SUMMARY

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. Thirteen of these 22 species are currently threatened by habitat destruction, introduction of predators and over-exploitation of eggs.

The megapodes are an unique group of birds as they utilise external sources of heat to incubate their eggs. Megapodes exploit external heat sources in two ways. Some species lay eggs in burrows in geothermally heated soil, or on exposed beach, and are called burrow nesters (*e.g. Macrocephalon maleo*). Other species construct mounds of sand, soil and decomposing vegetation within which they lay eggs and are called mound nesters (*e.g. Megapodius freycinet*). The chicks are supra-precocial; they are able to fly soon after emerging from the mound or burrow, and receive no parental care.

The Nicobar Megapode *Megapodius nicobariensis* is a mound building megapode, endemic to the Nicobar group of Islands in the Bay of Bengal. The polytypic Nicobar Megapode has two subspecies *M. n. nicobariensis* Blyth, in the Nancowry group of islands north of the Sombrero channel, and *M. n. abbotti* Oberholser, which is found in the Great Nicobar group of islands lying south of the Sombrero channel.

Megapode mounds are amongst the largest structures made by any non-colonial animal, and represent the harnessing of the energy produced by microbial respiration, and/or solar radiation by concentrating suitable material to provide optimal incubation conditions at about 33-34° C. Three major aspects of this unique breeding strategy were examined by this study.

First, incubation mounds vary considerably in size, location and composition, the majority of which are constructed in a narrow strip of flat coastal forest. Moreover, the distribution and density of the Nicobar Megapode and its mound varies within this coastal habitat. Thus, the microhabitat requirement of the Nicobar megapode was studied, particularly as its habitat is vulnerable to change due to human activity.

Second, variability in size, composition and location of incubation mounds indicates that the mounds differ in their source of heat. The sources of heat, its regulation and stability were studied to understand the effect of mound types and dimensions on the number of pairs that use a mound, the number of eggs laid and the hatching success.

Third, the social organisation of the megapodes is poorly understood. The social organisation of the Nicobar Megapode was studied to understand the behavioural consequences of an incubation mound nesting system.

The field studies were carried out in a 4.5-km strip of coastal forest at the southern tip of Great Nicobar Island. Field studies were conducted between December 1995 and July 1996,

December 1996 and June 1997, September and October 1997, and February and May 1998, covering three dry seasons (peak period of egg-laying) and a part of one wet season. In 1996, the study area was systematically surveyed and mapped, on which all active mounds present were plotted. The substrate of the study area was classified into three major types, sandy, sandy-loam and loamy (moist). Vegetation of the study area was classified into fourteen subtypes that were dominated by one or more species. These patches were measured and plotted on the map. To understand the abundance and dominance of trees, ten 20m x 50m quadrats were laid in the study area. All the trees with a girth at breast height (GBH) of 25 cm and above were sampled. Habitat use by megapodes was assessed by plotting sightings and calls heard according to the microhabitat patch that they occurred in. Habitat preference was arrived at by comparing the available area of the microhabitat with the number of mounds present, and of sightings and calls of the bird. This data was used to identify a) the microhabitat preference for the construction of incubation mound, b) the microhabitat preference of the Nicobar Megapode during dry and wet seasons.

Sandy substrate and the habitat that was dominated by Pandanus spp. was the preferred area for the construction of the incubation mound of the Nicobar Megapode. Habitat with a sandy substrate was utilised more by the birds during the dry season while in the wet season sandy-loam substrate was utilised more. Of the 14 habitats, habitats dominated by *Sterculia* sp., *Pandanus* spp, dense *Pandanus* with *Macaranga peltata*, or *Dracaena* sp., were the most preferred habitats. Microhabitats dominated by *Macaranga peltata* were used more during the wet season than the dry season, while there was no difference between the seasons, in selection and utilisation of other microhabitats.

