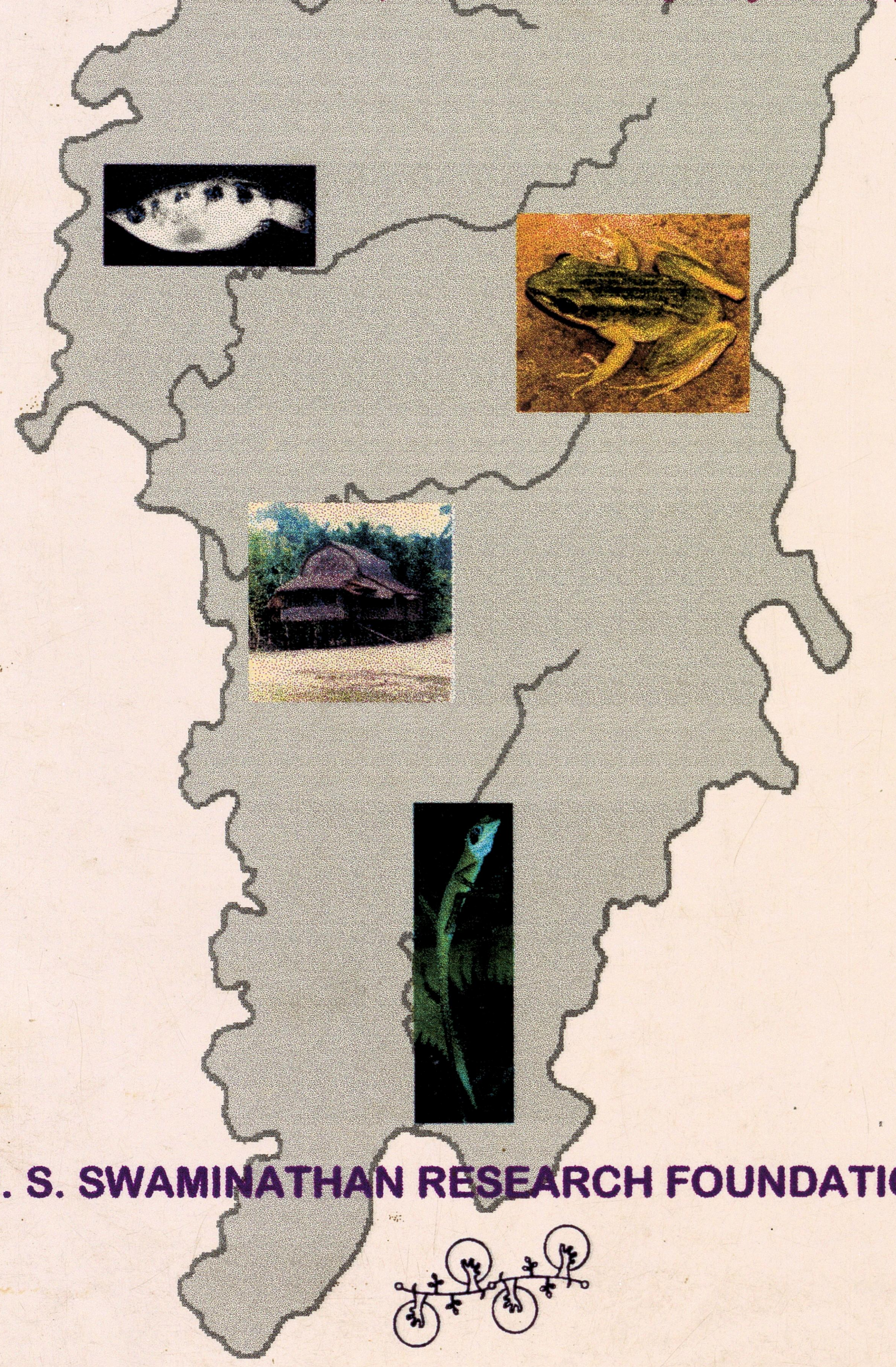
PATTERNS OF DISTRIBUTION OF VERTEBRATE DIVERSITY ON THE GREAT NICOBAR BIOSPHERE RESERVE



M. S. SWAMINATHAN RESEARCH FOUNDATION

PATTERNS OF DISTRIBUTION OF VERTEBRATE DIVERSITY ON THE GREAT NICOBAR BIOSPHERE RESERVE

(Ref. No. 14/26/92 - MAB/RE)

1997

FINAL TECHNICAL REPORT

SUBMITTED TO

THE MINISTRY OF ENVIRONMENT AND FORESTS
GOVERNMENT OF INDIA

BY

M. S. SWAMINATHAN RESEARCH FOUNDATION

Cover: Fish (*Toxotes jaculator*), Frog (*Rana chalconota*), Lizard (*Bronchocela danieli*), Shompen/Nicobarese hut.

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PREFACE

The Great Nicobar Island is one of the eight Biosphere Reserves declared under the Indian Man and Biosphere Programme. This island is the southernmost in the Andaman and Nicobar group of Islands and is the largest within the Nicobars. Biogeographically this island is unique. It may be considered appropriate to treat the Great Nicobar as a natural transition between India and Southeast Asia. While some authorities might dispute such statements, the following cannot be ignored.

From what we have learnt during the past nearly 100 years of biological expeditions to the Great Nicobar, a list of 170 species of vertebrates, including inland fishes, has been compiled. Although this list might seem comprehensive, during the past few years starting 1994 considerable additions have been made to the old lists. This has been possible by way of actually finding species never reported before on the Great Nicobar. Also, there has been substantial taxonomic and systematic revisions taking place amongst the known vertebrates. Consequently, the last 3 years have seen the emergence of 7 species of fish, 3 species of amphibians, at least 2 species of reptiles, 4 species of birds and probably one species of mammal for the first time on the faunal list of the Great Nicobar.

Much of the early discussions on the biogeographical affinities of the Andaman and Nicobar Islands have been based on flowering plants, birds and mammals. We know very little of the lower vertebrates and invertebrates. Further, the Great Nicobar Island which is less than 150 km north of Sumatra has always been treated as part of the Nicobar group of islands in all earlier biogeographical analysis. This may not be correct as the new vertebrates being added are either exclusive to the island or those showing greater affinities to the Southeast Asian fauna.

It is in this context that the decision of the Government of India to declare the island as a biosphere reserve becomes very appropriate. What is therefore of immediate concern is a comprehensive, carefully made biodiversity inventory of the Great Nicobar Island. The following project report is an attempt to achieve this, selecting the vertebrates as the starting point.

The three year project was possible through the financial support of the Ministry of Environment and Forests, Government of India (Ref. No. 14/26/92 - MAB/RE).

Prof. M. S. Swaminathan, Chairman, M. S. Swaminathan Research Foundation, Chennai, kindly gave his consent to the transfer of the project from the Madras Crocodile Bank to the Foundation and provided all the necessary support till its completion.

The efficient conduct of the project was made possible, thanks to the co-operation of Mr. R. S. Kuppuswamy (former Manager Personnel and Administration, MSSRF) and the very efficient financial management of Mr. C. K. Ramachandran (Manager Budget and Accounts, MSSRF) and colleagues.

Dr. Subodh K. Sharma (Additional Director) and Dr. (Ms.) Chhanda Chowdhury (Joint Director) of the Ministry of Environment and Forests extended their best services during the project.

