The Nicobar megapode

Status, ecology and conservation: Aftermath tsunami

K Sivakumar

Final Report

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Dehradun

February 2007

Acknowledgements

This survey was jointly carried out by the Wildlife Institute of India and the Andaman & Nicobar State Forest Department especially the Campbell Forest Division. I thank all the TRAC members of WII for encouraging to take up this task. I am grateful to Sh P.R. Sinha, Director, Wildlife Institute of India for his guidance and encouragement. Thanks to Prof.. V.B.Mathur , Dean, WII and Prof. B.C. Choudhury, WII for their help and encouragement. I am also thankful to all my faculty colleagues, Researchers and staff of WII for their help and encouragement.

I am grateful to Sh S.S. Choudhury, PCCF(WL), A&N FD, Sh Madhava Trivedy, CF(WL) and Sh C.R. Mallick, DFO, Campbell Bay, Sh J.C. Jayaraj, CF, Sh Ravichandran, DCF(WL), Sh Dharma Rao, Sh S. Durai, Sh Jona Phillips, Sh. Vishnudevan of Forest Department for their support and help. Thanks to Sh Nagendra Kumar, Sh Mahindra, Sh John, Sh Sivanandan, Sh Ravisundaram, Sh Virendra Sharma and all Nicobarese for their help in the field.

Special thanks to Dr. Ravi Sankaran, Dr. R. Jayapal, Dr. R.W.R.J. Dekker, Dr. Darryl Jones and Dr. Guntram for their valuable comments and suggestions on the final report.
I wish to acknowledge the contributions made by Sh S. K. Mukerjee, Sh V.B. Swarkar, Dr. A.J.T. Johnsingh, Dr. Asad Rahmani, Dr. K. Sankar, Dr. Qamar Qureshi, Dr. Karthikeyan Vasudevan, Dr. B.S. Adhikari, Dr. K. Ramesh, has greatly helped my research on megapode.

I thank the Andaman & Nicobar administration especially the District Commissioners of Andaman and Nicobar districts, Assistant Commissioners of Camphell Bay and Nancowry for their support.

Last but not the least, I am grateful to my survey team members Mr. Samuel Andrew, Mr. Jugulu Mehato, Mr. Chandrasekar Rao, Mr. S. Sivakumar, Mr. Koruma Rao, Mr. Damodhar Rao, Mr. Alkana, Mr. Rajan, Mr. Maianeus, Mr. Simos, Mr. James, Mr. Samuel and Mr. Rahul for having worked with me in a harsh climate. Their excellent cooperation and hard works made this survey successful. I am also grateful to my wife and son who have been a source of encouragement and suffered missing me for such a long period.

Executive Summary

1. The Wildlife Institute of India conducted a status survey of the Nicobar megapode along with other coastal endangered species in the Nicobar group of islands in an effort to document the adverse impacts on their populations due to tsunami that occurred on 26^{th} December 2004. The endemic Nicobar megapode population showed a dramatic decline (nearly 70%) in the number when compared to previous survey carried out in 1993-94. In 2006, there are approximately 800 breeding pairs in the coastal zones of these island group.
2. There was no evidence of Nicobar megapode in Megapode Island WLS and Trax Island during this survey where megapodes was reported earlier.
3. Crucial megapode habitats such as littoral forests of the island group were adversely affected. The populations of indicator species of the littoral forests *Barringtonia asiatica* and *Terminalia bialata* were severely impacted. However, regeneration of these species was found on the coastal region.
4. The island ecosystem are known for their resilience due to their ability for re-populating habitats and promoting regeneration. However, the restoration of the original biodiversity is possible only if the natural process such as recolonization is facilitated. The aftermath of the tsunami has left the trail of homeless families who need rehabilitation. Finding proper homes and alternate livelihood for them should not undermine ecosystem resilience. Raising plantation crops to generate revenue in the littoral forests should take into account the long term effects of habitat alteration.
5. Significant levels of wildlife habitats have been occupied by the tribals under the leadership of the tribal chiefs (known as Village Captain). Any conservation awareness programme with the help of these Village Captains would be useful for implementing recovery plans of declining species.
6. The Nicobar Division of the State Forest Department needs to be strengthened to facilitate wildlife protection and to take up appropriate wildlife management actions.
7. A total of 37 permanent monitoring plots have been identified and marked (Table 2) for long term monitoring of megapodes and its habitat. With some basic training, forest staff can collect data from these plots and within a weeks time all islands can be surveyed and collected data analyzed for developing appropriate conservation and management measures.

Content

Chapter 1
The Nicobar megapode

1.1. Introduction

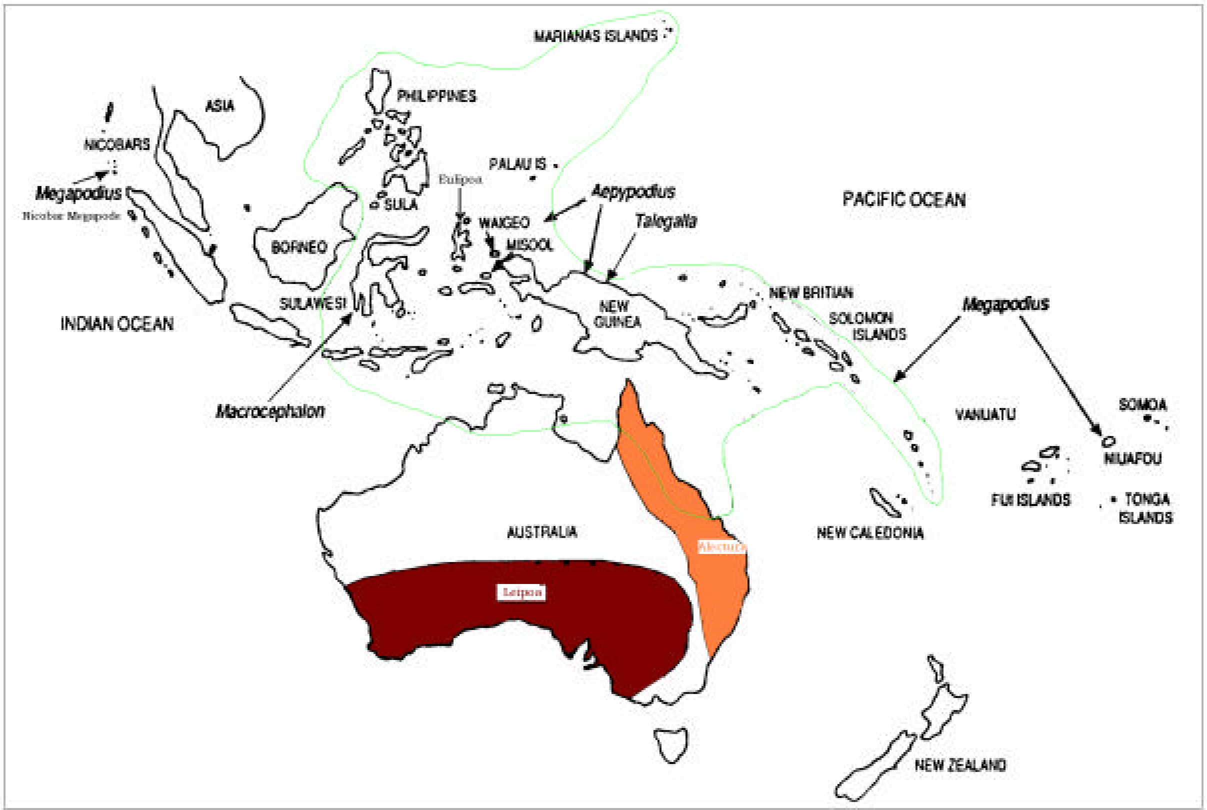
The megapodes are a unique group of birds as they utilise external sources of heat to incubate their eggs (Jones *et*. *al*. 1995). The Megapodiidae, literally meaning big feet after the disproportionately large feet of the birds, were first described to science during Magellan's 1519-1522 expedition to the Far East (Frith 1956 & 1959). The family Megapodiidae consists of 22 species in seven genera, most of which are island forms occurring in Australia, New Guinea and surrounding islands, eastern Indonesia, the Philippines, Niuafo'ou Island, the Palau and Mariana Islands and the Nicobar Islands (Dekker 1989, 1990 & 1992). Thirteen of these 22 species are currently threatened by habitat destruction, introduction of predators and over-exploitation of eggs (Jones *et al*. 1995).

Megapodes are heavy-bodied birds of the forest floor and resemble Galliformes in body shape and plumage. Most megapodes are brown, blackish, or grey in colour. Many have virtually bare areas on their face or neck and this exposed skin may be coloured yellow, blue, or dull red. Megapodes are opportunistic ground foragers, eating a wide variety of food such as insects, seeds, and fallen fruits. Although all are able to fly, and some make considerable flights on a daily basis, most species move primarily by walking (Jones *et al*. 1995).

The taxonomic position of the family Megapodidae is still subject to debate (Jones *et al*. 1995). In the past, megapodes were believed to have more affinities with Charadriiformes, Columbiformes, Passeriformes and even Falconiformes. Later megapodes were included in the order Galliformes along with Guans and Curassows which are sometimes classified under a separate order Craciformes (e.g. Sibley and Monroe, 1990). In 1899, Sharpe divided the Galliformes into several suborders, the "megapodii" was first among them. After studying the osteological, karyological and biochemical properties of egg white proteins of megapodes and other galliformes, Megapodiidae was considered as the sister group of all remaining Galliformes (Jones *et al*. 1995).

The family Megapodiidae contains seven genera : *Megapodius, Macrocephalon, Talegalla, Aepypodius, Alectura, Leipoa* and *Eulipoa*. The genera *Megapodius* and *Eulipoa* have the smallest megapodes and their geographical variation is considerable but most are domestic-chicken-sized birds with short tails and a short pointed nuchal crest (Beehler *et al*. 1986). The monotypic genus *Macrocephalon* is closely related to the genus Megapodius. The *Talegalla* species do not have wattles and are large sized black coloured megapodes. Alectura is considered to be closely related to *Talegalla* and *Aepypodius*, a group known as the Brush-turkeys, each having a bare neck and face that may be brightly coloured (Jones *et al*. 1995). *Alectura* and the two *Aepypodius* species also possess inflatable necksacs or wattles and combs, and have brilliantly coloured heads and necks (Jones *et al*. 1995). The Brush-turkeys are the only group in which sexual dimorphism is evident, with the males being slightly larger and more colourfully ornamented than the females. The *Leipoa* species is characterised by their contrasting body colour, dense feathering on head and neck, short and thin bill and short legs.

Figure 1.1. Distribution of the megapodes (source Jones 1989b)



The Megapodiidae are mainly found in the Indo-Australian region east of Wallace’s line (Jones *et al*. 1995) (Fig 1.1). There are three exceptions to this: *Megapodius nicobariensis* from the Nicobar Islands, *Megapodius pritchardii* from Niuafo’ou Island and *Megapodius laperouse* from the Pulau and Marianna Islands. Based on these exceptions, Lister (1911) said that these species were introduced into the respective islands by domestication and then transported from one island to another. This theory was later rejected and two new theories were presented to explain the distribution of the megapodes. Olson (1980) considered Phasianids and Megapodes as ecological counterparts that could not co-exist, and suggested that the megapodes were restricted largely to islands, due to the presence of galliformes on neighbouring mainlands. However, the co-occurrence of the Green Jungle Fowl *Gallus varius* and Orange-footed Megapode *Megapodius reinwardt* in the Lesser Sunda Islands, and similar cases of sympatric distribution of both Phasianids and megapodes in Palawan and Borneo, led to an alternative theory proposed by Dekker (1989). Based on mammalian predation, especially by cats and civets, Dekker (1989) proposed that mammalian carnivores prevented the expansion of the megapodes westward. The high predation pressure associated with the wide variety of large predators on the Greater Sunda Islands and on the mainland of Southeast Asia rendered these regions unsuitable for mound-building megapodes. The fact that the Nicobar Islands have never had a land connection (Dekker 1989) and are thus devoid of carnivores could explain the occurrence of the Nicobar Megapode. The predation theory, however, is also debatable because of the coexistence of carnivores (Little Civet *Vivericula indica* and Leopard Cat *Prionailurus bengalensis*) and the Orange-footed Megpode on the Lesser Sunda Islands (Jones *et al*. 1995).