All the incubation mounds in the study area were visited at least twice every day, during which, the presence of the birds on the mound, or the signs of birds on the mound subsequent to the previous visit were noted. The megapodes were intensively observed from observation hides constructed at four different mounds. The activities of the birds were classified into visit, pit-digging, egg-laying, and raking, covering, pits-filled, and miscellaneous activities. The intensity of digging activity was measured by counting the kick rates. The data collected was used to examine a) the process of mound construction and maintenance, and b) the contribution of sexes to mound construction and maintenance.

Both partners of the pair equally participated in the mound construction and maintenance, which starts from pit-digging and concludes with raking and covering the incubation mound such that all pits present were filled till the surface of the mound was smooth. Pit digging was the major mound activity followed by the raking during the dry season (peak period for egg laying). In the wet season raking was the major mound activity followed by digging. Egg laying was not observed during the wet season.

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 placing at the tip of a one metre long steel tube was inserted to depths of 30, 60 and 90 cm in the mound. 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. Microbial

activity was measured using a soil respirometer (PP Systems EGM-1 Environmental Gas Monitor with a SRC-1 Soil Respiration System), once every 10 or 15 days. The intensity of light falling upon the mound was measured using a lux metre and the amount of Photosynthetically Active Radiation (PAR) falling upon the mound and PAR absorbed by the mound were measured by using a Sunfleck Ceptometer. The data were used to examine a) temperature sources of incubation mound, b) the effect of incubation mound size on the incubation temperature, c) the effect of soil respiration and light intensity on the incubation temperature, d) the effects of incubation mound size on egg-laying and hatching success and e) the effect of incubation mound activity on the mound size and egg-laying.

Microbial activity as assessed from the soil respiration, appears to be the primary source of heat in the incubation mound of the Nicobar Megapode. Solar energy warms the surface of the mound, whereby dissipation of heat could reduce. Large sized mounds attract more birds and therefore more eggs were laid in them, but there was no relationship between the hatching success and the mound size.

During the study period, 28 megapodes were colour marked. Of these, both sexes were colour marked in five pairs, one bird each of 16 pairs and two unpaired birds. The sightings of all colour marked birds were plotted on detailed maps of the study area. The megapodes were intensively observed from the observation hides constructed at four mounds and opportunistically away from the hides. Size of the home range was estimated by using a minimum area polygon. The data was used to examine a) the pair bond, b) pair formation, c)

copulation & displays, d) establishment of territory, e) territory size and fidelity, and f) agonistic interactions between megapodes.

Although the Nicobar Megapode is largely monogamous, temporary bonds, change of partners, and extra pair copulation were present. There was no pre- and post-copulation display. However, they exhibited synchronous behaviour such as duetting. A mound was used by more than one pair, and pairs used more than one mound. During egg laying, a pair established a territory at a mound, which was strongly defended from others who used the same mound in the same period.. The territories varied in size and changed in location according to the hierarchical status of the pair at the mound, and whether it was laying eggs. The average size of the territory was 0.81 ha (SE 0.12), the minimum territory size was 0.19 and 2.28 ha was maximum.

The hatching and emergence of chicks from the mound was observed in five cases. The climb of the hatchling from the egg chamber to the surface is a long process that can take up to 83.8 hours (SE=12.7, max=118, min=48 hrs), and the mean rate of movement was about 1.25cm per hour (SE=0.07, n=5). As soon as the chick emerged out from the mound they performed both body and leg preening. Some of the chicks were born with eye disorder. Considering how alert the chicks are, it is likely that those preyed upon by the predators were also born with the eye disorder.

Food of the Nicobar Megapode, as evidenced from the stomach contents of three dead birds and from the stomachs of five birds flushed was identified and estimated its quantity. The percentage of time spent for foraging, and the difference between years is discussed.

The Nicobar Megapode nesting grounds attracted a wide range of predators as the main potential prey *M. n. abbotti* occurs in three types eggs, chicks and adults. Monitor lizard *Varanus salvator,* raptors, man, python sp., cat, dog and some invertebrates preyed on the eggs or chicks or adult megapodes. Monitor lizard not only fed on the eggs of the megapode and also laid its own within the incubation mound.