The Forest Department of Andaman and Nicobar Islands was extremely co-operative in providing the necessary permits to both work in the sanctuary areas as well as to collect certain specimens from the island. Special thanks are due to Shri. C. P. Oberoi, IFS (former PCCF and Secretary Environment and Forests) and Shri. Richard D'Souza IFS (Chief Conservator of Forests, WL). The DFO Shri. Ashok Kumar Biswal and ACF Shri. B. P. Yadav who are based in Campbell Bay were indeed helpful at all times.

Mr. Padma Dhev, Range Officer (WL), Campbell Bay and Mr. David, Territorial Range Officer, Campbell Bay extended their sincere co-operation.

Mr. Haridass and Mr. Prasanta Dass (Camp Officers) and Mr. Stanley Selvaraj (Forester) in Campbell Bay helped considerably.

The Andaman and Nicobar Administrators and the Assistant Commissioner Shri. Sanjay Gihar at Campbell Bay provided the necessary permits to enter tribal settlement areas.

Captain VRN Setty, Major K. Vardha and the Environmental NGO 'Parirakshak' at Campbell Bay played a key role in the successful implementation of the project. Capt. Setty was a godfather to the project.

Mr. Kalaimani, Clerk (Project Implementation Committee) Campbell Bay assisted in typing documents.

Mr. T. Narayan, Vice President, Campbell Bay Panchayat provided accommodation for the field staff.

Mr. Muttu, President, Nicobar Congress Committee was a liason between the field staff and the administrators in Campbell Bay.

Dr. P. T. Cherian, Officer-in-Charge, Zoological Survey of India, Chennai and Dr. (Ms.) Rema Devi helped in the identification of the fish collected from the island.

Dr. Ravi Sankaran and Mr. Sivakumar of SACON freely shared their knowledge of the island with us.

Dr. Indraneil Das identified samples of amphibians and reptiles. He also provided the recent literature on the herpetofauna of Andaman and Nicobar Islands.

Mr. Arintham Bhattacharya of Delhi University shared some photographs with us.

Early literature on the amphibians of the island were provided by Mr. Kaushik Deuti.

Prof. S. Ramachandran, Institute for Ocean Management, Anna University, Chennai kindly permitted us to consult the remote sensed data on GNI available at the institute.

Mr. Christ Daniel Toppo worked for a year as a field assistant in the project and contributed extensively to our study of fish.

Mr. Sabu Kuttan worked for 6 months in the project as field assistant and boatman.

Mr. G. Ravikumar (alias Babu) and Mr. Vinoth Pannah worked in the field with the project staff.

Mrs. G. Devika Rani (Police Radio) was more of a parent to the field staff throughout their stay in Campbell Bay.

Many others have helped in many ways during the 3 years of research in the Great Nicobar Island. Mr. V. Govindarajan (Research Assistant) who died while in Port Blair on 14.7.96 ought to be remembered for ever. He has left a question yet unanswered. "How are there so many koels on the island when there are no crows?" I dedicate this report to him.

R. J. Ranjit Daniels
Principal Investigator

July 1997

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1. INTRODUCTION

The Great Nicobar Biosphere was established on 6.1.89 vide GO. J22010/14/89-csc under the Man and Biosphere programme of the Government of India (Anon., 1989). This island biosphere reserve is one amongst the 8 biosphere reserves already declared in India. The total reserve area of 885 km^2 is distributed amongst the 2 core zones viz., Campbell Bay National Park (520 km^2) and Galathea National Park (185 km^2). These core areas are surrounded by a buffer zone of 180km^2 (see map). According to a document published by the Ministry of Environment and Forests, Government of India, the Great Nicobar Biosphere Reserve falls in the Indo-Malayan Region, tropical humid forest biome and the Andaman and Nicobar Islands biogeographic province (Anon., 1989).

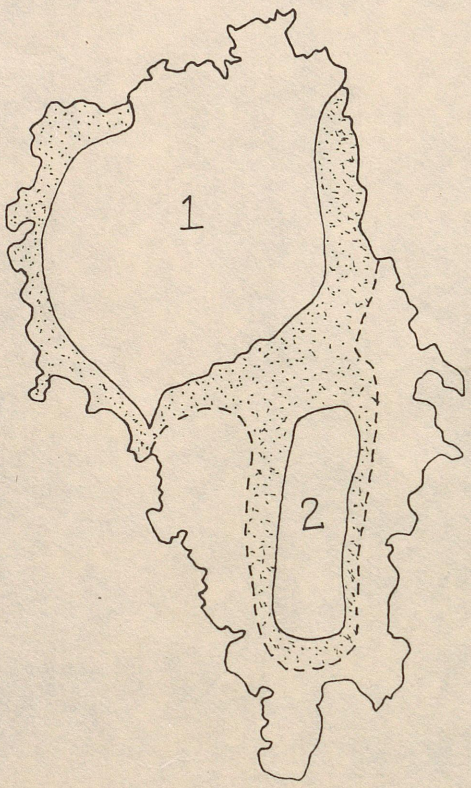
1.1. Geography and Vegetation

The Great Nicobar Biosphere Reserve (GNBR) is situated on the Great Nicobar Island (GNI). The GNI is the largest island in the Nicobars covering an area of 1045 km^2. Spread between 6°45′, 7°15′N, 73°38′ and 93°55′E, the island is 55 km long and has a maximum width of 30 km. The northern half of the island is hilly with peaks rising to over 400 m ASL. Mt. Thullier at 568 m ASL is the highest peak on GNI.

Climate is tropical. Temperature ranges from 25 - 30°C. GNI receives monsoon rains from April till December. Annual rainfall ranges from 370 - 390 cm. This coupled with high relative humidity (77 - 88%) has given rise to tall and dense tropical evergreen forests on the island.