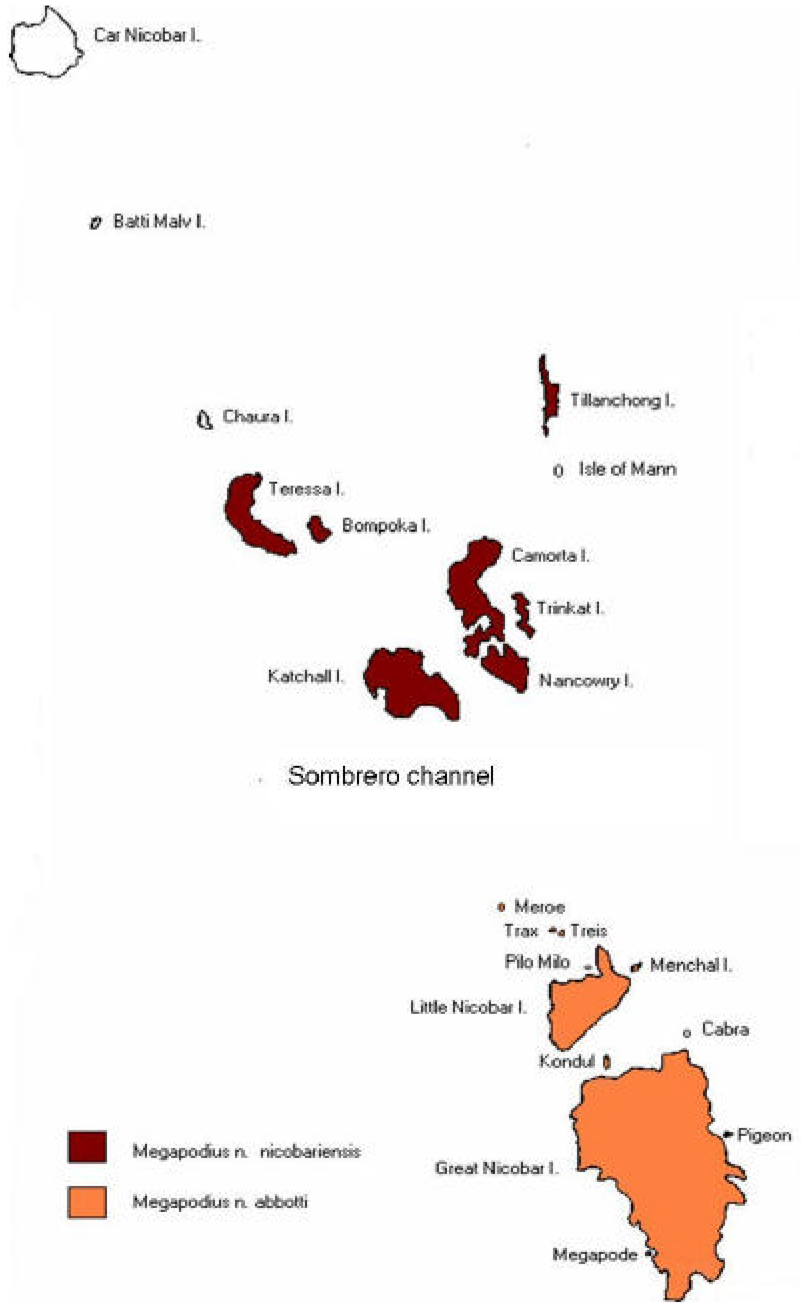
Megapode eggs are large and heavy compared with the eggs of birds of equivalent size, and 48 to 69 per cent of weight of the egg contents is yolk (Dekker and Brom 1990). These large-sized eggs are incubated by the megapodes in mounds or burrows. Based on this, megapodes are divided into two groups: species that lay eggs in burrows in geothermally heated soils are called burrow nesters (eg. *Macrocephalon maleo*) and the mound builders, which construct mounds of decomposing vegetative matter (eg *Megapodius nicobariensis*).

1.2. The Nicobar Megapode

The Nicobar Megapode *Megapodius nicobariensis*, a mound nesting megapode, is endemic to the Nicobar group of Islands in the Bay of Bengal, separated from its nearest congener by a distance of over 1500 km (Olson 1980). The polytypic Nicobar Megapode has two subspecies. *M. n. nicobariensis* Blyth, is present in the Nancowry group of Islands north of the Sombrero channel, and *M. n. abbotti* Oberholser, is found on the Great Nicobar group of Islands lying south of the Sombrero channel (Hume and Marshall 1878, Abdulali 1964, Ali and Ripley 1983, Fig 1.2).

A pair of the Nicobar megapode working on their mound nest

Figure 1.2. *Megapodius nicobariensis* occurs as two subspecies. *M. n. nicobariensis* found in the Nancowry group of Islands north of Sombrero channel and *M. n. abbotti* found in the Great Nicobar group of Islands.



The Nicobar Megapode is a terrestrial brown or reddish-brown bird with a pinkish-red bare patch around the eye and a greyish crown; the dorsal side of the leg is blackish-brown and the ventral side is yellowish. They are usually seen in pairs in forests close to the beach, the sexes are alike (Hume 1874, Sivakumar and Sankaran, 2003 and 2005). The total body length is 37-40 cm (Hume 1874, Ali and Ripley 1983, Jones *et al.* 1995, Table 1.1). Newly-hatched chicks have the crown, upperparts, and upper wing rufous brown, and the under parts a dull cinnamon-brown, sometimes with slight grey tinge, with the lower back inconspicuously rufous and black (Ali and Ripley 1983).

Table 1.1. Morphometric characters of *M. n. abbotti* (Sivakumar, 2000).

Bird	Structure	mm/gram* (Mean±SE)	n
Adult female	Tarsus	72.45 ±SE 0.56	6
	Wing	231.2 ± 3.99	6
	Culmen	27.8 ± 0.25	6
	Weight	783.5 ± 28.48	6
Adult male	Tarsus	73.69 ± 0.85	11
	Wing	243.45 ± 3.15	11
	Culmen	27.44 ± 0.34	11
	Weight	758.09 ± 25.42	11
Chick	Tarsus	25.6 ± 1.14	17
	Wing	87.96 ± 1.7	17
	Maxillary	18.3 ± 0.3	17
	Weight	63.9 ± 3.9	17
Egg	Length	83.6 ± 0.73	36
	Width	49.0 ± 0.3	36
	Weight	109.4 ± 5.8	36

* Weights are in gram and lengths are in mm

1.3. Historical distribution of the Nicobar megapode

Historically the Nicobar Megapode occurred on most Nicobar Islands (Hume 1874; Kloss 1903; Dekker 1992; Sankaran 1995a&b) barring Car Nicobar (Butler 1899), Chaura (Abdulali 1967) and Bati Malv (Sankaran 1995a). There were a few records from the Andaman group of Islands (Hume 1874; Butler 1899; Sewell 1922) and from the Coco Islands further north (Kloss 1903; Abdulali 1964). None of the records from the Andaman group are of recent origin and the species is now believed to be absent there (Sankaran 1995a & b). It may have existed on Car Nicobar a century ago (Kloss 1903) but no traces of mounds were found there (Sankaran 1995a&b). The Island of Chaura is only 11.5 km from Teressa and, considering the megapode's occurrence on the more remote Tillanchong, there is no reason why it should not have existed in Chaura (Sankaran 1995b). The presence of what was most probably an ancient mound indicates that the megapode did occur on Chaura historically (Sivakumar 2000). However, both Car Nicobar and Chaura are much too densely populated for the species to exist there now.

1.3.1. Megapodius nicobariensis abbotti Oberholser, 1919.

M. n. abbotti is common in all coastal forests, particularly uninhabited or sparsely inhabited areas, on Great and Little Nicobar. *M. n. abbotti* is believed to have disappeared from all areas colonised by mainlanders (Dekker 1992), but they continue to survive in small remnant pockets (Sankaran 1995b). Seven of the nine islets in the Great Nicobar group have habitat suitable for megapodes and two (Cabra and Pigeon) are too small. Small populations of megapodes are present on six of these seven islets. The seventh islet, Pilo Milo is inhabited, and the islet is mostly under coconut palms. Megapodes are apparently extinct on this islet. Over 50% of the forests of uninhabited Meroe, Treis, Trax, Menchal and Megapode Island have been converted to coconut plantation, and populations of megapodes on these islands are threatened (Sankaran 1995b).

1.3.2. Megapodius nicobariensis nicobariensis Blyth, 1846.

M. n. nicobariensis occurs on seven islands of the Nancowry group (Sankaran 1995b). On Camorta, Katchall and Trinkat, *M. n. nicobariensis* is patchily distributed, with very few locations having active mounds. Good populations of megapodes exist on Teressa and Bompoka and the density of active mounds is similar to that of Great and Little Nicobar. Tillanchong is mainly hilly with very little level coastal forest, thus megapodes are naturally scarce except in the low lying coastal forests.

1.4. Population status

The Nicobar Megapode is considered to be seriously endangered (Jones 1989; Jones and Birks 1992), and has featured in several lists of endangered species (e.g. Collar and Andrews 1988). In 1988, the extinction of the megapode from Kondul was reported, a population of less than 400 birds was estimated on Great Nicobar and the extinction of this species was predicted in the next 10 years (Sankaran, 1995b). However, Dekker (1992) estimated the population of *M. n. abbotti* at about 780 breeding pairs (if not more) in the coastal area of Great Nicobar and concluded that it was not threatened there. The population of *M. n. abbotti* was estimated to be between 3400 and 6000 birds and the number of active mounds at 849 (Sankaran 1995a). The population of adult breeding birds of *M. n. nicobariensis* was estimated to be between 1200 and 2100 birds and the number of active mounds to be a little over 300 (Sankaran 1995a). Currently, *Megapodius nicobariensis* is considered as vulnerable (Sankaran 1995a&b).

The Nicobar Megapode is protected under Schedule I of the Indian Wildlife Protection Act (1972) whereby hunting and trade is prohibited. However, as per the Section 65 of the Indian Wildlife (Protection) Act, 1972, nothing in this Act shall affect the human rights conferred on the Scheduled Tribes of the Nicobar Islands in the Union territory of Andaman and Nicobar Islands by notification of the Andaman and Nicobar Administration, No.40/67/F, No.G635, Vol. III, dated the 28th April, 1967. As per this Act, the ethnic tribes of the Nicobar Islands (Nicobarese and Shompen) are allowed to continue hunting on wild animals including the megapodes.

Chapter 2
The Andaman and Nicobar Islands

The Andaman and Nicobar Islands (latitudes 6^o 45' and 13^o 41' and longitudes 92^o 12' and 93^o 57') in the Bay of Bengal arch from Arakan Yoma in Mayanmar in the north to Sumatra in Indonesia in the south (Saldanha 1989; Dagar *et al*. 1991). The islands cover an area of 8,249 km^2, with a total coastline of 1962 km; the Andaman group has more than 325 islands (21 inhabited) covering 6,408 sq km, and the Nicobar group has over 23 islands (12 inhabited) with an area of 1,841 sq. km (Singh 1981; Saldanha 1989).

2.1. The Nicobar Islands

The Nicobar Islands can be subdivided into three distinct subgroups based on ornithological affinities (Sankaran 1997). To the south lies the Great Nicobar group consisting of two islands over 100 km^2 in area, nine islets less than five km^2 in area, and a few rocks. Among them, Great Nicobar, Little Nicobar, Kondul and Pilo Milo are inhabited, while Meroe, Treis, Trax, Menchal, Megapod, Cabra and Pigeon are uninhabited. Fifty-eight km north of the Great Nicobar group is the Nancowry group (middle Nicobar Islands), which consists of three islands larger than 100 km^2, two of 36 and 67 km^2, three less than 17 km^2, 2 small islets and a few rocks. Except islets, all other islands of Nancowry group are inhabited. The northernmost subgroup comprises of Batti Malv and Car Nicobar, which is 88 km north of the Nancowry group. Batti Malv is uninhabited and Car Nicobar has a population of over 19000 people (Sankaran 1995b).

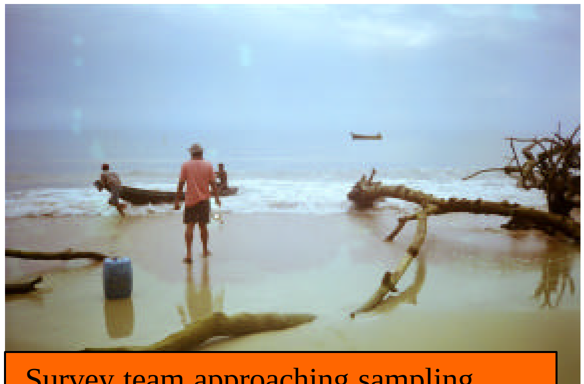
The shore line of Nicobar Islands are endowed with varied landscapes such as rocky shore, sandy beaches, backwaters, bays, lagoons, mangrove forests and coral reefs. To the interior most of the islands have undulating terrain with the main ridges running north-south, falling steeply and irregularly on both sides to the floor of the Bay of Bengal and the Andaman sea. The Great Nicobar groups is significantly more hilly than the Nancowry group, with the hight peak, Mt. Thullier at 670 MSL.

