other Behavioural Observations

Adults are known to scent mark branches, tree stumps and rocks either by rubbing their ano-genital region (with urine) or the chest and chin (in males, there is a musky and oily secretion from a glandular area in the neck). While urine markings lose their effect on conspecifics in a matter of minutes, mingling with the neck gland secretion usually cause them to persist for hours or days (Thenius 1990). Parent *T. belangeri* are known to scent mark their young ones to recognise their offspring during aggressive encounters with conspecifics (von Holst 1974). Stress caused to the mother prior to or during delivery sometimes results in the protective scents not being applied and devouring of the offspring by the mother (Thenius 1990). Stress and related aspects such as hormonal changes in captive treeshrews have been extensively studied for understanding the biology of stress in humans and other primates (von Holst 1974).

T. nicobarica are generally very alert animals. They are difficult to locate when they are silent, but contrary to what Emmons (2000) reports for some Bornean Treeshrews, the study animals called loudly and frequently, and as a result they were easily located. They were also not easily alarmed unless the investigator got too close. Natural predators for this animal in this area are few, as wild cats, mustelids, viverids or other mammalian carnivores are absent. In the study area, treeshrews were noticed to be alarmed in the presence of Crab-eating Macaques *Macaca fascicularis umbrosa*, Reticulated Pythons *Python molurus* and human-beings. It is possible that they are predated on by Crested-serpent Eagles *Spilornis cheela* and the young ones could be preyed on by small raptors, reticulated pythons and rats that are found in the island. Domestic cats belonging to settlers have been known to predate on the Treeshrews. The species exhibited a unique interspecific feeding association with Greater Racket Tailed Drongos *Dicrurus paradiseus* and an *Accipiter* (probably Chinese Sparrow-hawk, *Accipiter soloensis*) (Oommen and Shanker, in review). On many occasions, the Sparrow-hawk and Greater Racket-tailed Drongos were seen waiting a few feet away from resting Treeshrews, and it is also possible that these animals benefit from the alarm calls of the birds if predators approach. However, neither Drongos nor Sparrow-hawks made any alarm calls indicating the presence of people.

On many occasions it was suspected that Greater Racket-tailed Drongos were mimicking Treeshrew calls possibly to detect and join the latter. Emmons (2000) reports of a strange similarity between the alarm calls of *T. minor,* and *T. gracilis* with those of terrestrial pittas (*Pitta baudi, P. venusta*), but speculates this is a convergent trait. Alarm calls were reported to be frequent in the more social species such as *Ptilocercus lowii*, *T. minor* (Emmons 2000) and *T. nicobarica* and this may be related to predator detection strategies. Eight different vocalisations have been identified in *Tupaia* by Binz and Zimmerman (1989). These include loud 'squeals' of aggression, modulating 'screams' to indicate immediate danger, 'chatters' in response to disturbances and rhythmic 'clucking' and 'whistles' associated with courtship and mating.

T. nicobarica was observed to be a highly arboreal, diurnal and mostly insectivorous species during the period that it was studied. The most primitive living treeshrew (*Ptilocerus lowii*) is strictly arboreal and so is *T. minor*, which is similar in many ways to the study species (including the nearby island of Sumatra). However, the high arboreality of the Lesser Treeshrew *T. minor* is somewhat debated. Emmons (2000) did not observe the species on the ground, whereas D'Souza and Martin (1974) reported 11% of his sightings on the ground. Arboreality seems to be an ancestral trait among treeshrews. Arboreal *Tupaia* are, however, known to be more frugivorous. Initial results indicate a very pronounced insectivorous diet for the species. Only a handful of non-volant mammal species are known to forage arboreally for insects. From the present study, it appears that *T. nicobarica* is one of them.

On account of its high arboreality, insectivory and higher sociability, it would be interesting to investigate if *T. nicobarica* is an intermediary between *P. lowi* and *T. minor.* Further studies on this species may lead to solving questions about arboreality, insectivory and absentee parental care systems, all of which in turn could throw light on their radiation patterns. The present viewpoint is that *Ptilocercus*, with its cohesive social behaviour, and arboreality could be an antecedent of prosimians, but modern *Tupaia* seem to be improbable ancestors of primates, as they seem to have radiated terrestrially rather than arboreally and have different parental care and feeding systems (Emmons 2000). The foraging behaviour of *T. nicobarica* is almost identical to that of *T. minor* as described by Emmons (2000). It moves purposefully through the vegetation inspecting all types of foliage, green or dry curled leaves, tree ferns, dead wood and bark. Trees with a large number of climbers are often visited and inspected carefully, very often the animal pauses on its hind legs and pushing against twigs with the fore legs and then leans out to investigates leaves above. The foraging intensity is very high and sometimes the animals spend hours on a single tree. The insect prey of *T. nicobarica* and *T. minor* may be similar on account of the similarity in foraging patterns and sites. Scats of *T. minor* examined by Emmons (2000) contained Orthoptera of two kinds, crickets and cockroaches (50%), beetles (21%), and caterpillars and spiders (10%). Davis (1962) and Lim (1967) also found ants. Emmons (2000) also reports that although the prey base is extremely large (being tropical rainforests), *T. minor* generally ate the most common non-flying or slow-to-fly arthropods.