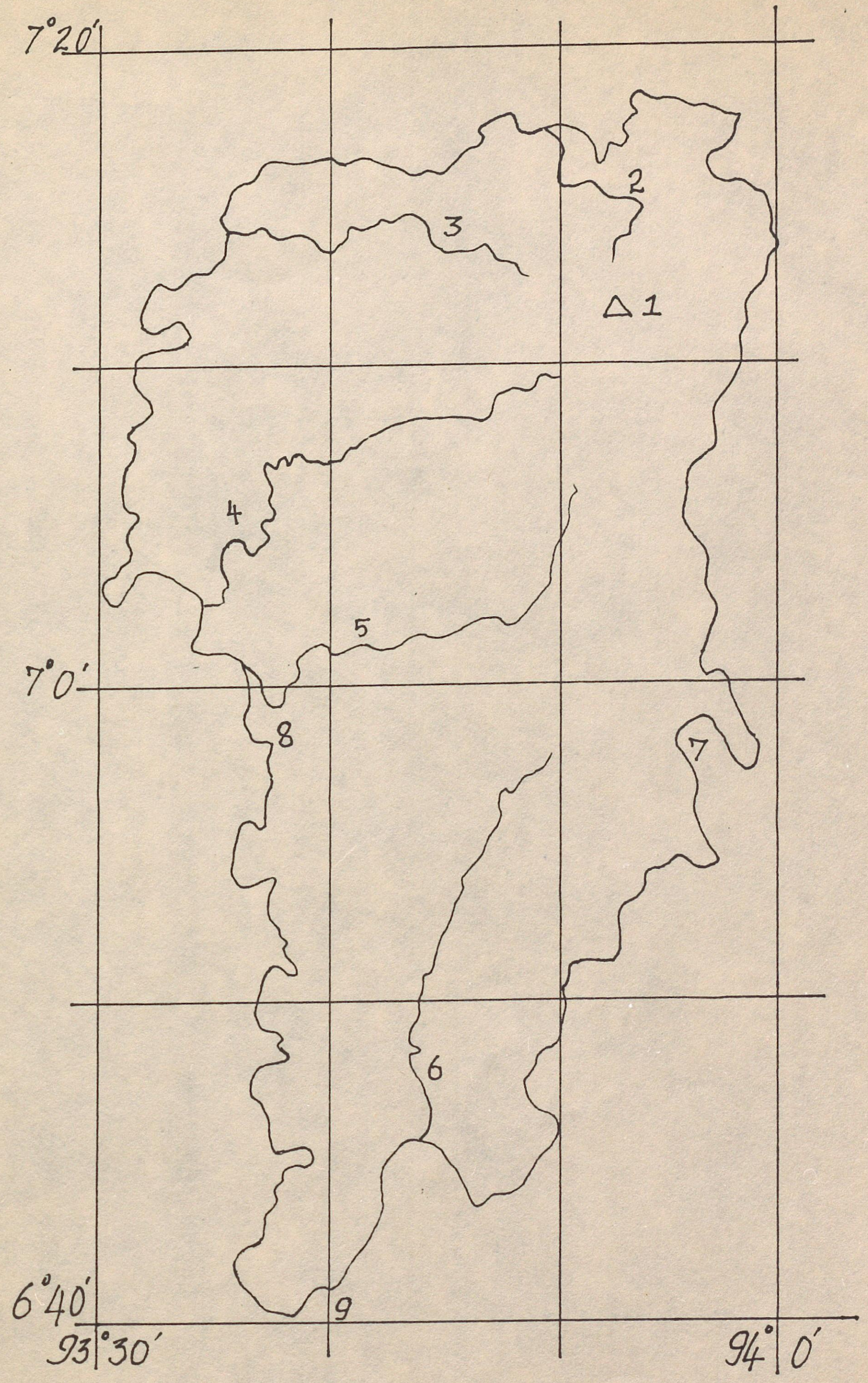
The GNI has 5 perennial rivers viz., Jubilee, Amrit Kaur, Dogmar, Alexandria and Galathea. Besides, there are over 25 smaller streams. Mouths of the rivers and

Great Nicobar Biosphere Reserve



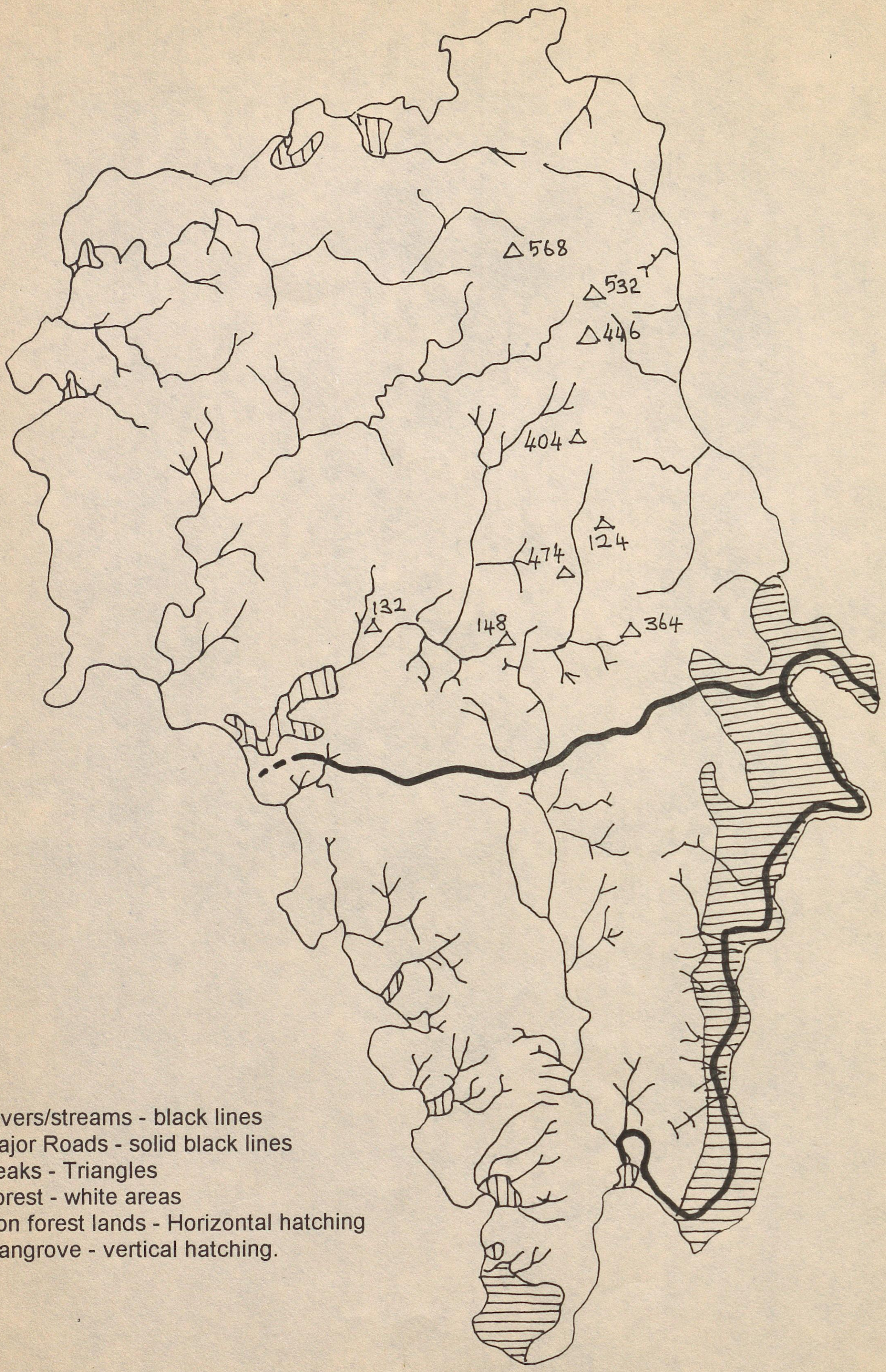
1. Campbell Bay National Park
2. Galathea National Park
Dotted area: Buffer Zone
Redrawn from Sankaran, 1995.