The soil shows considerable variability from heavy clay, loams, gravelly loams, sandy loam and sand. The depth of soil depends on the slope, with deep alluvial deposits often found along the lower reaches of the creeks. The soil lacks humus due to continuous leaching by heavy rainfall.

Four Islands in the Nicobar group have areas protected as wildlife preserves, and all islands are tribal reserves. Tillanchong, Batti Malv and Megapode Island, all uninhabited, are Wildlife Sanctuaries. Great Nicobar has two National Parks (536 km^2) and is also a Biosphere Reserve (885 km^2), whose core areas are the National Parks (Sankaran 1995a).

2.2. **Flora**

The vegetation and the floristic composition of the Car Nicobar group, Nancowry and Great Nicobar groups of islands differ from one another (Thothathri 1962). In general the vegetation of the Nicobar Islands can be classified into six groups: Marine vegetation, beach vegetation, tidal mangrove forest, inland evergreen forests, patches of deciduous forest and grass land and open vegetation (Thothathri 1962).



Survey team approaching sampling area

The beach forests or the dune forests are restricted to the beaches of fine calcareous sand which stretch along the shores. Creepers that mark the beginning of beach vegetation are *Ipomoea per-caprae, Vigna retusa, Ischaemum muticum, Phyla nodiflora* and herbs like *Acalypha indica* etc. *Scaevola frutescens* is the immediate successor to these plants. *Tournefortia argentina* is a large shrub with silvery pubescent leaves and is very common in Katchall, Camorta and Great Nicobar Islands (Thothathri 1962). *Pandanus leram, Pandanus tectorius* and *Pandanus furcatus* grow luxuriently in this forest. The shrub layer is accompanied by trees like *Barringtonia asiatica*, *Terminalia catappa*, *Calophyllum inophyllum*, *Hernandia peltata*, *Pongamia pinnata*, *Heritiera littoralis*, *Ficus rumphii*, *Odina wodier* and *Syzygium samarangense*. *Cycas rumphii*, *Cerebra manghas* and *Cerbera odollam* grow well under the shade of these trees. *Casuarina equisetifolia* is present on Great Nicobar. The ground cover consists of grasses like *Centotheca lappacea*, *Oplismenus compositus, Chrysopogon aciculatus*.

Mangrove forests are found in patches of varying sizes in most islands. The dominant species present in this mangrove forests are *Rhizophora mucronata*, *Bruguiera gymnorrhiza, Excoecaria agallocha, Carallia brachiata, Sonneratia acida, Timonius jambosella* and *Nipa fruticans*.

True tropical evergreen forests are present in the Nicobar Islands (Thothathri 1962). In Great Nicobar the forests are extensive and completely cover the hill ranges and even lowland areas. The most common and dominant tree species in tropical evergreen forests of Great Nicobar are *Calophyllum soulattri, Sideromylon longipetiolatum, Endospermum malaccense, Garcinia xanthochymus, Adenanthera pavonia, Albizzia lebbek, Pisonia excelsa* and *Mangifera sylvatica* (Sahni 1953). Patches of deciduous forest with *Terminalia procera* and *Terminalia bialata* have been reported at low elevations in Great Nicobar (Sahni 1953). The forest floor is covered with herbaceous plants such as *Blumea myriocephala, Lasianthus laevicaulis, Homalonema aromatica, Adenostemma viscosum* and *Maranta dichotoma*. In areas where rainwater accumulates *Helminthostachys zeylanica* is common, growing together with *Polygonum flaccidum* (Thothathri 1962).

Grasslands are peculiar to Camorta, Nancowry, Trinkat, Terressa and Bompoha Islands (Thothathri 1962; Sankaran 1995b) and in some patches of Chaura and Car Nicobar. *Imperata cylindrica* and *Saccharum spontaneum* are the most dominant grass species present in these islands (Thothathri 1962).

2.3. Fauna

The Nicobar Islands are the summits of a submarine mountain range contiguous with the Arakan Yoma of Burma (through the Andaman Islands) in the north and the island festoons of Sumatra in the south. The Nicobar Islands contain an impoverished Sumatran fauna (Smith 1930), but Stoliczka (1870) remarked that several species of lizard and snake are common to both Andaman and Nicobar Islands, and the whole fauna generally resembles the Malayan, gradually passing into Burmese fauna. Affinities of mammalian and avian species of these islands seem to be closer to India than Burmese and Malay (Abdulali 1964). The islands are characterised by the absence of large mammals and the presence of a significant number of endemics among the island's vertebrates (Sivakumar 2000).

Within the Nicobar group of Islands there are notable differences in the faunal profile (Sankaran 1997). For example, the Nicobar Parakeet *Psittacula caniceps* occurs on Great Nicobar, Little Nicobar, Kondul and Menchal but is absent in the Nancowry group. The Nicobar Bulbul *Hypsipetes nicobariensis* is present in the Nancowry group but is absent in the Great Nicobar group. The Nicobar Racket-tailed Drongo *Dicrurus paradiseus nicobariensis* occur on Great Nicobar, Little Nicobar, Katchall, and Car Nicobar but is absent on other islands of the Nancowry group (Sankaran 1995b). The differences are also evident in the herpetofauna; Pit vipers are common on the Nancowry group but are absent in the Great Nicobar group. The Nicobar Crab Eating Macaque *Macaca fascicularis umbrosa* is present only on Great Nicobar, Little Nicobar and Katchall. The Nicobar Tree Shrew *Tupaia nicobarica* is present on Great Nicobar and Little Nicobar Islands but is absent on other Nicobar Islands (Tikadar and Das 1985).

2.4. Climate and weather

The island is exposed to both south-west and north-east monsoons, with an average rainfall of 200 cm (Sivakumar, 2000). The bulk of the rainfall comes during the southwest monsoon, and the wettest months are August to November, while the driest months are February and March when less than 5 cm of rainfall is received. The climate is humid, tropical-coastal due to its proximity to the equator. The average temperature varies from 25.5^{o}C and 34.4^{o}C. The average relative humidity is 80.8% and seldom goes below 70%. The islands get northeast wind from November to January and southwest from May to October. Cyclones sometimes bring huge devastation, endangering life. These islands are prone to earthquakes, which were experienced several times during the study period.

2.5. People

The survival, amelioration or degradation of ecosystem depends largely on man. Within the confines of an island ecosystem, the arrival of humans, especially in large numbers, can bring about great changes. Great Nicobar shows the impact of such an intervention. The human population on Great Nicobar (6831 people) has both tribal (8%) and mainland Indians including settlers. The tribals are thinly distributed along the southern, western and northern coasts and interior forest. Nearly 55% of the mainlanders are in the township of Campbell Bay midway up the east coast, and the remainder pursue agrarian livelihoods along the south-eastern coast.

Two groups of tribals inhabit Great Nicobar. The Shompen,who now number less than 150, are a semi-nomadic tribe who inhabit the forests of the central uplands. It is probable that they were pushed into inaccessible areas by the Nicobarese who have several settlements along the coast. The Nicobarese constitute the largest tribal group in the islands. Belonging to the Mongoloid race probably the Indomalayans, these horticulturist-herders now number around 400 on Great Nicobar.

Communities in Nicobars have a long tradition of natural resource use. They depend on natural habitats as a source of food, fuel, and building materials. Traditional forms of natural resource exploitation can be sustainable when practiced by human populations living at low densities to meet their subsistence needs. But recent decades have been characterized by unprecedented economic, social, and demographic changes. With a high population growth rate, general lifestyle is marked by high degree of consumption. These changes led to overexploitation of natural resources and inadequate development planning, which exert significant impacts on biodiversity.

2.6. Tsunami

The earthquake of magnitude 9.15 with its epicentre at 3.29^{o}N and 95.94^{o}E off the coast of Sumatra with a focal depth of 30 km occurred on 26th December 2004 at 06: 28: 50 hrs. The earthquake occurred at the interface between the India and Burma plates and the epicentre was very close to the Nicobar group of islands. The tsunami that followed was within a few minutes of the earthquake. The tsunami waves reached the coast first, causing a phenomenon called draw down, where the sea level dropped considerably. The draw down was followed by the crest of the wave, which resulted in sea inundating land, also known as the run-up. There appears to have been three waves in succession, with the second being the largest. The waters took several days to recede completely, leaving in its wake a devastation of unimaginable magnitude on the people and wildlife of Nicobar islands (Sankaran, 2005). In Nicobar group of Islands where endemism is very high in some faunal groups such as mammals, birds and reptiles, it was expected that the highly diversified coastal biodiversity with high endemism may have been adversely affected by the tsunami. With this assumption, the Wildlife Institute of India conducted a status survey of certain focal endangered species such as the Nicobar megapode and their habitats in the Nicobar group of islands.

Chapter 3

Objectives

Though the ecology of the Nicobar megapode is fairly well known (Sivakumar 2000), the information on the population trends is essential for the long-term conservation status of this species (Dekker *et al.* 2000). It was also expected that the coastal living Nicobar megapodes might have adversely been affected by the tsunami. Hence, this study was proposed with the following objectives.

1. To assess the present conservation status and distribution of the Nicobar Megapode *Megapodius nicobariensis*

2. To assess the habitat availability, threats and conservation of this species.

3. To identify the permanent sampling sites for continuous long-term monitoring of population and habitat of these birds.

Littoral forest of southern tip of the Great Nicobar Island before (A) and after (B) tsunami

Chapter 4

Methods

The Nicobar islands have been surveyed between 10 March 2006 and 7 May 2006. Firstly, the southern group of Nicobar islands were surveyed using seven observers between 10 March 2006 and 5 April 2006, and between 26 April 2006 and 30 April 2006. Nancowry group of islands were surveyed using same man power between 7 April and 25 April 2006. A total of 15 islands have been surveyed. A boat was used to reach each sampling points. This survey has covered the entire range of the Nicobar megapode, except the Megapode Island, which could not be sampled as entire island was under water.

Megapode habitat: coastal littoral forests are better habitat of the Nicobar megapode.

As mounds are stationary, inanimate and represent breeding signs, the best way to estimate and monitor the megapode populations is by assessing the number of active mounds those in use (Sankaran 1995b, Sivakumar & Sankaran 2003). The coastline of 15 islands where the species was reported earlier have been surveyed for mounds by following standardized survey protocols (Sankaran 1995b). To estimate the total number of active mounds, the coastline of each island was divided into two segments such as 'Potential coastal habitat for megapode (PCHM)' and 'Non-conducive coastal habitat for megapode (NCHM)'. Potential coastal habitat of megapode was identified based on habitat preference of this species (Sivakumar, 2000). Various habitat parameters have been considered to identify these two habitats which are listed in the Table 4.1. Total available PCHM and NCHM areas of each island were measured by ground-truthing all around the island using a pedometer, GPS, a small boat and the latest satellite habitat imageries.

Table 4.1. Various habitats considered for *Potential coastal habitat for megapode* (PCHM)' and '*Non-conducive coastal habitat for megapode* (NCHM)'

Sl. No.	Potential coastal habitat for megapode	Non-conducive coastal habitat for megapode
1	Low-lying coastal habitat between beach and up to near by hills	Coastal habitat with cliffs, hilly and rocky

2	Coastal habitat with sand and sandy-loam substratum	Substratum with muddy or clay
3	Coastal habitat with dry deciduous forests	Mangrove, grasslands, coconut plantation
4	Coastal habitat without inundation during monsoon or high tide	Inundation during monsoon or high tide
5	Coastal habitat without human disturbance or with least disturbance	Habitation or with more anthropogenic pressure

Variable width belt transects were used to count all the mounds present within sampled area. Length of transect, and distance between the two transects was set according to the size of the islands but it was uniform for any given islands. Average length of belt transect was 2 km, however, in some cases the length of the transects were small due to smaller sizes of islands. Width of the each transect varied depending upon the extent of low lying forest from the shore to near by hills The census was carried out with seven observers walking at 20 m interval abreast parallel to the seashore. Interior forests of Great Nicobar, Little Nicobar, Kamorta, Katchal and Teressa islands were also sampled with fixed width transect i.e. 140 m width and 1 km long. Total number of active mounds, abandoned mounds, inactive mounds, mound types, mound size, canopy cover over mound, substratum of mound, number of pits present, possible number of megapode use the mound, and the distance between high tide mark and mounds were recorded. Mound substratum type was assessed based on Wentworth particle scale. Apart from this, anthropogenic disturbances such as plantation, fire, logging, wood cutting, evidence for hunting, and socio-economic condition of near by habitation were also collected in every sampled area. Presence of predators such as water monitor lizard, python, dog and cat were also recorded in each sampled transects.

Active mounds those are in use were identified by signs of recent digging by megapodes or by checking the mound whether the soil was compact and hard with vegetation growth on it (abandoned mound) or loose and easily penetrable with a stick (active mound) (Sankaran 1995b). In some mounds, there was no sign of recent digging but the soil was loose without vegetation on it and though these mounds had a chance of reuse by megapodes those mounds were considered as inactive.

