Chapter I

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 birds disproportionately large feet, were first described to science during Magellan's 1519-1522 expedition to the Far East (Frith 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 1990). Thirteen of these 22 species are currently threatened by habitat destruction, introduction of predators and over-exploitation of eggs (Jones et al. 1995).

The taxonomic classification of the Megapodiidae is still subject to debate (Jones et al. 1995). The megapodes were believed to have more affinities with Charadriiformes, Columbiformes, Passeriformes and even Falconiformes. Later megapodes were included in the order Galliformes and were believed to be closely related to Guans and Curassows. 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, the monophyletic origin of Megapodiidae was considered as the sister group of all remaining Galliformes (cf. Jones et al. 1995).
Megapodes are heavy-bodied birds of the forest floor and resemble other 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 foods 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 family Megapodiidae contains seven genera (Appendix I): 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.
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 pheasants on neighbouring mainlands. However, the occurrence of the Green Jungle Fowl *Gallus varius* and Orange-footed Megapode *Megapodius reinwardt* in the Lesser Sunda Islands, and similar types of sympatric distribution of both Phasianids and megapodes in Palawan and Borneo, resulted in 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 Megapode on the Lesser Sunda Islands (Jones et al. 1995)
Figure 1.1. Distribution of the megapodes (source Jones 1989b)
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 (e.g. *Macrocephalon maleo*) and the mound builders, which construct mounds of decomposing vegetative matter (e.g. *Megapodius nicobariensis*).

1.1 THE NICOBAR MEGAPODE

The Nicobar Megapode *Megapodius nicobariensis*, a mound nesting megapode, is endemic to the Nicobar Islands in the Bay of Bengal, over 1500-km from its nearest congeneric (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).

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
Figure 1.2. Study area. *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 (A). The intensive study area was at the southern tip of Great Nicobar (B).
yellowish. Usually seen in pairs in forests close to the beach, the sexes are alike. The total body length is 37-40 cm (Jones et al. 1995, Appendix II). Newly hatched chicks have the crown, upper parts, 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).

The Nicobar Megapode occurred on most Nicobar Islands (Hume 1874; Kloss 1903; Dekker 1992; Sankaran 1995) but was not found on Car Nicobar (Butler 1899) and Chaura (Abdulali 1967). 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 believed to be absent there (Sankaran 1995a & b). It may have existed on Car Nicobar (78 km north of Teressa the nearest megapode population) 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 there (Sankaran 1995). The presence of what was most probably an ancient mound indicates that the megapode did occur on Chaura historically (Sankaran pers. commn.). However, both Car Nicobar and Chaura are much too densely populated for the species to exist there now.
1.1.i. *Megapodius nicobariensis abbotti* Oberholser, 1919.

*M. n. abbotti* was common in all coastal forests, particularly uninhabited or sparsely inhabited areas, on Great and Little Nicobar. *M. n. abbotti* was believed to have disappeared from all areas colonised by mainlanders (Dekker 1992), but they continued to survive in small remnant pockets (Sankaran 1995a, b). Seven of the nine islets in the Great Nicobar group had habitat suitable for megapodes and two (Cabara and Pigeon) were 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, though reports of calls heard indicate that it may still survive there. Over 50% of the forests of uninhabited Meroe, Treis, Trak, Menchal and Megapode Island have been converted to coconut plantation, and populations of megapodes on these islands may be threatened.


*M. n. nicobariensis* occurs on seven islands of the Nancowry group (Sankaran 1995a, b). On Camorta, Katchall and Trinkat, *M. n. nicobariensis* was patchily distributed, with very few locations having active mounds and even fewer where mounds were abundant. Good populations of megapodes existed only on Teressa and Bompoka and the density of active mounds was similar to that of Great and Little Nicobar. Tillanchong is mainly hilly with very little level coastal forest, thus megapodes were naturally scarce except in the level forests.
1.2. THE MOUND OF THE NICOBAR MEGAPODE

The Nicobar Megapode builds mounds of sand, loam, pieces of coral and rotting vegetation within which the eggs are laid. Mounds varied in height from 10 cm to 2.1 m and in basal circumference from 7 m to 45 m (Sankaran 1995a, b). Basically three types of mounds were built by the Nicobar Megapode and have been described by Dekker (1992) as: Type 'A' mounds or true mounds, regular in shape and built on an open spot away from trees; Type 'B' mounds, irregular in shape, built against the buttress or stem of a large living tree; Type 'C' mounds, also irregular in shape but built against, around, under or over a dead rotting tree stump or log.