Map of Great Nicobar Island



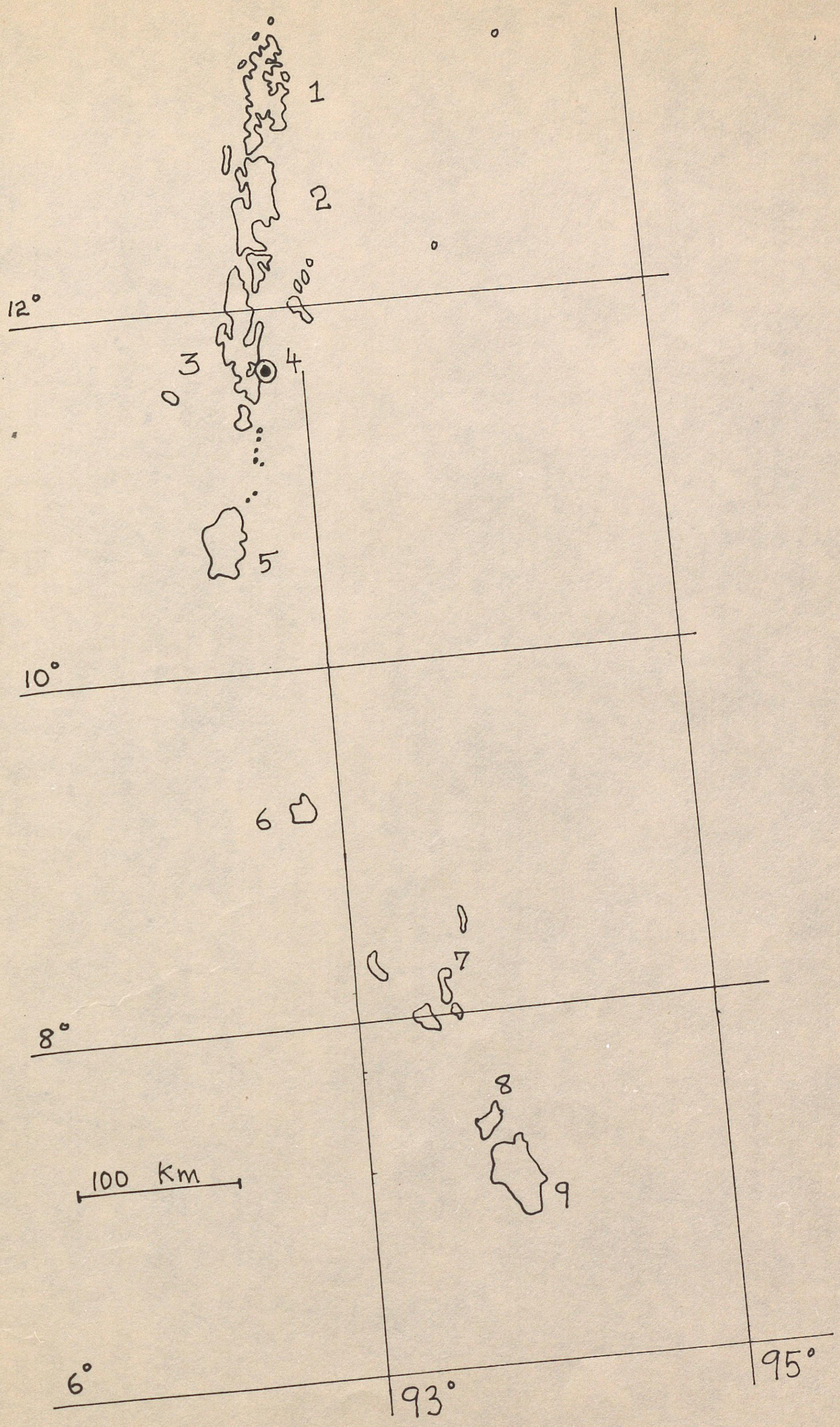
1. Mt. Thullier, 2. River Jubilee, 3. River Amrit Kaur, 4. River Dogmar, 5. River Alexandria, 6. River Galathea, 7. Campbell Bay, 8. Kopen Heat, 9. Pygmalion Point.

Great Nicobar Island: Relief and Vegetation



Rivers/streams - black lines
Major Roads - solid black lines
Peaks - Triangles
Forest - white areas
Non forest lands - Horizontal hatching
Mangrove - vertical hatching.

Map of Andaman and Nicobar Islands



1. North Andaman, 2. Middle Andaman, 3. South Andaman, 4. Port Blair, 5. Little Andaman, 6. Car Nicobar, 7. Camorta/Trinket, 8. Little Nicobar, 9. Great Nicobar

streams harbour dense growth of tall mangrove including lush stands of *Nypa fruticans* palms (see map).

Littoral forests along the flatter coastal zones are dominated by a species of *Pandanus* that grows tall and in dense formations. Giant sized *Calophyllum inophyllum* trees are frequent in the littoral forests.

A remarkable feature about the vegetation on GNI is the almost pure stands of tree ferns (*Cyathea* sp). These are tall, growing along the exposed slopes in the central and northern parts of the island. Occasionally such monotypic formations of tree ferns enter the valleys also, especially where tree density is low (presumably the result of felling operations).

1.2. Biogeography

GNI is part of the large chain of Andaman and Nicobar Islands (see map) in the Bay of Bengal. It is the southernmost island and placed only 144 km north of Sumatra. Biogeographically it is treated as belonging to the Indo-Malayan region in the Andaman and Nicobar Islands province.

The Andaman and Nicobar Islands are considered biogeographically unique. These islands (numbering 324 in all) that spread between the southern end of Mayanmar and the northern tip of Sumatra are known for their endemic biodiversity and aboriginal human beings.

As many as 32 taxa of mammals, 95 taxa of birds and 23 taxa of reptiles are endemic to the islands (Tikader and Das, 1985). These islands have also been the home to 14 aboriginal tribes - 12 negritto and 2 mongoloid. (For a recent review of the status of these aborigines please see Daniels, 1996a).

Biogeographical affinities of the Andaman and Nicobar Islands have been of interest for a considerable length of time. More recently, Ripley and Beehler (1989) have reviewed the history of biogeographical studies of these islands. Based on their study of breeding birds they have concluded that these islands show greater affinity to Myanmar and Malay Peninsula than to India and Indonesia. This is however different from the conclusions drawn by Chaturvedi (1980) after an analysis of mammalian affinities. According to Chaturvedi, the island shows greater mammalian affinity to India than to other east and Southeast Asian countries.

In the absence of any detailed analysis of the distribution and diversity of lower vertebrates, especially, amphibians and reptiles, it is rather premature to draw conclusions as that discussed above. It is quite likely that some of the earlier conclusions will be ignored when results of such analysis are brought to light (Biswas and Sanyal, 1997).

1.3. Fauna of GNI

Although considerable literature exists on the faunal diversity of Andaman and Nicobar Islands or Nicobar Islands as a whole, very little information is available on GNI as such. For instance the document prepared by the Ministry of Environment and Forests, GOI says "there is no detailed faunistic work on the island. Several wild animals and birds are known here. Some of these are endemic"(Anon., 1989).

Probably the most recent and comprehensive list of fauna that could be consulted is that given in Pande *et al* (1991). From this source a list of nearly 200 vertebrates excluding fish could be compiled. However, again, it was not clearly traceable if all of these really occured on the GNI.

The problem with most published lists of vertebrates is that they do not often state specifically from where the species was recorded. They instead say 'Andamans', 'Nicobars' or 'Andaman and Nicobar'. For instance see Das (1994). As a result several published and unpublished works have to be consulted before a reliable, comprehensive list of vertebrates, including fish for the GNI can be prepared.

The following publications were consulted in compiling a list of the vertebrates. Menon and Talwar, 1972; Tikader and Das, 1985 (fish), Boulenger, 1920; Mansukhani and Sarkar, 1980; Sarkar, 1990; Das, 1994, 1995 and 1996 (amphibians), Biswas and Sanyal, 1977; Tikader and Das, 1985; Das, 1994 (reptiles), Abdulali, 1967 and 1978; Sankaran, 1995a (birds) and Hill, 1967; Chaturvedi, 1980; Saha, 1980; Tikader and Das, 1985 (mammals). From these publications what has been certainly recorded from GNI turns out to be around 160 species of vertebrates (see Appendix I).