Since the distribution of mounds was not uniform (Sankaran 1995b), PCHM and NCHM coastal areas were sampled separately as a part of stratified sampling. Mound density was also estimated separately for each segment. A total of 328 km long coastal habitat was identified as PCHM in the Nicobar islands; of these, 157.5 km coastal forests were sampled in 80 transects. Of the 80 transects, 68 transects were 2 km long, 10 transects were less than 2 km and two transects were more than 2 km. Of the 358.8 km long NCHM, 77.9 km long coastal stretches have been sampled in 39 transects. In a majority of islands, the standard deviation for 'mean mound density' for a transect was high or in some cases higher than mean; it revealed that the mound distribution within a segment

(PCHM) was also not uniform, hence, the mound density of a island was estimated using the following formula:

$$\text{Mound Density (D)} = \left(\frac{N}{S_a}\right) H_a$$

Where N = total number of mounds found in ‘S_a’, a = type of segments (PCHM or NCHM), S = total area sampled in segment ‘a’ and H = total area available for segment ‘a’.

Megapodes also occur in the interior forests of islands and it is believed that about 20% total population live in these interior forests. Due to difficulty in sampling in the interior forests, less number of transects were laid to count the mounds. A total of 11 transects were laid in the Great Nicobar, four in Little Nicobar, four in Kamorta, three in Katchal, and two each in Teressa and Nancowry islands. Of these 26 transects, mounds were found only in three transects, one from the southern tip of Great Nicobar Islands, and two mounds from two different locations of the Kamorta Islands. Hence, the detection or availability of mounds in the interior forests was small and the interior populations have not been considered in the current population estimates.

The basal circumference, height and diameter of the mounds were measured to estimate their sizes. Mounds were uneven in shape with a cone like appearance. The mound size, expressed as volume, was derived from the equation for the volume of a cone: $1/3\pi r^2h$ where ‘r’ is the radius and ‘h’ the height, giving an approximate volume of the mound (Sivakumar and Sankaran, 2003).

Chapter 5
Results and Discussion

5.1. Distribution of the Nicobar megapode and its mounds

After tsunami 2004, the Nicobar megapode continued to be found on all but two islands viz Trax and Megapode in the Nicobars from where it had been reported earlier. Car Nicobar, Chaura and Batti Malv islands of Nicobars were not surveyed as there was no record of megapode in these islands in the recent past (Sankaran 1995b) and extinction of population at Pilo Milo was re-confirmed. Polytypic *Megapodius nicobariensis* occur in Nicobars in two sup-species. *Megapodius nicobariensis abbotti* occurred on Great Nicobar, Little Nicobar, Kondul, Menchal, Treis, Meroe. *M. n. nicobariensis* was present on Camorta, Trinkat, Nancowry, Katchall, Teressa, Bompoka and Tillanchong islands.

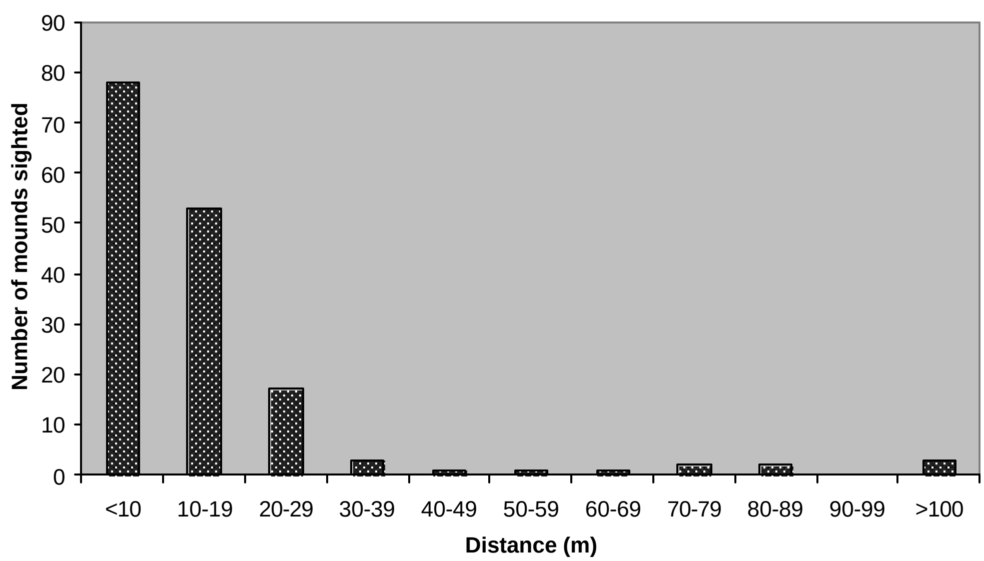
The Megapode Island was fully submerged due to rise in sea water level after tsunami. Megapodes from this island were either killed by tsunami waves or the birds flew to the nearby Great Nicobar Island which was less than 150 meter in distance. The Nicobar megapode was not found on Trax Island (Fig 5.1) and it was believed that the bird

Figure5.1 Trax Island after tsunami. Megapodes from this island are believed to be extinct

probably became extinct here due to tsunami waves.

Incubation mounds of the Nicobar megapode have been found on all islands where megapodes were seen. More than 90% of mounds were built within 30 m distance from the shore (Fig 5.2) and this preference for nesting near the beach is due to availability of certain substratum (Sivakumar 2000). Compared to previous survey (Sankaran 1995b) the concentration of mounds towards fringe of sea shore was high and it might be due to tsunami which has significantly reduced the potential coastal habitat. Around 16% of active mounds were found within 5 m distance from shore which may probably be influenced by high high-tide water during full or new moon days. Maintaining mound temperature at a constant rate is important for the successful egg hatching (Sivakumar and Sankaran, 2003), however, influence of sea water on the incubation temperature of these mounds is expected to adversely affect the hatching success of those mounds which are very close to the shore.

Figure 5.2. Distribution of active mounds from sea shore



5.2. Status of the Nicobar megapode

Knowledge of population size of a threatened species is crucial to monitor the success of any conservation actions. Since, there is a relationship between the number of pairs that use a mound and mound size (Sivakumar 2000), better way of estimating the population size of the Nicobar megapode is to count the inanimate stationary mound nests of this species along with estimating mound size. Larger mounds attract more pairs than smaller one (Sivakumar 2000, Sivakumar & Sankaran 2003). And also it is imperative to know the number of birds that use a mound in a year to estimate the population. Mound nesting Nicobar megapodes are mostly seen in pairs (Dekker, 1992, Sankaran, 1995b, Sivakumar, 2000). Dekker (1992) estimated an average of two pairs per mound as a conservative lower limit but Sankaran (1995b) estimated two pairs per mound for the lower limit and 3.5 pairs per mound for a upper limit and Sivakumar (2000) estimated 2.5 pairs per mound based on his observation on more than 30 mounds for the period of three years. However, in this survey most of the mounds found were too small to accommodate more than one pair, although, I estimated two pairs per mound as a conservative upper limit.

Table 5.1. Past and present status of the Nicobar megapode

Island	Estimated no. of active mounds in 1994*	Estimated no. of breeding pairs 1994*	Estimated no. of active mounds in 2006	Estimated no. of breeding pairs 2006
Great Nicobar	515	1416	203	405
Kondul	11	31	1	2
Little Nicobar	311	855	82	165
Menchal	2	6	6	12
Meroe	1	3	2	4
Pilo Milo	0	0	0	0
Trax	3	9	0	0
Treis	4	10	3	6
Nancowry	60	165	7	15
Katchal	69	190	9	17
Camorta	20	55	7	13
Tillanchang	10	28	27	53
Trinket	8	22	26	52
Teressa	119	328	9	18
Bampoka	26	72	13	25
Total	**1159**	**3190**	**394**	**788**

***** Source Sankaran, 1995b.

Of the total 687 km long coastal line of megapode lands, 328 km long coastal forest was identified as the 'Potential Coastal Habitat for Megapode' and remaining 359 km long coastal forests were identified as 'Non-conducive coastal habitat for megapode'. It was estimated about 800 breeding pairs of the Nicobar megapode occur on the coastal habitat of the Nicobar islands after tsunami, which is nearly 70% less than what was reported a decade before (Table 5.1 & 5.2.).

5.2.1. Megapodius nicobariensis nicobariensis

Megapodius nicobariensis nicobariensis occurs on all seven islands of Nancowy group of islands. The potential coastal habitat of this sub species is shrunken and only 37% of the coastal habitats is now available for them for mound building. It is also estimated to hold 97 active mounds. A total of maximum 194 breeding pairs occurs in the coastal habitat of these islands. There is no active mound found in the Non-conducive coastal habitat of these islands which comprises 63% of total coastal habitat mainly with coconut plantation, mangroves, habitations and mountain cliffs.

Good population of megapodes nearly 50% occurs in Tillanchang and Trinket islands despite their smaller sizes. However, in 1993-94, good density of megapodes have found in Teressa and Bompoka islands (Sankaran 1995b) of this islands group. Bompoka Island is again better off when compared to Teressa where more than 90% of population vanished. Sankaran (1995b) could estimate 119 active mounds and observed 113 abandoned mounds on Teressa Island but with almost similar sampling effort I could estimate only nine active mounds and there was no abandoned mounds observed on coastal forests.

The megapodes populations on major islands such as Camorta, Katchal, Teressa and Nancowry are estimated around 63 breeding pairs which is 88% less than what was in 1993-94. All major islands in this group is thickly populated by mainly indigenous people who are known to hunt megapodes.

Largest mound nest of the Nicobar megapode seen in Tilanchong Island

Sankaran (1995b) has earlier cautioned about the growing tribal population and the resultant conversion of primary coastal forest to coconut and other plantations, which continue to encroach into megapode habitat. Though, tsunami is suspected to be one of the factors for the decline of megapodes in Nancowry groups, the other factor which might have adversely affected the megapodes is the large scale encroachment of coastal forest for coconut and other plantations. Hunting of this species should not also be ruled out here. The Tillanchang Island is a protected Wildlife Sanctuary where the megapode population shows an increasing trend. In Tillanchang, few mounds have however been observed with leg-snares on it probably fishermen. Though, the larger portion of Trinket Island is inhabited by humans, the southern part is comparatively undisturbed where good numbers of megapodes are found.

In general, the population of *Megapodius nicobariensis nicobariensis* has been continuously declining on all islands except Tillanchang and Trinket, where their populations have increased moderately. In overall, there is a 70% of population decline in this sub species in the last decade.

5.2.2. Megapodius nicobariensis abbotti

Megapodius nicobariensis abbotti occurs on all southern group of Nicobars barring Pilo Milo, Megapode and Trax islands where the populations of megapodes either became extinct or too small to detect.

Of the 314 kilometer long coast line, 61% of coastal low-lying forests have been identified as the potential coastal habitat of megapodes. On this potential coastal habitat, it was estimated that 286 active mounds were found here. On the non-conducive coastal habitat of this group of islands, 11 mounds have been estimated. Collectively, the total number of active mounds found on the coastal forests of southern group of Nicobars was 297. It has been estimated that a total of 594 breeding pairs occurs on the coastal habitat of these islands.

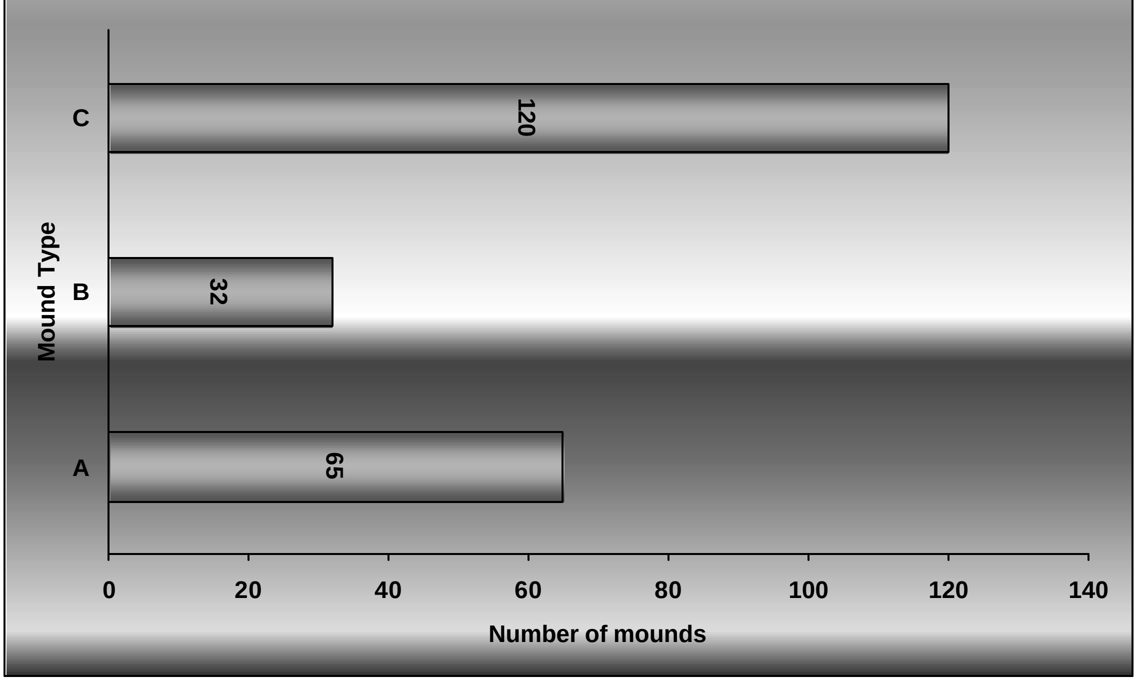
The largest population of megapodes occurs on Great Nicobar Island where 405 breeding pairs have been estimated (Table 5.1). The second largest population is in the Little Nicobar Island. Both islands are largest in this group and own 96% of megapodes. However, when compared to previous survey (Sankaran 1995b), 65% of megapode *Megapodius nicobariensis abbotti* have disappeared from these two islands.