1.3. STATUS

The Nicobar Megapode was considered to be seriously endangered (Jones 1989b; 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 (Anon. 1988). 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. The ethnic tribes of the Nicobar Islands (Nicolarese and Shompen) are exempt from the Act.

Studies on the Nicobar Megapode so far focused on assessing the status of the species (Dekker 1992, Sankaran 1995a, b). There was no other detailed ecological study about this bird in the literature.

1.4. OBJECTIVES

1. To assess the microhabitat preferences of the Nicobar Megapode.

2. To understand the incubation conditions of the mound,

3. To understand the social organisation of the Nicobar Megapode.

1.5. STUDY AREA

1.5.1. The Andaman and Nicobar Islands

The Andaman and Nicobar Islands (latitudes 6° 45' and 13° 41' and longitudes 92° 12' and 93° 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 km², 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).
1.5.2. 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. Great Nicobar, Little Nicobar, Kondul and Pilo Milo are inhabited. Meroe, Treis, Trax, Menchal, Megapod, Cabra and Pigeon are uninhabited islets. 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 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.

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 high peak, Mt. Thullier at 670 m above MSL.

The soil shows considerable variability from heavy clay, loam, gravely loam, 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. However, a police out post has been established in Tillanchong during the early months of 2000. Great Nicobar has two National Parks (536 km²) and is also a Biosphere Reserve (885 km²), whose core areas are the National Parks (Sankaran 1997).

1.5.2.i. 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 grassland and open vegetation (Thothathri 1962).

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 such as 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 luxuriantly in this forest. The shrubby layer is followed by trees such as 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 some islands. The ground cover consists of grasses such as Centotheca lappacea, Oplismenus compositus, Chrysopogon aciculatus.

Mangrove forests are found in patches of varying sizes in most islands. The dominant species present in the 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 flat areas. The most common and dominant tree species in tropical evergreen forests of Great Nicobar are Calophyllum soulattri, Sideromyelon longipetiolatum, Endospermum malaccense, Garcinia xanthochymus, Adenanthera pavonia, Albizia lebbeck, 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, Teressa and Bompoka Islands (Thothathri 1962; Sankaran 1995) and in some patches on Chaura and Car Nicobar. *Imperata cylindrica* and *Saccharum spontaneum* are the most dominant grass species present in these islands (Thothathri 1962).

1.5.2.ii. *Fauna*

The Nicobar Islands are the summits of a submarine mountain range having a continuation 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 Burman and Malay (Abdulali 1964). The islands are characterised by the absence of large mammals and the presence of a considerable number of endemics among the island’s vertebrates (Appendix III).

Within the Nicobar group of islands there are significant differences in the faunal profiles (Sankaran 1997). For example, the Blyth’s 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 1997). 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 *Tupaiia nicobarica* is present on Great Nicobar and Little Nicobar Islands but is absent on other Nicobar Islands (Tikadar and Das 1985).

1.6. GREAT NICOBAR

The intensive study area was on Great Nicobar Island, which is located between 6°45' N - 7°15’ N, and 93°38’ E - 93°55’ E. The total area of the island is 1045 km² with five perennial rivers and five hill ranges. The highest point is Mt Thullier (670 MSL). Indira Point, where the intensive study area is located, is situated at the southern tip of this island (Fig. 1.2).

1.6.i. Climate and weather

The island is exposed to both Southwest and Northeast monsoons, with an average rainfall of 200 cm (recorded at Campbell Bay between 1996 and 1998; Fig 1.3). 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°C to 34.4°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. Detailed weather data collected between 1996 and 1998 at both Campbell Bay and the study area is presented in figures 1.3 to 1.6.

1.6.ii. 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 pursues agrarian livelihoods along the southeastern 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, now number around 400 on Great Nicobar.