Further, endemism amongst vertebrates on the GNI is poorly stated in literature. One good source of information on endemic vertebrates is Tikader and Das (1985). More information is available on endemic birds than other vertebrates (Tikader 1984). A detailed discussion of endemic birds generally on the Nicobars and specifically on GNI can be seen in Sankaran (1995a). As has been more often the case, here again, endemic species and subspecies/races are both treated alike.

1.4. Objectives of the present study

The present study has the following five broad objectives.

1.4.1. Preparing benchmark inventories of the vertebrates communities:

Although the GNI is now declared a biosphere reserve, we do not have a comprehensive list of vertebrates for the reserve (Anon., 1989). While we have some information on the presence of vertebrates in the different parts of the GNI, there is little information on habitat requirement and how the different species are organised into communities. It was also felt, that once detailed inventories are available, field guides can be produced to the GNI starting with the vertebrates.

1.4.2. Identifying habitats of higher species diversity and conservation value with special emphasis on endemics, habitat specialists and endangered species:

It is now established beyond doubt that species diversity is not randomly distributed. While some habitats are very rich others are not. Both biogeography and ecology including human influence play a significant role in determining species diversity in a habitat. In the present study it was envisaged that a careful analysis of habitat quality taking species diversity, number of endemics and endangered species as key indicators, conservation values could be assigned to different parts of the GNI.

1.4.3. Monitoring habitat degradation brought about by humans:

Human interference in the tropical humid forests can result in local and landscape level changes in the biodiversity. Earlier, such changes were demonstrated in the Western Ghats (Daniels, *et al*, 1990a; Daniels, *et al*, 1995). Under insular situations, as that in islands, human impacts can adversely affect habitats and thus biodiversity. This needs to be understood.

1.4.4. Identifying habitats of lower vertebrates such as amphibians, reptiles and freshwater fish:

Most information for GNI is on birds. Information on fish, amphibians and reptiles are coming to light only now and that too sporadically (see for instance Das, 1994, 1995, 1996, 1997). Biologists worldwide feel that the lower vertebrates, especially amphibians, which are also poikilotherms, are the best indicators of habitat health (Blaustein and Wake, 1990). Looking at the list of vertebrates expected to occur on

GNI (Pande, *et al*, 1991) it was apparent that about 45% of it was of, amphibians and reptiles. It was therefore considered important to study the habitat requirement of such little known organisms as well.

1.4.5. Identifying habitat requirement and Communities of Sea Snakes:

Nearly 20 species of sea snakes are reported from the Bay of Bengal and coasts of India. While compiling the list of vertebrates for GNI it was surprising to learn that only 2 species had been reported authentically for the Andaman and Nicobar Islands. Das (1994) lists 3 species of estuarine snakes and 4 species of sea snakes for the Andaman and Nicobar Islands. Of these 3 have been reported as occuring in the 'Nicobars'. There have also been some unpublished reports of sea snakes (*Laticauda* sp) hibernating within holes and crevices on trees on certain islands in the Nicobars. While there are some studies on this sort of arboreal behaviour of otherwise fossorial or aquatic snakes (see Gaulke, 1995) nothing is known of this habit in Indian snakes. Sea snakes were hence considered an essential subject of study in this project.

2. METHODOLOGY

The GNI was surveyed using equal sized grids. Grid size of 5 km X 5 km was chosen considering both the overall objective and the practical limitations in the field. The following factors were borne in mind while designing the study methodology.

- The lack of adequate prior knowledge of the topography, vegetation and biodiversity of the GNI.
- The emphasis laid in the project on understanding the broad patterns of vertebrate distribution and diversity on the GNI.
- Limited manpower and skills: The project provided for 2 Technical Assistants and one Field assistant. These staff had limited skills in field identification of vertebrates.
- Remoteness of GNI: The time taken to commute from Madras to GNI including the delays in Port Blair was often very long. During the three years the effective number of days spent by the field staff in GNI was 460.
- Difficulty in getting reliable maps of the island, especially toposheets.
- Maximizing the information on vertebrates that could be generated while taking care to minimize the errors.

The GNI was divided into 55 equal sized grids (fig 2.1). This gridded map was computerized and all the information generated were periodically stored gridwise in the computer. During the project period, 36 of the 55 grids (65%) were visited at least once and data on vertebrates, habitat quality and human interference were collected. During the first phase starting January 1995, the grids that could be approached by road were covered. The existing landmarks such as rivers, milestones, human habitation, etc. were used to locate grids in the field (see Appendix II). The large size of the grids minimized the errors of location due to approximation in the field. The more remote and interior grids of the island could only be approached by boat and forest tracks. This was done during the year 1996-97 as a second phase of the project. Despite all our efforts due to a number of practical constraints, only 65% of the island was covered. As shown in figure 2.1, the northern central portion of GNI which encompasses the Campbell Bay National Park and the hilly areas of the island has been inadequately surveyed.

2.1. Data Collection

Much of the terrain being unfamiliar and the vegetation dense, transects and quadrats were not used for surveys. Instead all data are based on sight records as present and absent on the different grids visited. The information thus generated is hence not uniform (Table 2.1). We have information on amphibians from 25 grids, on reptiles from 34 grids, on birds for 32 grids and on mammals from 29 grids. On 20 out of 36 grids (56%) surveyed do we have information on all 4 groups of vertebrates, viz., amphibians, reptiles, birds and mammals (see Table 2.2).

Fish surveys were less systematic. We relied on the local fishermen's catches. One of the field assistants regularly accompained the local fishermen and collected samples from their nets of the different species. Data was recorded using the local names of fishes mostly collected from the eastern parts of the GNI from the creeks. Additional data on fish were obtained more opportunistically by sight records wherever the water was clear and shallow.

During the 3 year study, a total of 120 species of vertebrates have been recorded (Table 2.3). This amounts to 71% of the known vertebrate fauna of the island. Direct records include collection of samples (fish, amphibian and reptiles) and field identification of birds and mammals. Bird identifications were reconfirmed by the Principal Investigator during his field visit in March 1996. Additional information was obtained on the correct identity wherever necessary from researchers of SACON who have been on the island at that time.

Most mammals on the island were rodents and bats. These could not be correctly identified since they were not trapped. Hence the data has been grouped for analysis as species groups instead of individual species. Thus 'rats' can include more than one species of *Rattus*.

Fishes were collected, as mentioned above from local fishermen. Amphibians and reptiles frequently found killed on roads provided reliable data. Besides these, collections were made of selected species of amphibians that posed difficulty in field identification vide a permit (No. (WLW/WL/38/1624 dt. 10.2.1997) issued by the Andaman and Nicobar Island, Forest Department.

2.2. Identification of species

Except the common mammals, no attempt was made to establish specific identity to those species encountered in the study.

As mentioned earlier, correct identification of birds upto the level of species was possible in the field by using standard guides (Ali and Ripley, 1983).

Samples of fish were identified by Dr (Ms) Rema Devi of the Zoological Survey of India, Madras.

Amphibians and reptiles were identified using standard keys by the Principal Investigator. These were reconfirmed by Dr. Indraneil Das.

Once fish, amphibians and reptiles were correctly identified, colour photographs of live or dead specimens were used as field guides for further data collection (see Plates).

2.3. Data on Habitat Quality

Gridwise information on type of forests present and the various human influences were recorded for all the grids surveyed in a separate data sheet (Table 2.4). The data is of qualitative nature recording only the presence and absence of any of the predetermined habitat variables. This data was stored on the computerised map of GNI for further analysis.