Good population of megapodes are present on both north-eastern and western coastal forests of the Great Nicobar. However, most of active mounds found were smaller in size. High density of megapodes found on the southern tip of the Great Nicobar (Sankaran 1995b, Dekker 1992) in the past has been washed away where the influence of tsunami waves were witnessed up to five kilometer inside the forests. Large sized mounds have been located on the north-eastern coastal areas of the Great Nicobar, where the indigenous Shompens live, and they were not affected by tsunami much.

5.3. Mound types, status and ecology

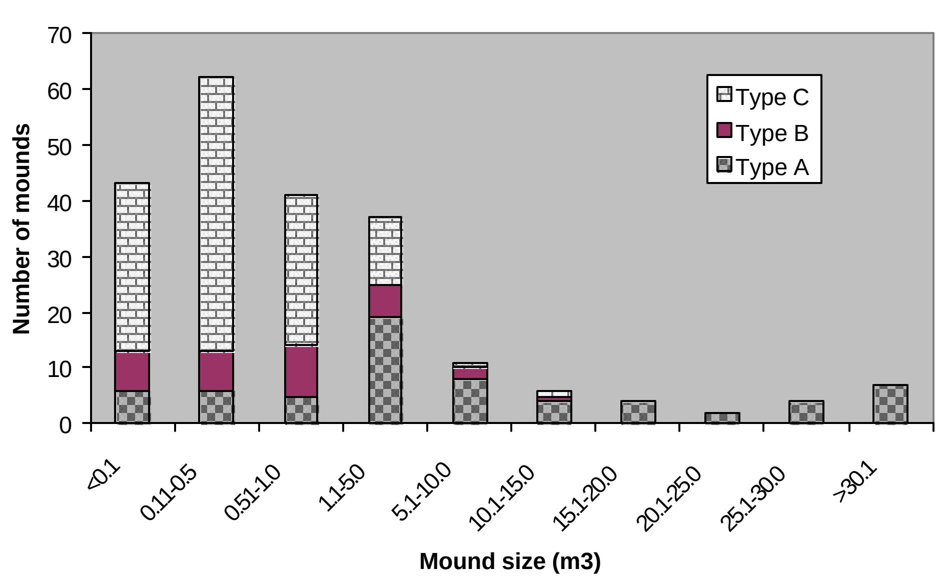
The Nicobar megapode builds three types of mounds in general (Dekker 1992, Sankaran 1995b, Sankaran and Sivakumar, 1999 and Sivakumar 2000). Of the observed mounds, 55% of mounds were Type C, mounds built at the base of dead trees (Fig 5.3). A good number of Type A, mounds built on open area were also found. However, the number of Type B, mounds, built at the base of live trees, were less probably due to non-availability of larger live trees on the coastal areas.

Fiure 5.3. Different types of mound of the Nicobar megapode



Most of the Type C mounds were one or two year(s) old and smaller in sizes.

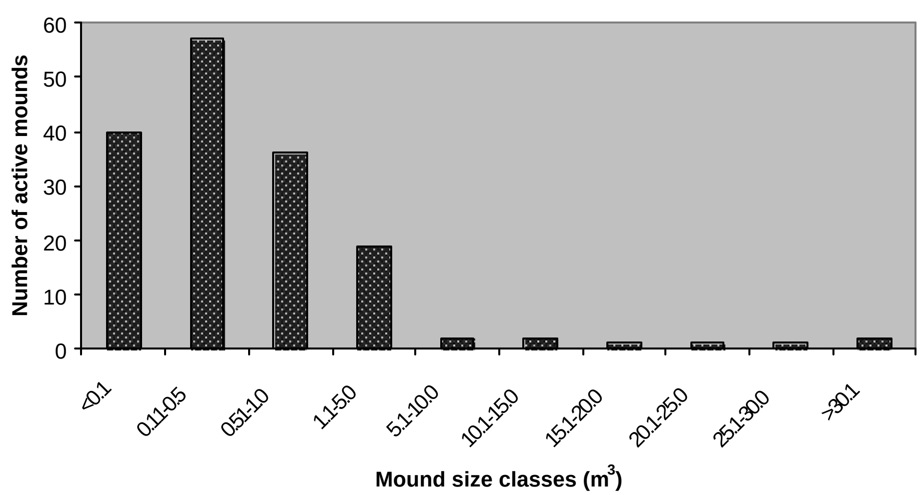
Figure 5.4. Various mound types and mound sizes of the Nicobar megapode



Mounds varied in sizes between 0.01 m^3 and 71.45 m^3. Of the observed 217 mounds, majority of mounds (84%) were less than 5 m^3 and 67% of mounds were less than one cubic meter in size. Larger mounds such as above 20 m^3 in size were less than 6% and all of them were Type A. Since, most of the mounds were new and constructed after tsunami the average size of the mound (3.78±0.62 m^3) was smaller when compared to previous study (Sivakumar and Sankaran, 2003). Type A mounds were found in different size classes. However, type B and C mounds were smaller in sizes with no bigger size mounds (Fig 5.4).

Among the active mounds, most were smaller in size (fig 5.5) and it confirmed the fact that most of active mounds were constructed after tsunami and old active mounds near the shore must have been washed away.

Figure 5.5. Distribution of mound size classes of the Nicobar megapode

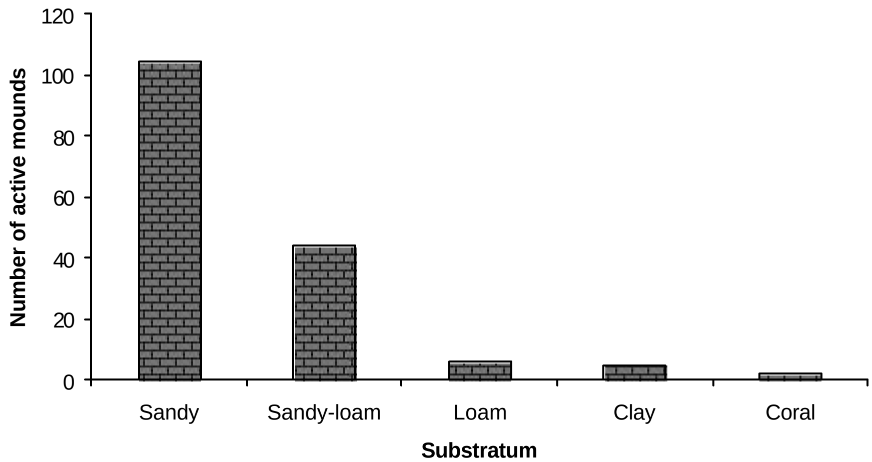


As reported earlier, sand and sandy-loam substratum was preferred for mound construction, as majority of the mounds were found on these substratum (Fig 5.6). Of the five major types of soil substrates present in the coastal area, the Nicobar megapode preferred to construct mounds in sandy substratum, followed by sandy-loam, probably because those substrates are easier to dig into, and of superior drainage. There were few mounds found on clay substratum and corals. Since the coastal habitat of the Nicobar

A mound from the interior forest is mainly built with vegetative materials

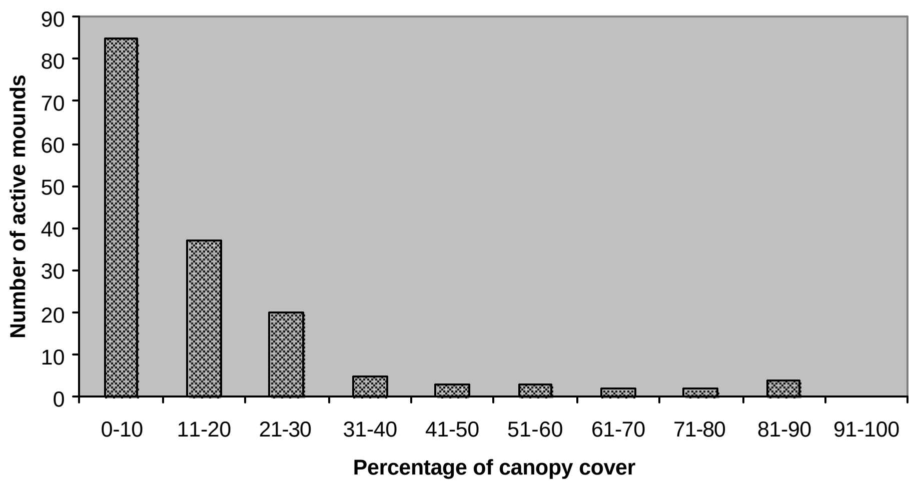
Islands is mainly composed of sand and sandy-loam soil (Thothathri 1962; Saldanha 1989), this would account for the clumped distribution of the Nicobar Megapode towards the coastal region (Dekker 1992; Sankaran 1995b; Jones *et al*. 1995, Sivakumar 2000, and Sivakumar and Sankaran 2003).

Figure 5.6. Mound substrata of the Nicobar megapode



It is believed that the temperature generated through fermentation of vegetative materials inside the mound is a major source of incubation temperature (Sivakumar and Sankaran 2003), however, ambient temperature is also thought to contribute to the incubation process especially in the case of type A mounds. Most of active mounds found on Nicobars were built at the base of available trees on the coastal area. Since most of trees dried due to tsunami waves, green canopy cover over mounds was less or nil (Fig 5.7). It is expected that all the dead trees (snag) would decompose soon and in that case these type C mounds would become type A mounds. Direct fall of sunlight on the mound through day may not be good for the incubation mound of the Nicobar megapode, as direct sunlight for a longer period may warm up the mound quickly and killing the embryo in an egg. It is a serious concern for the long term survival of this species. However, natural resilience of coastal ecosystem of islands may change this situation provided there is no human intervention.

Figure 5.7. Canopy cover over the mound of the Nicobar megapode



Chapter 6
Threats

6.1. Habitat loss and degradation

Apart from stochastic events such as tsunami which had adversely affected almost all potential coastal habitat of Nicobar megapode, the habitat loss due to human activities is suspected to be a major cause for the decline of the Nicobar megapode. The Nicobar megapode preferred to construct mounds on sandy & sandy-loam substrates of coastal forests, probably because those substrates are easier to dig into, and of superior drainage (Sivakumar 2000). Since the coastal habitat of the Nicobar islands are mainly composed of sand and sandy-loam soil, this would account for the clumped distribution of the Nicobar Megapode towards the coastal region. Coasts are also favoured by human who could establish their hamlets surrounded with horticulture crops such as coconut and arecanut. Because of increase in population there is a continuous expansion of the coconut plantation on the coastal areas which ultimately led to shrinkage of megapodes habitat. Habitat loss remains the single biggest threat to the megapode even after a decade (Sankaran, 1995b).

Tsunami has devastated the coastal habitat of the megapode

6.2. Inadequate PA coverage

The existing protected area network is inadequate in the Nicobar islands to safeguard the megapode and its habitat. Currently, less than 40% of potential coastal habitat of megapode under protection. Out of these, *M. n. abbotti* has been fairly protected in Great Nicobar but *M. n. nicobariensis* was not given much attention earlier and this apathy pushed this sub-species into the verge of extinction. Tillanchang Wildlife Sanctuary is the only Protected Area for *M. n. nicobariensis*, covering less than 3% of total habitat of this sub-species, though 27% of population occur in this island, which is also not having permanent human settlement. Remaining 73% of *M. n. nicobariensis* is not protected and their habitat under the severe threat after tsunami due to post-tsunami rehabilitation process.