1.7. INDIRA POINT (Intensive study area)

The Study area lies at the southern tip of Great Nicobar Island and on the coast, is about 4 km long, and is bisected by a disused metalled road, which ends at the light house at Indira Point (Fig 1.2). The intensive study area, where the mounds are present is a narrow strip of forest between 40 m and 300 m wide, that is bounded by the beach to the east and to the west by either wetlands, or forests that are inundated. The soil within this strip of forest is sandy, loamy and muddy, and the dominant trees are Barringtonia asiatica, B. r'ecemosa, Terminalia bilata, Terminalia catappa, Syzygium samarangense, Thespesia populnea, and Macaranga spp. The study area has dense stands of Pandanus tectorius and P. odoratissimus in patches, and the road is fringed by stands of Lea angulata, L. grandifolia, and Draceana spp. There are a few patches where the ground is open and with little vegetation. The soil of the forest type to the west of this coastal forest is wet and clayey, and covered with Areca spp. as well as trees like Ixora barbata, Bongama pinnata, Alstonia kurzii, Adentania paranina, Aisandra butyracea, Horsfieldia irya, Myristica andamanica, and Celtis timorensis.

1.8. STUDY PERIOD

The ecology of the Nicobar Megapode was studied between December 1995 and July 1996, December 1996 and June 1997, September and October 1997, and February and May
1998. The study period includes three dry season (peak period of egg laying) and part of one wet season.

Figure 1.3. The average monthly total rainfall and percentage of the humidity recorded at Campbell Bay during the study period.

Figure 1.4. The average percentage of the humidity and monthly total of rainfall recorded at the study area in the respective month.
Figure 1.5. Maximum and minimum temperature recorded in the study area. (Average of year)

Figure 1.6. The average temperature at Campbell Bay during the study period. (Average of year)
1.9. GENERAL METHODOLOGY

1.9.1. Mapping the study area

In 1996, the study area was systematically surveyed and mapped with the aid of a compass and measuring tapes. The positions of incubation mounds, and other landmarks such as the road, huts and wells, were plotted on this map.

1.9.2. Habitat Utilisation

The vegetation of the study area was classified into fourteen microhabitats that were dominated by one or more species. These patches were measured and plotted to scale on the map. To understand the abundance and dominance of flora, ten 20m x 50m quadrats were laid in the study area. All the trees with a girth at breast height (GBH) of 25 cm or above were recorded. Within each quadrat, five subquadrats sized 1m x 1m were laid within which the percentage of herb, shrub and weed cover, were estimated visually. Relative frequency, relative dominance, relative abundance, important value index (IVI) were calculated by using the formula listed in table 1.

Micro-habitat utilisation (level of utilisation) of the Nicobar Megapode was calculated by using Neu’s (1974) method (Allredge and Ratti, 1992), whereby the sightings and calls heard were identified according to the micro habitat patch that they occurred in. Habitat preference was arrived at by comparing the available area of the microhabitat with the number of sightings and calls of the bird. Ratio of the sightings and calls per unit area of the respective microhabitat was estimated by using the following formula.
Table 1. Formulae used for vegetation analysis.

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<td>Basal area (or Dominance)</td>
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<td>Species cover</td>
<td>Sum(cover(_i/100)); where (i=1) to (n); (n=#) of individuals of species</td>
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<td>Relative dominance</td>
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<td>Importance value index</td>
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1. **Ratio of the sightings and calls per unit area of the habitat**
   
   Proportion of the sightings and calls \(i_{ini}\) the habitat
   
   \[ = \]

   Proportion of the area available for the habitat
2. Proportion of the area available for the habitat

\[
\text{Total available area of the habitat} = \frac{P_m}{P_a}
\]

\[
\text{Total study area}
\]

3. Proportion of the sightings and calls on the habitat

\[
\text{Total number of sightings and calls on the habitat} = \frac{P_m}{P_a}
\]

\[
\text{Total number of sightings and calls on the study area}
\]

Both dead and living tree species present in or on the mound were identified and recorded for studying the tree preference of the Nicobar Megapode for mound building.

The ratio of the mounds distributed per unit area (M) of the various soil substrates or microhabitats was estimated by using the formula

\[
M = \frac{P_m}{P_a}
\]

Where, \(P_m\) is proportion of mounds distributed in particular substrates or habitat, and \(P_a\) is proportion of area available for that substrates or habitat.

1.9.3. Incubation conditions within mounds

At the start of the study, or as and when a new mound was constructed, detailed drawings to scale were made of the mounds using measuring tapes and compass, and on to these, salient characteristics such as living trees and dead logs or tree stumps were plotted.
1.9.3.i. **Size of mounds**

The basal circumference, height and diameter of mounds were measured once a month. Mounds are uneven in shape with a cone like appearance. The mound size, expressed as a volume, is derived from the equation for the volume of a cone: \( \frac{1}{3}\pi r^2 h \) where \( r \) is the radius and \( h \) the height, giving an approximate volume of the mound.