2.4. Data Analysis

Considering the nonuniformity of the available data and the various constraints that have introduced sampling biases during the study, no rigorous statistical analysis is being attempted. Instead the broad patterns of diversity and distribution of vertebrates are shown on computer generated maps. Wherever appropriate, ranks and scores have been used for interpreting the patterns.

Fig. 2.1 GRIDDED MAP OF GREAT NICOBAR ISLAND

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

The shaded grids were surveyed during the project.
Grid size 5 km X 5 km

Table 2.1 Number of grids on which data on each of the 4 classes of vertebrates excluding fish are available

	Data available	Data unavailable
Amphibians	25	30
Reptiles	34	21
Birds	32	23
Mammals	29	26

Table 2.2 Number of grids for which data on one or more classes of vertebrates excluding fish are available

Amphibians	Reptiles	Birds	Mammals	No. of grids
0	0	0	0	19
0	0	1	1	1
1	0	1	1	1
0	1	0	0	1
0	1	1	0	2
1	1	1	0	1
1	1	0	0	3
0	1	1	1	7
1	1	1	1	20

0 - unavailable
1 - available

Table 2.3 Number of inland vertebrate species recorded during the present study

Class of vertebrate	Total No. of species on GNI[1]	No. of species recorded[2]	% recorded
Fish	34	14	**41.0**
Amphibians	13	8	**61.0**
Reptiles	32	22	**69.0**
Birds	76	67	**88.0**
Mammals	15	9	**60.0**
Total	**170**	**120**	**71.0**

[1] Please see Appendix I.
[2] Number recorded during the present study including the unconfirmed.

Table 2.4 **GREAT NICOBAR ISLAND - HABITAT INFORMATION**

GRID NO. :			DATE :	
ALTITUDE : MIN		MAX		
TEAM MEMBERS :				
Sl. No.	ATTRIBUTE	YES	NO	REMARKS
1)	FIRE			
2)	AGRICULTURE			
3)	HUMAN SETTLEMENT			
4)	FIRE WOOD			
5)	FODDER/GRASS			
6)	LOGGING			
7)	HUNTING			
8)	CATTLE/SHEEP			
9)	TALL TREES			
10)	DENSE VEGETATION			
11)	OPEN VEGETATION			
12)	METAL ROADS			
13)	SWAMPS			
14)	BIRD ROOSTS			
15)	TURTLE BREEDING			
16)	SEA SNAKE HABITATS			
17)	FISHING			
18)	SAND MINING			
19)	ROCK QUARRYING			
20)	OTHERS			

3. RESULTS OF THE STUDY

The main results of the study are being presented and discussed under the respective objectives.

3.1. Benchmark Inventories of the vertebrate communities

Probably the earliest and most concerted effort to reliably inventory the vertebrates of the GNI was that by the interdisciplinary team of scientists that was sent on an expedition to the Andaman and Nicobar islands by the Government of India in 1966. After this pioneering survey which involved a substantial manpower of over 100 people benchmark lists of vertebrates started appearing in published literature. Important amongst these are that of Abdulali (1967) on birds, Menon and Talwar (1972) on inland fishes and Biswas and Sanyal, 1977 on reptiles. Detailed lists of amphibians and mammals got published only more recently (Chaturvedi, 1980; Sarkar, 1990 and Das, 1994). Over the past 2-3 years a number of sporadic publications as that of Sankaran (1995a), Das (1995 and 1996) and Daniels and David (1996) have added many more species to the list of vertebrates of GNI. What we thus have is currently a list of 170 vertebrates including 34 species of inland fish for the GNI (see Table 2.3 and Appendix I).

We may consider the above list as a benchmark inventory of the vertebrates of GNI to start with. The current study has added information to this inventory by not only confirming the presence of 120 species of vertebrates but also by providing data on their distribution on the island. Further, we now have some information on the vertebrates within the core area of GNBR (see Appendix III).

Fig 3.1 shows how widespread are these species of vertebrates (excluding the fishes) on the GNI (see Appendix IV). Of the 106 species of amphibians, reptiles, birds and mammals recorded during the study over 13% are widespread; i.e., they were recorded on more than 50% of all the grids surveyed. Fig. 3.2 shows the ranges of some of these widespread vertebrates.

Fig 3.1: Distribution of vertebrates excluding fish on the Great Nicobar Island

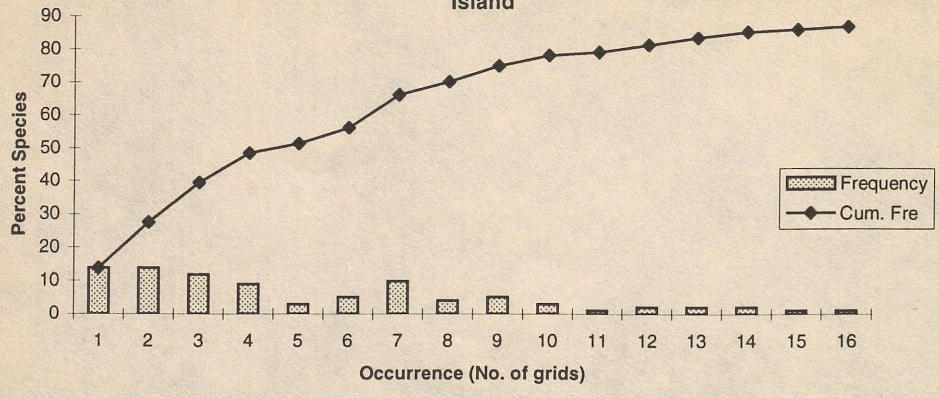
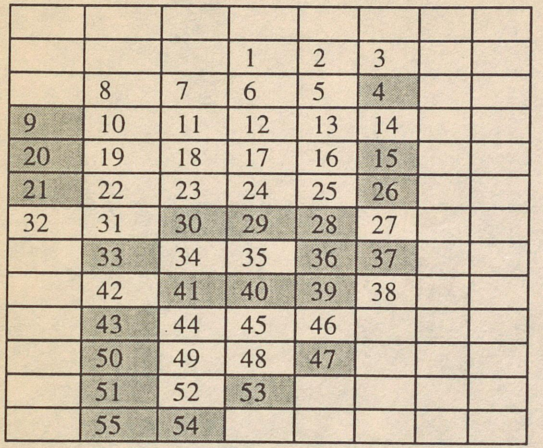
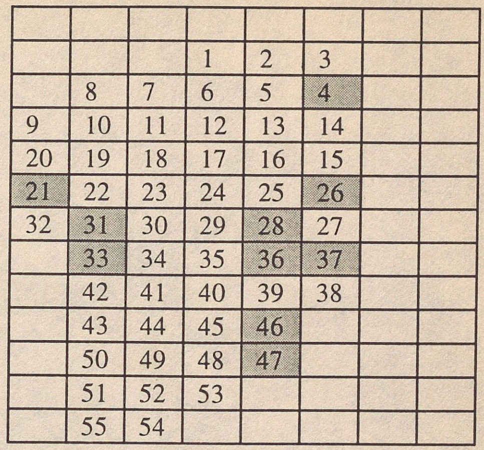


Fig 3.2 Distribution patterns of some of the most widespread species of amphibians, reptiles, birds and mammals on GNI