The largest population of the Nicobar megapode occurs in the Great Nicobar Island. Major portion of this Island is notified as Biosphere Reserve but has not been designed to sufficiently protect the prime coastal habitat of the Nicobar megapode owing to settlement of indigenous people all along the coastal areas.

The unique culture and lifestyle of the indigenous people such as Shompens and Nicobarese is now threatened by a rapid influx of modern lifestyle through contact with mainlanders, along with road building, agricultural expansion and other developmental activities. Because of this shift in lifestyle, the existing Protected Areas in Nicobars for megapodes are under threat and other megapode habitats occurring outside Protected Areas are also threatened.

6.3. Introduction of Alien Invasive Species and agricultural plants

Alien invasive species (AIS) are one of the major threats to the ecological and economic well being of the planet (McNeely et al. 2001). It is widely known that island ecosystems are particularly vulnerable to AIS, and that their impacts are especially severe (Veitch & Clout 2002) on endemic species. The island ecology is continually changing as a result of intensified land use and modifications due to human pressure. These changes alter the conditions of the dynamic relationships between the introduced and native species interactions. Symptoms of avian cholera were noticed in megapodes when the outbreak of this disease killed more than 50% of introduced domestic fowl in the Great Nicobar in 1997 (Sivakumar, 2004). After tsunami, the State Administration had a plan to supply 4,00,000 fowl and 9000 ducks to farmers and tribals which may threaten the native birds including megapode. Introduced dogs and cats are also known for threatening egg laying megapodes (Sivakumar 2004 & 2000).

After tsunami, the state agricultural departments initiated several projects as a part of the rehabilitation process, to restore the livelihood of locals including the plantation of cashew in a larger scale in the Nancowry group of islands. This again poses a grave threat to already shrunken habitat of megapodes. Bamboo might be a better alternative for cashew which is exotic and known for not allowing any undergrowth in it.

6.4. Hunting and egg collection

It was believed that the Nicobarese do not hunt or collect eggs of megapodes extensively because megapodes have spiritual and medicinal values (Sankaran 1995b) but this spiritual value seems to be gradually disappearing and almost all Nicobarese whom I met have admitted that they have eaten the meat and eggs of megapodes. Traditionally, Nicobarese are hunter gatherers but in the course of modernisation they have taken to more of horticultural activities and less of hunting. After tsunami, they lost most of the horticulture crops in Great Nicobar, Little Nicobar, Pilo Milo islands) and partially in Nancowry group of islands which forced them to hunt whatever they could get from the forest. One to five air guns could be seen in a house and megapodes were one of their favourite targets.

After tsunami hunting birds become the important recreational activities of tribals. One to five airguns have been seen in a tribal house.

Mainlanders are also known for hunting the megapodes. This is borne out by the fact that areas of mainlander settlement or their presence have no sign of megapodes or highly depleted population, especially in Nancowery group of islands and some part of Great Nicobar. Compared to areas of mainlanders settlements, the indigenous people habitations are still recognized as the potential coastal habitat for megapodes and megapodes are seen there. However, this may change in future as life style of native people gradually matching with that of mainlanders.

Evidence for megapode hunting i.e. leg traps on or near the mound were also seen near the Shompen-inhabited areas such as Lawful and Trinket Bay of Great Nicobar Island, where several large sized old active mounds were found. Leg traps were also seen in Tillanchang Wildlife Sanctuary possibly by the Nicobarese who occasionally visit this island for coconut harvesting or non-native fishermen who illegally camps here.

6.5. Post tsunami impact

Since the tsunami waves have washed away most of the planted as well as wild coastal coconut and acrecanut palms, plantation of these palms has become important for the future survival of tribals in this region. There is a lot of possibility that the plantations will encroach the majority of the potential coastal habitats of the Nicobar megapode and its associated species if the necessary care in this regard is not taken. After tsunami most of the low-lying coastal areas submerged and megapodes have built their mounds in evacuated villages. But when the tribals started returning, they began hunting the megapodes. More than 95% of coconut plantations on the southern group of Nicobar islands were washed away, which was the major source of income for tribals. In years to come, it is expected that tribals will be left with fishing and hunting of wildlife for their survival apart from livelihook support from the Government. Each tribal family has one to four airguns. The Nicobar megapode, Pied Imperial Pigeon, Andaman Green Imperial Pigeon, Green Pigeon and Nicobar Pigeon are most favoured targets of these airguns. Near Koshingdon (a village on west coast of Great Nicobar) I came across an abandoned camp which was probably used by the poachers a week before our survey. There is a possibility that poachers may be taking advantage of absence of people in this region.

Chapter 7
Conservation perspectives

7.1. Management of Habitat

The Nicobar megapode is included in the Schedule I of the Indian Wildlife (Protection) Act, 1972 and this species is considered as globally 'Vulnerable' (IUCN, 2006). This was in response to its dwindling population size and being the flagship species of the Nicobars. Around 70 % of the population of Nicobar megapode had disappeared over the last 12 years. The major reason for the sharp decline is believed to be the tsunami which washed away their habitat along with nests. However, habitat destruction and hunting are the major human induced factors still adversely affect the megapodes, and these forces are likely to continue until a serious conservation programme is implemented. As per the IUCN criteria for endangered species, the Nicobar megapode is now globally endangered (Criteria A1, B2 and C1). The link between local people and the megapode has a long tradition and there are many cultural references to this species. While the threats to megapodes are many and varied, the principal concern is loss of habitat through forest removal/modification especially for plantation. A growing tribal population and its pressure on megapode habitat are expected to be continuing. The following actions are required to minimize further habitat loss.

Regeneration of *Terminalia spp.* and *Barringtonia spp.* was observed on the tsunami affected coastal area of the Nicobar islands

Action 1: Restoration of the megapode habitat on the west coast of the Great Nicobar Island is urgently required. Most of the people from this coast were killed by tsunami waves and less than 10 persons belong to this coast survive that too in rehabilitation camps. Since, the west coast of this island is no more suitable for people to live, therefore, the entire coastal areas need to be included in the existing Protected Areas and there should not be any plantation project initiated in this region. More than 100 km long coastal line of west coast has a lot of potential to become a better habitat for megapodes as well as other coastal species including sea turtles to nest.

Action 2: A conservation awareness programme needs to be initiated immediately through tribal captains of Nicobarese villages. This programme should clearly address reasons for the decline in Nicobar megapode populations, and how these trends can be arrested or reversed (Dekker *et al.* 2000). Since the habitat destruction is a major human induced cause for the decline of megapodes, it needs to be communicated properly.

Action 3: Further plantation or developmental activities must be contained and expansion of plantation area in newer forest land should not be allowed.

Action 4: Since there is a strong relationship between poverty, development and wildlife conservation, further developmental activities aimed to eliminate poverty need to be encouraged without undermining the importance of biodiversity. A proper EIA studies by genuine experts should become a mandatory step to take up any developmental projects in Nicobar islands.

Action 5: A long term monitoring of habitat of Nicobar islands needs to be initiated with help of experts. A section in the Forest Department should involve in the research and monitoring part of the wildlife and its habitat.

Action 6. Major developmental/infrastructural projects (for example a proposal to make Great Nicobar a free port for international shipping at the mouth of the Galathea river) should not be encouraged as they are expected to damage the highly sensitive insular ecosystem and its wildlife.

7.2. Review on Existing PA Network for the Nicobar megapode:

At present, two National Parks and two Wildlife Sanctuaries cover the megapode populations. Both the National Parks are in the Great Nicobar Island where *Megapodius nicobariensis abbotti* occur and one Wildlife Sanctuary 'Megapode Island' is submerged fully, after tsunami. Tillanchang Wildlife Sanctuary is the only protected area that protects the *Megapodius nicobariensis nicobariensis.* Though the habitat of *M. n. abbotti* has been fairly protected in the Great Nicobar Island, yet major portions of the potential coastal habitat especially along the west coast are outside protected areas. It is even worse in the case of *M. n. nicobariensis.* Following actions are required to review the existing PA Network:

Action 1: Entire portion of west coast and southern part of the Great Nicobar Island needs to be included in the adjoining National Parks as these areas are devoid of human settlement and known to have better habitats for megapodes. This will also protect all other insular fauna of this region including the nesting beaches of sea turtles.

Action 2: If possible, after having consensus with the local communities, the Little Nicobar may be declared as a 'Conservation Reserve', so that, the degraded habitat can be restored with the participation of local communities.

Action 3: Entire Nancowry group of islands may also be declared as the 'Conservation Reserve'. However, opinions of the local communities should be obtained before declaring these areas as the Conservation Reserve. Since these islands are thickly populated and disturbed heavily, conservation reserve concept is expected to help to restore the natural habitat as well as to protect wildlife of this region, without jeopardizing the livelihood of local human populations. Indigenous people must be given a major stake in the proposed conservation reserves.

7.3. Management of alien invasive species

Since the symptoms of avian cholera were noticed in megapodes when the outbreak of this disease killed more than 50% of introduced domestic fowl in the Great Nicobar in 1997 (Sivakumar, 2004). After tsunami, the State Administration had a plan to supply 4,00,000 fowl and 9000 ducks to farmers and tribals which may threaten the native birds including megapode. Introduced dogs and cats are also known for threatening egg laying Nicobar megapodes (Sivakumar 2000). The following actions are recommended to manage the invasive species in the habitat of megapodes.

Action 1. Awareness programme targeting all stakeholders and get the support of local communities to manage the invasive species such as domestic fowl, cat and dogs in Nicobar islands.

Action 2. Immediate removal of all major vertebrate invasive species from the Protected Areas in the Nicobar islands.

Action 3. A study on invasive species ecology and its management in the Nicobar islands for their successful eradication.

7.4. Hunting and egg collection:

After tsunami, hunting on megapodes seems to be on increase in several folds. Though, the Nicobarese attach traditionally cultural values to megapodes, scarcity of animal protein has forced them to hunt megapodes intensively. The two aboriginal tribes of Nicobar islands viz Nicobarese and Shompens are exempt from the Indian Wildlife (Protection) Act, 1972. Considering the changing lifestyle of these tribes, this immunity may be reviewed. In particular, the Nicobarese should be brought under the purview of the Wildlife Protection Act, 1972, while Shombens may be allowed to hunt wild animals.

Action 1. Awareness programme targeting all people through tribal captains needs to be initiated. This programme should clearly address reasons for the decline in Nicobar megapode populations, and how these trends can be arrested or reversed (Dekker *et al.* 2000). Since, hunting is the second major human induced cause for the decline of megapodes, it needs to be communicated properly.

Action 2. Use of air guns may be prohibited in the Protected Areas and in the proposed Conservation Reserves.

Action 3. Food for guns programme needs to be initiated. Guns from the tribal people may be compensated with food by opening up controlled poultry or piggery farms. This will also give the employment opportunities to tribal people.

7.5. Research and monitoring

Scientific knowledge on the ecology of a species is necessary for *in situ* management of populations. Though, the habitat use and social organisation of this species is fairly known (Sivakumar, 2000, Sivakumar & Sankaran 2003), it is important to know the population dynamics and the factors which govern the population dynamics of this species. Following projects are proposed for future researches on this species.

Project 1. Long term monitoring of the Nicobar megapode and its habitat. Since, information on population trends is essential for understanding the long term conservation status of this species (Dekker et al 2000), one of the objectives of the current survey was to identify permanent sampling sites to monitor the populations of megapodes for a longer period. In this context, more than 30 transects have been identified (Table 9) which represent various habitats of Nicobar islands and a simple data sheet has been prepared (Data sheet 1) to collect data from this transect. People who has just working knowledge of Hindi or English can use this data sheet with one day training. The data collected can be used to highlight particular regions of concern and establish where further conservation effort should be targeted. This project has also been mentioned in the IUCN Megapode Conservation Action Plan (Dekker et. al. 2000).

Project 2. Population dynamics of the Nicobar megapode. This project is to investigate the viability of small populations by developing population.. This project should culminate in a strategic assessment of the best way forward for the long-term conservation of the species. This project has also been mentioned in the IUCN Megapode Conservation Action Plan (Dekker et all 2000).

Project 3. A detailed study on social organization and breeding biology of the Nicobar megapode. Though such intensive study on breeding biology and social organization have been carried out (Sivakumar 2000), it is essential to address several questions that still remain unanwerered. Especially, the fate of chicks, fate of solitary birds, pair formation, reason for low clutch size and reason for multiple mound use of a pair need to be investigated..

Project 4. A detailed survey on the Nicobar megapode in interior forests. Till now there was no detailed survey on the megapode population occuring in the interior forest. In the current survey, some transects were laid to look for mounds but the detection probability was very low due to inaccessible terrain and thick vegetation cover. It is essential to know the population size of megapodes inside the interior forests.

Project 5. Habitat use of the Nicobar megapode. A detailed study on this aspect has already been carried out (Sivakumar 2000). However, there was no study on their habitat with reference to food resources.