1.9.3.ii. **Mound use**

All the incubation mounds in the study area were visited at least twice every day in the morning and in the evening and occasionally during midday, to identify whether megapodes had worked on the mounds, and what type of activity they had engaged in. During the visits to the mound the following data was collected:

a) Presence or absence of megapodes on the mound.

b) Signs of megapode on the mound subsequent to the previous visit.

The activities at the mound were further separated into:

(i) **Scratching**: When the birds scratched on or around the mound.

(ii) **Digging of pits**: The digging of pits was a major activity on the mound. Three types of pits were distinguished as *shallow pits*, *deep pits* and *egg pits* according to their depth and purpose. As Megapodes usually lay eggs in pits that are over 60 cm in depth, pits that were less than 30 cm were considered to be shallow pits and those deeper than 30 cm were considered to be deep pits. Egg pits were considered to be...
pits in which eggs were laid. The pits were plotted on a map, and their depth measured and monitored.

(iii) **Raking:** The activity in which materials were collected from the surrounding area of the mound and spread onto the mound was called raking. The materials raked were mainly composed of the surrounding vegetation litter and soil.

(iv) **Egg laying:** After digging a deep pit, the female entered into the pit and laid an **egg**. Mostly egg laying was confirmed after checking the pit by digging in and marking the egg.

(v) **Pits-filled:** Both pits-filled and mound covering (below) were similar activities that the mound was covered with soil etc. However, the end result was different. In pits-filled only the egg pit or some shallow or deep pits was filled while the other pits on the mound remained unfilled.

(vi) **Mound covering:** Mound covering differs from pits-filled as all the pits were covered till the surface of the mound was smooth.

(vii) **Visit:** A brief arrival and departure of the megapode on the mound without working on it was recorded as a visit. This was also evidenced from tracks on the mound without digging signs.

(viii) **Random activity:** Shallow pit digging, scratching here and there on the mound, raking, covering, all done simultaneously, was recorded as random activity.

At the mound, the megapodes were intensively observed following the focal animal sampling method (Altmann 1974), from observation hides constructed at four different
mounds, which were under intensive study. All the hides were positioned between two and 10 meters distance from the mound. Observations from the hide usually started from before the arrival of birds at the mound (at 0500 to 0530 hours) and ended after the birds left the mound. Observation recommenced at about 1400 hours and was carried on till dusk. The activities of the birds were classified into visit, pit digging, egg laying, raking, covering, pits-filled, and random activity. Apart from that the speed of the activity was also measured by counting the kicking rate.

1.9.3.iii. Mound temperatures

In 1996, four temperature probes were implanted at depths between 20 and 75 cm, in seven mounds that had been selected for intensive studies. However, after about two months these probes malfunctioned, probably due to high humidity and rainfall. In 1997, a temperature probe placed at the tip of a one metre long steel tube was inserted to depths of 30, 60 and 90 cm to measure the temperature. By this method the temperature of all the mounds in the study area was measured once a month and for the target mounds once every 10 or 15 days. Temperature data from each mound was collected twice a day, in the morning and evening. Occasionally the temperature of the mound was measured during midday.

1.9.3.iv. Microbial activity

Microbial activity was measured using a soil respirometre (PP Systems EGM-1 Environmental Gas Monitor with a SRC-1 Soil Respiration System), assuming that in those mounds where microbial activity was high greater amounts of CO$_2$ would be emitted. The
soil respirometre measures the CO$_2$ change in a fixed volume over a known time and fits a quadratic equation to the data to arrive at a value 'SR' which is the soil respiration rate in g CO$_2$/m$^2$/hour. Soil respiration was measured for the seven mounds that were under intensive study once every 10 or 15 days. Like temperature, data on the soil respiration of mounds were collected twice a day.

1.9.3.v. Solar Radiation

The intensity of light falling upon the mound at different times of the day was measured using a Lux meter. The amount of Photosynthetic Active Radiation (PAR) falling upon the mound and PAR absorbed by the mound were measured by using Sunfleck Ceptometer (Decagon, Pullman, WA). This was also measured outside the mounds. The gap in the canopy cover was measured above the mound by using a concave mirror that was uniformly graduated.