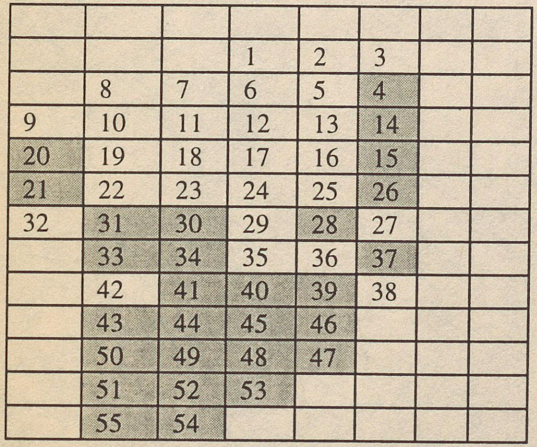
Bufo camortensis



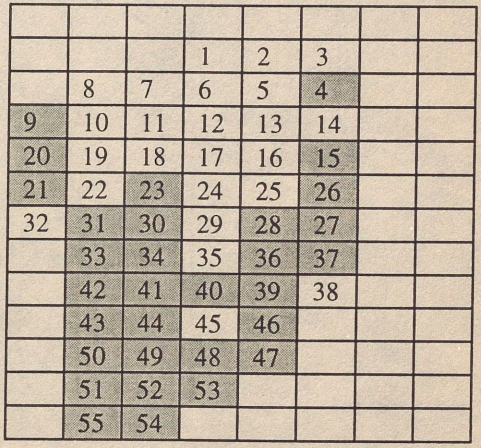
Microhyla heymonsi



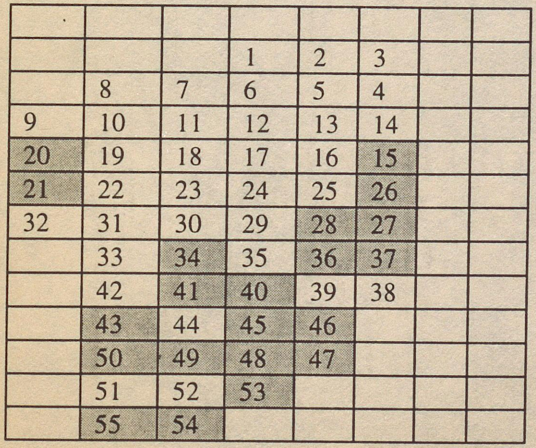
Lipinia macrotympanum



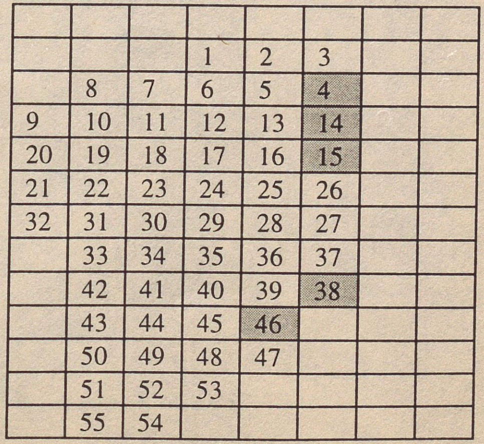
Mabuya rudis



Varanus salvator



Laticauda spp



Dendrelaphis humayuni

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Aplonis panayensis

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Psittacula longicauda

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Dicrurus paradiseus

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Gracula religiosa

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	8	7	6	5	4		
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	43	44	45	46			
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	51	52	53				
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Ducula aenea

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Fig 3.2 (Contd.)

Macropygia rufipennis

			1	2	3		
	8	7	6	5	4		
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20	19	18	17	16	15		
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	55	54					

Treron pompadora

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	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Nectarinia jugularis

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	8	7	6	5	4		
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20	19	18	17	16	15		
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	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Macaca umbrosa

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	8	7	6	5	4		
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20	19	18	17	16	15		
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32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
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	50	49	48	47			
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Tupaia nicobarica

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	8	7	6	5	4		
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20	19	18	17	16	15		
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	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
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Pteropus spp

			1	2	3		
	8	7	6	5	4		
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	42	41	40	39	38		
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Fig 3.2 (Contd.)

3.1.1. Inland Fish

Menon and Talwar (1972) have listed 27 species of fish as occurring in the inland waters of GNI. Seven species of fish have been added to the list of Menon and Talwar (1972) during this study (see Appendix I). Of these, *Apogon thermalis* (a single specimen) is noteworthy. This species has never before been recorded from the Andaman and Nicobar Islands (Talwar and Jhingran, 1991). Although the data on fish was collected more opportunistically, presence and absence of the identified species were recorded widely on the GNI (see fig 3.3). To understand how exactly fish communities are organised in the inland waters of GNI we need to discuss the possible origins and compositions of the fish fauna.

The inland fish fauna of GNI is characterized by

- a lack of primary freshwater fish. All species known, except those introduced, are secondary invaders from estuarine and marine habitats.
- amongst the introduced fish *Heteropneustes fossilis* (cat fish) and *Oryzias melastigma* (rice fish) are naturalized. Species of *Channa* were found only in wells within human habitation.
- *Oryzias melastigma* ranges from inhabiting small pools of backwaters close to the sea (within 2-3 meters) to flowing freshwater upstream. Large numbers of this fish was seen in the heart of GNI around the Shompen Hut.
- amongst the secondary invaders, there is a greater representation of Gobioid fishes especially sleepers (Eliotrididae). Two species of sleepers found most commonly are *Ophieleotris aporos* and *Ophiocara porocephala*. The former which is also larger is locally known as 'kala jiga'. These two species both appear and behave much like the common snakeheads (*Channa* spp). In their natural habitats, sleepers seem to play a major role as aquatic predators.

Fig 3.3 Grids in which fishes were sampled

			1	2	3		
	8	7	6	5	4		
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20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
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	55	54					

3.1.2. Amphibians

Appendix I lists 13 species of amphibians as occurring on GNI. Of these 8 species have been recorded during the present study. The existence of *Polypedates leucomystax* and *Limnonectes macrodon* on GNI reported by Sarkar (1990) seems to be doubtful. The only species of tree frog that was repeatedly encountered during our surveys has been described as *Polypedates insularis*, a species endemic to GNI (Das, 1995). Similarly, the largest ranid frog on the island, that was probably considered in the past as *Rana (Limnonectes) macrodon* has been recently described as *Limnonectes shompenorum* (Das, 1996). Barring these 2 species we have 11 species on GNI.

Of the 11 species of amphibians, *Bufo camortensis* is the most widespread followed by the Microhylid frog *Microhyla heymonsi* (see fig 3.2). Other species apparently have more localized distribution.

Very little could be said of community organisation amongst amphibians on GNI. Das (1995) has reported the coexistence of *Bufo melanostictus, Rana nicobariensis, Rana chalconota, Limnonectes shompenorum* and *Microhyla heymonsi* with

Polypedates insularis. During our surveys, in one situation within an open well in the middle of rice fields, in Campbell Bay we found *Bufo camortensis, Rana chalconota* and *Rana erythraea* (Daniels, pers. obser.). This was during the night. In small freshwater creeks in Campbell Bay a few individuals of *Rana erythraea* could be seen together. Within human habitation in Campbell Bay, *B. camortensis* was common. Calls of what appeared to be *B. melanostictus* were also heard in the same area during March 1995. *Microhyla heymonsi* was frequently seen crossing metalled roads during rainy nights. *Rana chalconota* also enters human habitation.