7.6. Protection measures

Protection of habitat and megapode populations is essential as habitat loss and hunting are the two major factors for population decline. The State Forest Department lost their entire infrastructure in the Nicobar group of islands due to tsunami, and it needs to be restored immediately with the provision of modern facilities such as good patrolling boats, wireless communication etc. The following actions are recommended to strengthening the wildlife protection in the Nicobar islands.

Action 1. Re-establishment/estabilishment of 'Wildlife monitoring-cum-anti poaching camps' in Navy Dera, Kopenkeat, Chingham/38 km, Kondul, Pilo Milo, South Katchal, Kakkana (Kamorta), Trinket, Tillanchang and Bamboka is urgently required. These camps may be established on nearby hill areas where freshwater is also (except Trinket and Bamboka).

Action 2. Recruitment of adequate staff for patrolling and vigilance

Action 3. Minimum two patrolling motorboats with communication systems are immediately required for the Great Nicobar group of Nicobar islands. Two more boats required for Katchal and Kamorta islands. These boats may also useful for the staff to travel to anti-poaching camps.

Action 4. Creation of a post of the Assistant Conservator of Forests for Nancowry group of islands is essential. He may be given a responsibility of formulation of detailed proposal for creation of Conservation Reserves in this region. Range Forest Officers of Katchal and Camorta islands may report to this ACF.

Action 5. Special incentives need to be provided to staff who have been posted in the anti-poaching camps.

Chapter 8
Protocol for monitoring megapodes and their habitats

As mounds are stationary, inanimate and represent breeding, the best way to estimate and monitor the megapode populations is by counting mounds. The coastline of 15 islands where the species is present was surveyed for mounds and I have identified 38 transect sites (including Trax Island where mounds were not seen after tsunami) for long term monitoring of this species. Average length of these transects was 2 km, however, in some cases the length of the transects was small due to smaller size of islands. All the mounds inside the transect need to be counted. The width of the transect is between sea shore and till end of the low-lying forests or 300 m distance whichever is less. Total number of active mounds, abandoned mounds, mound size (circumference and height), number of pits present in a mound and a distance between high tide mark and mound are to be collected on the transect. Habitat parameters such as plantation, fire, logging, wood cutting, evidence for hunting and invasion of weeds in the transect area are also to be collected. A data sheet to collect the information from the field is available with the State Forest Department (Data sheet 1).

Active mounds in use are identified by signs of recent digging by megapodes or by checking the mound whether the soil is compact and hard with vegetation growth over on it (abandoned mound) or loose and easily penetrable with a stick (active mound).

Table 8.1. Present status of active mounds in the permanent monitoring plots.

Island	No. of permanent transects (PT)	Active mounds observed in PT in 2006	Abondoned mounds observed in PT in 2006	Proportion of abandoned mounds
Great Nicobar	11	46	12	0.26
Kondul	1	1	0	0.00
Little Nicobar	4	15	6	0.40
Menchal	1	3	1	0.33
Meroe	1	2	1	0.50
Pilo Milo	1	0	0	
Trax	1	3	1	0.33
Treis	3	3	0	0.00
Nancowry	3	3	0	0.00
Katchal	2	2	0	0.00
Camorta	3	3	2	0.67
Tillanchang	3	9	5	0.56
Trinket	2	10	0	0.00
Teressa	4	6	0	0.00
Bampoka	1	5	1	0.20

A total of 111 active mounds observed from 38 transects are identified for permanent monitoring (Table 8.1), which is 65.68% of the total active mounds observed from all transects surveyed in 2006. Hence, it is believed that any major changes in the abundance of active mounds from these permanent transects would directly reflect the total population of mounds as well as megapodes.

Monitoring the megapodes from permanent transects will give an idea about the trends in the population and changes in the habitat, but not the actual size of the population. For estimating the total coastal population of megapodes, a total survey of mounds in all transects at five years interval is shyly recommended.

Survey Time: February to April

Survey Programme

Sl. No.	Activity	Days
1	Orientation for surveyors at Campbell Bay and Kamorta	1
2	Mound count by concerned islands forest staff	10
3	Data entry and compilation at Campbell Bay by DFO	3
4	Report preparation by DFO, Campbell Bay	5
5	Discussion on survey findings at Head Quarter under the chairmanship of PCCF(WL)	1
6	Action on Report	To be initiated within 15 days

DATA SHEET 1

Nicobar megapode population and habitat monitoring

Observer Name: Date: Island: Place: Transect No.
Begin GPS: Lat: N, Long: E Total Kms. Walked:
_________Km.

Sl. No.	Mound Type (Active/Abandoned)	Distance from shore	Mound size (Circumference X Height)	Number of pits	Habitat Disturbance (any symptoms within 100 m distance around the mound (Yes or No))						Remarks
					Human	Plantation	Clearing forest	Poaching	Weed	Fire	

Table 5.2. Summary of the Nicobar megapode *Megapodius nicobariensis* survey 2006.

Island	Potential Coastal Habitat for mound building										Non-conducive coastal habitat for mound building				Total no. of active mounds	Total no. of breeding pairs
	Total area (km)	Total area sampled (km)	No. of transects	Observed active mounds	Estimated active mounds	Estimated abandoned mounds	Estimated inactive mounds	Active mound/ km coastal stretch	SD	SE	Total area (km)	Total area sampled (km)	Observed active mounds	Estimated active mounds		
Great Nicobar	130	42.5	20	64	195.8	45.9	21.4	1.46	1.07	0.24	83	12	1	7	203	405
Kondul	1	1	1	1	1.0	0.0	0.0	NA	NA	NA	6.5	2	0	0	1	2
Little Nicobar	55	17.5	9	25	78.6	31.4	9.4	1.46	1.16	0.39	23	6	1	4	82	165
Menchal	1	0.5	1	3	6.0	2.0	0.0	NA	NA	NA	2.3	1	0	0	6	12
Meroe	2	2	1	2	2.0	1.0	0.0	NA	NA	NA	3.25	1	0	0	2	4
Pilo Milo	0	1.5	1	0	0.0	1.0	0.0	NA	NA	NA	3	3	0	0	0	0
Trax	0	0	0	0	0.0	0.0	0.0	NA	NA	NA	1.2	1.2	0	0	0	0
Treis	2	2	1	3	3.0	1.0	0.0	NA	NA	NA	0.7	0.7	0	0	3	6
Nancowry	17	16	8	7	7.4	1.0	0.0	0.44	0.56	0.20	27.3	10	0	0	7	15
Katchal	30	14	7	4	8.6	2.1	0.0	0.29	0.49	0.18	48	12	0	0	9	17
Camorta	35	21	11	4	6.7	6.7	0.0	0.23	0.34	0.10	77.5	12	0	0	7	13
Tillanchang	15	9	5	16	26.7	16.7	0.0	1.80	0.27	0.12	27	6	0	0	27	53
Trinket	15	11.5	6	20	26.1	0.0	0.0	1.75	1.26	0.51	15	4	0	0	26	52
Teressa	20	16	7	7	8.8	0.0	0.0	0.46	0.59	0.22	33.25	6	0	0	9	18
Bampoka	5	2	1	5	12.5	2.5	0.0	NA	NA	NA	7.75	1	0	0	13	25
Total	328	157.5	80	161	383.0	111.3	30.8				358.75	77.9	2	11	394	788

References:

Abdulali, H. 1964. The birds of the Andaman and Nicobar Islands. *J. Bombay Nat. Hist. Soc*. **63**, 140-190.

Abdulali, H. 1967. The birds of the Nicobar islands with notes on some Andaman birds. *J. Bombay Nat. Soc*. **64**, 140-190.

Ali, S. and Ripley, S.D. 1983. Handbook of the birds of India and Pakistan, Compact edition. Oxford University Press, Bombay.

Beehler, B. M., Pratt, T.K., and Zimmerman, D.A. 1986. Birds of New Guinea. Princeton University Press.

Butler, A.L. 1899. The birds of the Andaman and Nicobar Islands. *J. Bombay Nat. Hist. Soc.* **12**, 386-403.

Collar, N.J. and Andrew, P. 1988. Birds to watch. The ICBP world checklist of threatened birds. *International Council for Bird Preservation*, Cambridge.

Dagar, J.C., Mongia, A.D. and Bandopadhyay, A.K. 1991. Mangroves of Andaman and Nicobar Isalnds. *Oxford & IBH Publ. Co*. New Delhi.

Dekker, R.W.R.J. 1989. Predation and the western limits of megapode distribution (Megapodiidae;Aves). *Journal of Biogeography*, **16**, 317-321.

Dekker, R.W.R.J. 1990. Conservation and biology of megapodes (Megapodiidae, Galliformes, Aves). *Unpublished D.Phil. thesis,* University of Amsterdam.

Dekker, R.W.R.J. 1992. Status and breeding biology of the Nicobar Megapode *Megapodius nicobariensis abbotti* on Great Nicobar, India. Report, National Museum of Natural History, Leiden.

Dekker, R.W.R.J., and Brom, T.G. 1992. Megapode phylogeny and the interpretation of incubation strategies. In Proceedings of the first international megapode symposium, Christchurch, New Zealand, December 1990, (ed. R.W.R.J. Dekker and D.N. Jones). *Zoologische Verhandelingen,* **278**, 19-31.

Frith, H.J. 1956. Breeding habits in the family Megapodiidae. *Ibis,* **98**, 620-640.

Frith, H.J. 1959. Breeding of the Mallee Fowl, *Leipoa ocellata* Gould (Megapodiidae). *CSIRO Wildlife Research,* **4**, 31-60.

Hume, A.O. 1874. Contributions to the ornithology of India. The islands of the Bay of Bengal. *Stray feathers*, **2**, 29-324.

Hume, A.O. and Marhsall, A. H. T. 1878. The game birds of India, Burmah and Ceylon. Publ. By authors. Calcutta.

Jones, D.N. 1989. Modern Megapode Research. A post-Frith review. *Corella* **13**, 145-154.

Jones, D.N. and Birks, S. 1992. Megapodes: recent ideas on origins, adaptations and reproduction. *Trends in Ecology and Evolution*, **7**, 88-91.

Jones, D.N., Dekker, R.W.R.J., and Roselaar, C.S., 1995. The Megapodes. *Oxford University Press.* 262 pp.

Kloss, C.B. 1903. In the Andaman and Nicobar Islands. *John Murray*. London.

Lister, J. J. 1911. The distribution of the avian genus Megapodius in the Pacific Islands. *Proceedings of the Zoological Society of London*, **52**, 749-759.

Olson, S.L. 1980. The significance of the distribution of the Megapodiidae. *Emu*, **80**, 21-24.

Sahni, K. C. 1953. Botanical exploration in the Great Nicobar. *Indian For*. **79**, 3-7.

Saldanha, C.J. 1989. Andaman, Nicobar & Lakshadweep. An environmental impact assessment. *Oxford & IBH Publ. Co.* New Delhi.

Sankaran, R. 1995a. The distribution, status and conservation of the Nicobar Megapode *Megapodius nicobariensis*. *Biological Conservation*, **72**, 17-25.

Sankaran, R. 1995b. The Nicobar Megapode and other endemic Avifauna of the Nicobar Islands (Status and conservation). *SACON technical report* **2**.

Sankaran, R. 1997. Developing a protected area network in the Nicobar Islands: The perspective of endemic avifauna. *Biodiversity and Conservation* **6**, 797-815.

Sankaran, R. and Sivakumar, K. 1999. Preliminary results of an ongoing study of the Nicobar Megapode *Megapodius nicobariensis* Blyth. *Zoologische Verhandelingen*, **327**, 75-90.

Sankaran, R. 2005. The islands: In: The Ground Beneath the Waves: Post-tsunami impact assessment of wildlife and their habitats in India. Volume II. Kaul, R. and Menon, V (Eds.). Widlife Trust of India, New Delhi.

Sewell, S.R.B. 1922. A survey season in the Nicobar Islands on the R.I.M.S. "Investigator", October, 1921, to March, 1922. *J. Bombay Nat. Hist. Soc*. **28**, 970-989.

Sibley, C. G., and B. L. Monroe, Jr. 1990. Distribution and Taxonomy of Birds of the World. Yale University Press, New Haven, Connecticut.

Sivakumar, K. 2000. A study on breeding biology of the Nicobar megapode *Megapodius nicobariensis*. Unpublished Doctoral Thesis, Bharathiyar University, Tamil Nadu.

Sivakumar, K. 2000. *Varanus salvator* (Water monitor). Nesting behavior. *Herpetological Review*.

31(4):243-244.