1.9.3.vi. Humidity

Soil samples were collected from the surface of the mound and then sun dried for an hour. Percentage of the humidity was measured by using the following formula:

Humidity =\{(Wet soil weight-sun dried soil weight)/Wet soil weight\} X 100
1.9.4. Fecundity and hatching success

During the breeding seasons of 1996, 1997 and 1998, 37 mounds were monitored. When an egg was laid, it was dug out and weighed to the nearest gram by using a spring balance (Pesola 300 g). Eggs were also measured with Vernier calliper and marked with a number and date by a HP graphite pencil or ballpoint pen. After weighing and marking, the egg was reburied in the same egg chamber and the mound re-built. To observe hatchling behaviour inside the mound, glass plates were placed adjacent to the egg chambers of five eggs.

During 1997 and 1998 thirty-three eggs were marked and monitored directly. The marked eggs were monitored by relocating it once every 15 days. Temperature at the egg chamber was measured once every 15 days to determine the incubation temperatures. At the beginning of 1998, all the mounds were thoroughly checked with the help of 1997 mound maps where the locations of eggs were clearly plotted.

Successful hatching of eggs was evident from eggshell fragments and pieces of shell membrane where the eggs had been. Emergence from the egg by the chicks during the course of incubation and hatching were easily observed through the glass plates. Eggs which remained in the mounds for the entire breeding season, or an egg which covered more than 100 incubation days were opened and examined.
1.9.5. Social Organisation

Adult birds were trapped near their incubation mounds or foraging ground. In 1996, mist nets were placed on the route that megapodes used to or from the mound. When the birds were seen working on the mound, the nets were spread. When the birds had completed work on the mound, they were chased and flushed into the nets. The trapped birds were then ringed with aluminium numbered tags and with a combination of plastic wrap around colour rings whereby individual identity was established. However, this method proved to be both time-consuming and had a very low success rate of six successful captures in 72 attempts. In 1997 and 1998 foot nooses were used which gave a significantly higher success rate of one in six attempts. The disturbances caused by nooses were also less, as evidenced by the time taken between trapping and first mound visit by the colour marked bird. Birds trapped by the mist net returned to the mound after 5 to 10 days but birds trapped by nooses returned the same or the next day. The outer end of the wrap around colour band was glued to the layer below, as the megapodes were easily able to pull off these rings; at least three colour marked birds lost their colour ring during the study period.

During the study period, 28 birds were colour-marked, which included 21 pairs and two unpaired individuals. Of these both sexes were colour marked in five pairs.

In 1996, six birds from two mounds were colour-marked which included an unpaired bird, both sexes in two pairs, and one individual of a third pair. In 1997, 17 birds from 9 mounds
were colour-marked, including one unpaired bird, both sexes in three pairs, and one bird each of 11 pairs. In 1998, five birds of four pairs were trapped from four mounds.

The sighting of all colour-marked birds were plotted on detailed maps of the study area. Size of the home range was estimated by using minimum area polygon (Odum and Kuenzler 1955), by connecting the outer locations of sightings of the animal.

1.9.6. Food of Nicobar Megapode

The food of the Nicobar Megapode was ascertained from gut samples of two specimens acquired from tribals, which were shot by them, and a dead individual found in the study area. The gut contents were identified, sorted out and then grouped. The stomach contents of two deceased chicks were examined but no volumetric analysis was attempted.

In 1998, a plastic tube of 4-mm diameter attached to a 500-ml plastic bottle filled with saline was moistened with the saline solution for lubrication and inserted into the stomach stopping just above the entrance to the gizzard. The bird was then inverted over a plastic cup so that, as fluid was forced into its stomach, the excess fluid plus the stomach contents flowed into the cup. Hess (1997) used the same methodology in the Red-cockaded Woodpecker Picoides borealis. By this method five megapode stomachs were flushed.

The preference rank of each food item consumed by the Nicobar Megapode was arrived at both by volumetric method and occurrence method.
The volume of the food items was estimated by the volumetric method or the water displacement method. This was then expressed as a percentage of the volume of individual food items from the total. Apart from the volumetric estimation, occurrence of food items was recorded from the collected specimen. For example, if ants were present in the stomach of two bird out of the seven then ants were scored two points. This was then expressed as the percentage of each food item from the total points scored.

1.9.7. DATA ENTRY & ANALYSIS

Data analyses were done in Lotus, Microsoft-Excel and SPSS software.