T. nicobarica is similar to *T. minor* in appearance, arboreality and most of its behaviour. Therefore, it is possible that the latter may be more frugivorous during some periods, especially when fruiting peaks occur. A detailed study of the phenophases of fruit trees may be required before conclusions about the degree of frugivory of the species under study can be reached. Emmons (2000) reports that the fruit eating pattern in most species follows habitat-wide overall fruiting phenologies and that during some months they were not detected to be eating any fruits.

Conservation Status

On the basis of their geographical separation, two subspecies have been recognised: *T. nicobarica nicobarica* Zelebor 1869 on Great Nicobar Island and *T. nicobarica surda* Miller 1902 on Little Nicobar Island. Till date, molecular studies have not been carried out to examine if these populations are really distinct. The taxonomic references available for *T. nicobarica* are (1) *Cladobates nicobaricus* Zelebor 1869, Reise Novara, Zool. Theil., 1 : 17, pl. 1. figs 1, 3 and pl. 2 (2) *T. nicobarica* Blanford (1888 – 91, p. 212) Ellerman and Morrison-Scott (1951, p. 12). Napier and Napier (1967, p. 330). (3) *T. nicobarica surda* Miller 1902, Proc. U.S. Nat. Mus. 24 : 774.

T. nicobarica nicobarica and *T. nicobarica surda* have been classified as endangered (B1 & 2C) by the IUCN (1995). This status has been accorded due to the restricted distribution of the species. The combined area of occupancy for the two subspecies in The Great and Little Nicobar Islands put together is less than 1,200 sq. km. No prior population estimates were available for this species.

The numbers of *T. nicobarica* seem to be comparable to those from Southeast Asia, but since the encounter rates are underestimates, and since actual densities could not be calculated, formal comparisons are not being made. The densities of *T. glis* varied between 6-12 per ha in Thailand (Lekagul and McNeely 1977) and 2-5 per ha in Malaysia (Langham 1982). Emmons (2000) reports that for six species

of Bornean treeshrews, densities ranged from 0.13 to 1.2 individuals per ha.

There are no direct threats to the species at present. The habitat of this species is presently well protected, and in relative terms may be regarded as one of the least populated and most pristine protected areas of the country (Oommen, *in press*). The adequacy of the protected area network in this area has been examined for taxonomic groups such as birds (Sankaran 1997), and the some of the recommendations hold true for endemic mammals such as the Nicobar Treeshrew. For example, the need for protection of the southern part of the island from development activities and the inclusion of the buffer zone between the Campbell Bay and Galathea National Park into the formal protected area network as suggested by Sankaran (1997) would provide a large contiguous patch of protected forest. The treeshrews are not hunted; on the other hand Nicobari villagers keep some individual as pets. However, owing to the highly arboreal nature of the species, and due to recorded adverse effects on a similar arboreal species (*T. minor*) to selective logging, it is suggested that the canopy contiguity of the forests be maintained to ensure the survival of this species. Also, introduced carnivores, especially domestic cats are known to successfully predate on *T. nicobarica* and might decimate local populations if the number of human settlements increases. *T. nicobarica* may be regarded as a species of high conservation importance for India, as it is an endemic *Tupaia* and one of the three species of the narrowly distributed and primitive order Scandentia.

Extensive areas in both the Great and Little Nicobar islands were submerged and partially destroyed as a result of the Indian Ocean tsunami of December 2004 (Andrews and Vaughan 2005). The intensive study area at the Galathea river mouth is believed to have been entirely flooded, and the same applies for some of the other areas that were surveyed. Although some amount of habitat alteration would have taken place, it is likely that this species may not have been adversely affected at least in the interior of Great Nicobar, which has higher terrain. There have been some unconfirmed reports that a great deal of wood will be extracted from the forests to rebuild the destroyed settlements in the area. Forest Department rules at this point of time are likely to be relaxed and it may be inevitable that some amount of trees will be cut for this purpose; as the number of settlements is small, this activity may not cause significant changes. *T. nicobarica* is of interest from biological and conservation perspectives, and future studies and surveys may provide interesting insights.

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