Sivakumar, K. 2004. Introduced mammals in Andaman & Nicobar Islands (India): A conservation perspective. *Aliens.* 17 : 11

Sivakumar, K and R. Sankaran, 2003. Incubation mound and hatching success of the Nicobar Megapode *Megapodius nicobariensis. Journal of Bombay Natural History Society. 100 (2&3): 375-387*

Sivakumar, K and R. Sankaran. 2005. Natural history notes on chicks of the Nicobar Megapode *Megapodius nicobariensis. Journal of Bombay Natural History Society.101(3):452-453*

Smith, M.A. 1930. The Reptilia and Amphibia of the Malay peninsula from the islands. A supplement to G. A. Boulengers Reptila and Batrachid, 1912. *Bull. Raffles*. Mus. **3,** 1-149.

Stoliczka, F. 1870. Observation on some Indian and Malyan Amphibia and Reptilia. *J. Asiat. Soc. Bengal*, **39**, 136-138.

Thothathri, K. 1962. Contributions to the flora of the Andaman and Nicobar Islands. *Bull. Bot. Surv. India.* **4**, 281-296.

Tikadar, B.K. and Das, A.K. 1985. Glimpses of Animal Life of Andaman and Nicobar Islands. *Zoological Survey of India*, Calcutta. 170 pp.

Annexure I (Table 9). Details about transects surveyed in the potential coastal habitat and the location of permanent transects for the continuous monitoring of the Nicobar megapode population.

sl. no.	Island	Place	Total Length	Active	Abandoned	Inactive	Substratum	Megapode sighting	GPS N	GPSE	Direction from GPS location	Transect for Permanent monitoring
1	Great Nicobar	Trinket Bay	2	5	0	0	Sandy	Yes	71247.7	935103.2	North	Y
2	Great Nicobar	South Trinket	2	4	1	1	Sandy-loam	Yes	71305.5	935208.5	North	
3	Great Nicobar	Lawful North	2	4	1	1	Sandy-loam	Yes	71143.7	935255.9	North	
4	Great Nicobar	lawful	2	8	4	1	Sandy-loam	Yes	71018.1	935242.8	North	Y
5	Great Nicobar	North Dungi nala	2	3	1	0	Sandy	No	70352.9	935419.1	North	
6	Great Nicobar	Navy Dera South	2	1	0	0	Sandy-loam	No	70438.5	935341	North	
7	Great Nicobar	Navy Dera	2	2	2	1	Sandy	Yes	70814.4	935306.8	North	Y
8	Great Nicobar	Chodi nala	2	5	4	3	Loamy	Yes	70726.7	935314.8	North	Y
9	Great Nicobar	Ganges creek	2	0	0	0	Clay	No	71405.9	934951.5	West	Y
10	Great Nicobar	Indira point	2	0	0	0	Sandy	No	64525.2	934936.1	North	
11	Great Nicobar	Megapode camp	2	2	0	0	Clay	No	64552.1	935010.7	North	Y
12	Great Nicobar	Binfen	2	0	0	0	Sandy	No	64811.7	935247.1	South	
13	Great Nicobar	Pulo Bhabi	2	4	1	0	Sandy	No	65402.4	934613.3	South	Y
14	Great Nicobar	Kosingdon	4.5	10	1	0	Sandy	Yes	65616.8	934508.8	North	Y
15	Great Nicobar	Alexandria	2	3	0	0	Sandy	No	65851.8	934358.9	North	
16	Great Nicobar	Pulo Kunj	2	1	0	0	Sandy	No	70148.9	934016.8	South	
17	Great Nicobar	Pilo Bakka	2	2	0	0	Sandy-loam	No	64941.1	934735.8	South	Y
18	Great Nicobar	Pulo Bed	2	2	0	0	Sandy	No	70352.1	934010.6	South	
19	Great Nicobar	Rekoret	2	6	0	0	Sandy	No	70810.5	934021.2	South	Y
20	Great Nicobar	Habra Bay	2	2	0	0	Sandy	No	71119.3	934220.1	West	Y
21	Kondul	Kondul	1	1	0	0	Sandy	Yes	71231.8	934307.9	North	Y
22	Little Nicobar	Pulo Patia	2	2	1	0	Loamy	Yes	71918.5	934341.6	North	
23	Little Nicobar	North Patia	1.5	6	1	1	Sandy	Yes	72121.2	934511.6	North	Y
24	Little Nicobar	Pulo Panja	2	2	2	1	Sandy-loam	Yes	72256.1	934437.1	North	
25	Little Nicobar	School Point	2	1	3	0	Loamy	No	72339.4	934333.2	North	Y
26	Little Nicobar	Minlana	3	5	2	1	Clay-Loam	No	72505.9	934236.1	South	Y
27	Little Nicobar	Pulo Kiyang	1.5	0	1	0	Sandy-loam	No	71504	933827.8	South	
28	Little Nicobar	Muhincohin	2	4	0	0	Sandy-loam	No	71812.6	933748.2	South	
29	Little Nicobar	Bahua	2	2	0	0	Sandy	No	71933.7	933817.4	North	
30	Little Nicobar	Enfok	1.5	3	0	0	Sandy	No	72217.7	933829.9	West	Y

31	Menchal	Men	0.5	3	1	0	Loamy	No	72343	934554.2	North	Y
32	Meroe	Meroe	2	2	1	0	Sandy	No	73257.1	932450.4	South	Y
33	Pilo Milo	Pilo Milo	1.5	0	1	0	Clay	No	72402.3	934134.1	North	
34	Trak	Trak (NCHM)	<1	0	0	0	Sandy	No	72839.1	933755.5	South	Y
35	Treis	Treis	2	3	1	0	Sandy	No	72831.5	933852.8	North	Y
36	Nancowry	North to Tapang	2	0	0	0	Sandy	No	80044.4	933411.7	North	Y
37	Nancowry	Tapang	2	0	0	0	Sandy	No	75913.5	933448.1	North	
38	Nancowry	Connaught Bay	2	3	0	0	Sandy	Yes	75605	933446.1	North	Y
39	Nancowry	North to Cape Connaught	2	1	1	0	Sandy-loam	No	75627	933342.6	North	
41	Nancowry	South to Hindrah	2	1	0	0	Sandy-loam	No	75716.1	933243.6	North	
42	Nancowry	South to Lapat	2	0	0	0	Sandy-loam	No	75847.5	933058.3	North	Y
43	Nancowry	North Lapat	2	2	0	0	Sandy	No	75918.7	933032.3	North	
44	Nancowry	Chinla	2	0	0	0	Sandy-loam	No	75947.5	933310	West	
45	Katchal	South Point	2	2	0	0	Loamy	No	75508	932753.7	South	Y
46	Katchal	South to Kallatopaini	2	0	0	0	Sandy-loam	No	75541.4	932742	South	
47	Katchal	East Bay	2	0	1	0	Sandy-loam	No	75736	932527.7	South	
48	Katchal	Yuns Yenkui	2	0	0	0	Sandy-loam	No	75313	932157.2	North	Y
49	Katchal		2	0	0	0	Sandy	No	80034.8	932423.2	North	
50	Katchal	South to Jula	2	2	0	0	Sandy	No	80120.8	932301.9	West	
51	Katchal	Jula	2	0	0	0	Sandy	No	80034.7	932122.7	East	
52	Camorta	Near Pullaw (Expedition harbour)	2	0	0	0	Sandy	No	80427.2	933030.2	South	
53	Camorta	Dring	2	1	1	0	Loamy	Yes	80618.4	932929.8	South	Y
54	Camorta	South to Dring Harbour	2	1	1	0	Clay	No	80445.5	932903.6	South	
55	Camorta	North to Ittiya Harbour	2	0	0	0	Clay	No	81038.6	932740.6	South	
56	Camorta	Ronyok	2	1	1	0	Sandy-loam	No	80812.8	932741.9	South	Y
57	Camorta	Ol Hinpun	2	0	0	0	Sandy	No	80953.8	932723.7	South	
58	Camorta	Nighreak	2	0	0	0	Sandy	No	81157.7	932938.8	South	
59	Camorta	Bada Eneka	2	0	1	0	Clay	No	80447.6	933244.1	North	
60	Camorta	Kakana	2	0	0	0	Sandy	No	81005.6	933133.3	North	
61	Camorta	Kakana North (Interior)	1	1	0	0	Loamy	No	81235.5	933222	North	Y
62	Camorta	Kakana Noth coastal	2	0	0	0	Sandy	No	81139.5	933232.1	North	
63	Tillanchang	Castle bay	1	2	1	0	Sandy	Yes	82634.8	933823.9	North	Y
64	Tillanchang	South to Cape	2	3	1	0	Sandy	No	83215.3	933757.7	South	Y

		Mand										
65	Tillanchang	Near Maharani Peak	2	3	2	0	Sandy-loam	No	83042.4	933841.9	South	
66	Tillanchang	Noth cheela	2	4	3	0	Sandy	No	82925.4	933745.8	North	
67	Tillanchang	Cape Winifred	2	4	3	0	Sandy	No	82624.9	933712.8	South	Y
68	Trinket	Piyang	2	4	0	0	Sandy	No	80513.8	933522.5	South	
69	Trinket	Muk Kang	1.5	3	0	0	Sandy	No	80346.5	933529.8	South	
70	Trinket	Safed Balu	2	1	0	0	Sandy-loam	No	80712.5	933354.4	East	
71	Trinket	Trinket (Laful)	2	2	0	0	Sandy	No	80338.3	933432.5	North	Y
72	Trinket	Trinket	2	2	0	0	Sandy-loam	No	80455.8	933500.5	North	
73	Trinket	Near Light House	2	8	0	0	Sandy	Yes	80303.5	933458.1	South	Y
74	Teressa	North to Bangala	4	1	0	0	Sandy-loam	Yes	81854.5	930754.1	North	Y
75	Teressa	Alurang	2	2	0	0	Sandy-loam	No	81944.3	930548.5	North	Y
76	Teressa	Hiram	2	0	0	0	Sandy	No	81534.3	930546.1	South	
77	Teressa	Minyuk	2	0	0	0	Sandy	No	81528.6	930813.6	South	Y
78	Teressa	Laksi	2	0	0	0	Sandy	No	81219.4	930934.1	North	
79	Teressa	Kolaru	2	1	0	0	Sandy	No	81328.4	931108.1	South	
80	Teressa	Rakraka	2	3	0	0	Sandy	No	81206.4	931209.8	West	Y
81	Bampoka	Poakat	2	5	1	0	Sandy	No	81432.9	931325.9	North	Y

Annexure II (Table 5.2). Summary of the Nicobar megapode *Megapodius nicobariensis* survey 2006.

Island	Potential Coastal Habitat for mound building										Non-conducive coastal habitat for mound building				Total no. of active mounds	Total no. of breeding pairs
	Total area (km)	Total area sampled (km)	No. of transects	Observed active mounds	Estimated active mounds	Estimated abandoned mounds	Estimated inactive mounds	Active mound/ km coastal stretch	SD	SE	Total area (km)	Total area sampled (km)	Observed active mounds	Estimated active mounds		
Great Nicobar	130	42.5	20	64	195.8	45.9	21.4	1.46	1.07	0.24	83	12	1	7	203	405
Kondul	1	1	1	1	1.0	0.0	0.0	NA	NA	NA	6.5	2	0	0	1	2
Little Nicobar	55	17.5	9	25	78.6	31.4	9.4	1.46	1.16	0.39	23	6	1	4	82	165
Menchal	1	0.5	1	3	6.0	2.0	0.0	NA	NA	NA	2.3	1	0	0	6	12
Meroe	2	2	1	2	2.0	1.0	0.0	NA	NA	NA	3.25	1	0	0	2	4
Pilo Milo	0	1.5	1	0	0.0	1.0	0.0	NA	NA	NA	3	3	0	0	0	0
Trax	0	0	0	0	0.0	0.0	0.0	NA	NA	NA	1.2	1.2	0	0	0	0
Treis	2	2	1	3	3.0	1.0	0.0	NA	NA	NA	0.7	0.7	0	0	3	6
Nancowry	17	16	8	7	7.4	1.0	0.0	0.44	0.56	0.20	27.3	10	0	0	7	15
Katchal	30	14	7	4	8.6	2.1	0.0	0.29	0.49	0.18	48	12	0	0	9	17
Camorta	35	21	11	4	6.7	6.7	0.0	0.23	0.34	0.10	77.5	12	0	0	7	13
Tillanchang	15	9	5	16	26.7	16.7	0.0	1.80	0.27	0.12	27	6	0	0	27	53
Trinket	15	11.5	6	20	26.1	0.0	0.0	1.75	1.26	0.51	15	4	0	0	26	52
Teressa	20	16	7	7	8.8	0.0	0.0	0.46	0.59	0.22	33.25	6	0	0	9	18
Bampoka	5	2	1	5	12.5	2.5	0.0	NA	NA	NA	7.75	1	0	0	13	25
Total	328	157.5	80	161	383.0	111.3	30.8				358.75	77.9	2	11	394	788