3.1.3. Reptiles

Thirty two species of reptiles are known from GNI (Appendix I). Of these 20 were recorded during the present study. An additional two species viz., the Andaman day gecko *Phelsuma andamanense* and pit viper *Trimeresurus* sp possibly exist on GNI. There are many unconfirmed sight records of the gecko by local field guides. The species is generally considered absent in the Nicobar islands (See Daniels, 1996). Local people have also reported of a pit viper on GNI.

A species of krait (*Bungarus* sp) was sighted twice on GNI (once photographed) in La Foul and within Galathea NP. Hitherto there have been no reports of kraits from GNI (Das, 1994).

Ranges of a few of the most widespread reptiles on GNI are shown in fig 3.2. Skinks are very common on the forest floors and roadsides. *Mabuya rudis* and *Lipinia macrotympanum* are amongst the most frequently seen skinks. Monitor lizards (*Varanus salvator*) are common and widespread. Of the snakes the bronzeback (*Dendrelaphis humayuni*) is the most common. This otherwise arboreal snake rests frequently on roads and gets crushed by passing vehicles. The most often encountered road kills of snakes on the island are of this species.

On at least 4 independent occasions the Malayan box turtle (*Cuora amboinensis*) was sighted during our study. All the individuals were juvenniles, of less than 10 cm carapace length. There were also 4-5 sightings of sea snakes on the GNI. These belonged to *Laticauda* spp.

We have very little information on the arboreal communities of reptiles on GNI. Skinks dominate the litter community. The top carnivores on the GNI are also reptiles - *Crocodylus porosus, Python reticulatus* and *Varanus salvator*. The crocodile and python are rather shy (presumably due to pressures of poaching) and rarely encountered. The monitor lizard on the contrary is fairly common. Although less diverse than birds in terms of number of species, reptiles are more widespread on GNI and more frequently encountered than amphibians, birds and mammals. Reptiles thus seem to be a major component of the vertebrate fauna of GNI.

3.1.4. Birds

Seventy six species of birds are reported from GNI (see Appendix I). Of these 56 species were sighted during the study. Another 11 species encountered are being treated as unconfirmed due to inadequate information. Large hawk cuckoo (*Cuculus sparverioides*), Andaman drongo (*Dicrurus andamanensis*), Brown flycatcher (*Muscicapa latirostris*) and Redthroated pipit (*Anthus cervinus*) are new records for GNI. The hawk cuckoo is an addition to the birds of Andaman and Nicobar Islands as a whole.

Many birds are widespread on GNI. The most widespread species are parakeets (*Psittacula caniceps and P. longicauda*), glossy stare (*Aplonis panayensis*), racket-tailed drongo (*Dicrurus paradiseus*), hill myna (Gracula religiosa), pigeons (*Ducula aenea* and *Treron pompadora*), Andaman cuckoo dove (*Macropygia rufipennis*) and olive backed sunbird (*Nectarinia jugularis*) (see fig 3.2). The whitebreasted waterhen (*Amaurornis phoenicurus*) is the most widespread and frequently encountered ground bird on GNI. The megapode (*Megapodius nicobariensis*) is rather localized and most often seen on the southern coastal sides, especially near the Pygmalion Point on GNI. Sankaran (1995a) reports high densities of the megapode on the northern shore as well. We however have not visited those parts of GNI.

The following patterns of the avifaunal composition and distribution on GNI are of interest.

- There is a domination of non-passerine birds in the avifauna (75%). This pattern is similar to that of the Andaman and Nicobar Islands as a whole (Ripley and Beehler, 1989). This is also similar to that of southwestern India where non passerines dominate (62% of the avifauna, Daniels, 1997). Insular and isolated tropical rainforests as those on the islands and the Western Ghats tend to become impoverished with respect to passerines. The Indian subcontinent's avifauna on the contrary consists 54% of passerine birds.
- The GNI has a fairly large population of the koel (*Eudynamys scolopacea*) which is also widespread. Males are more often seen. Do these birds breed on GNI in the absence of crows? Although Abdulali (1967) mentions it, we have no evidence of the koel parasitizing either the hill myna (*Gracula religiosa*) or imperial pigeons (*Ducula* spp) on GNI.
- The avian community of the canopy is dominated by frugivorous birds (fruit pigeons, parakeets and hill myna).
- Strictly insectivorous species are generally scarce (21%).
- 30% of the avifauna is of species that would normally prey on fish, amphibians or reptiles.

3.1.5. Mammals

At least 15 species of mammals are known from GNI (see Appendix 1). Of these 5 species were recorded with certainty. Another 4 species of bats and rodents have been doubtfully identified during the study.

As shown in figure 3.2 the two most widespread mammals on GNI are the crab-eating macaque (*Macaca umbrosa*) and the tree shrew (*Tupaia nicobarica*). Although arboreal rats were encountered on many occasions, they could not be identified since no trapping was attempted. Similarly, we have recorded flying foxes (*Pteropus* spp) on many parts of the island (see fig 3.2). Smaller bats and pipestrelles could not be correctly identified in the field.

Wild pigs (*Sus scrofa*) are distributed all over the GNI. However, they are shy and hence chances of encounter during the day is much less. Wild pigs have been observed feeding on shore crabs during nights.

The only carnivorous mammal known till date on the GNI is the feral cat (*Felis domesticus*). We however have an unconfirmed sight record of the marbled cat (*Felis marmorata*) crossing the road near Vijaynagar-Laxminagar (Grid no. 39). One of our research assistants who saw this cat tried but failed to photograph it. Although there are no reports of native cats on either Andamans or Nicobars earlier, considering the range of the marbled cat, its occurrence on GNI is quite probable. The species which ranges from northeast India to Indonesia, is described as a 'little known' arboreal cat in literature (Prater, 1980). In Indonesia it is known as far north as Sumatra. The possibility of the existence of a small population of this species within the dense forests of GNI can hence not be ignored.

3.2. Habitats of higher species diversity and conservation value: Emphasising endemics, habitat specialists and endangered species.

The habitats on the GNI can broadly be grouped as aquatic and terrestial. The aquatic habitats include the upland streams which are freshwater, tidal rivers, coastal creeks, swamps and mangroves. The tidal and coastal waters are often difficult to further divide. It is simpler to treat all aquatic habitats under two categories viz., freshwater and saltwater.

Terrestial habitats are largerly of tall tropical rainforests. Areas that have been cleared are currently under betelnut, coconut and orchards. Large areas have been brought under rice cultivation. All along the southeastern coast, roads and human settlements have transformed the island's original landscape. While the interior parts of the island are rather uniformly covered by rainforests, the coastal areas, especially the southeast are a mosaic of creeks, mangroves, littoral forests, human habitation and cultivation. Available vegetation maps broadly categorise the landscape as under forest, mangroves and non-forest (see map in section 1.0). Remote sensed data of 1994 available at the Institute for Ocean Management, Anna University, Chennai, has also provided only such broad categories. (Information on the landscape and landuse collected during the present study will be discussed in detail in section 3.3).

For practical purposes we classify the habitats on GNI as the following

- Inland aquatic (freshwater)
- Inland forests
- Inland non-forest (tribal settlements)
- Coastal aquatic (including mangrove areas)
- Coastal forests (littoral)
- Coastal non-forest (settlers' habitation and agriculture).

We may first consider how the diversity of vertebrates are distributed on the GNI. As mentioned earlier, data on fish is more opportunistically collected than the other classes of vertebrates. Fish are therefore not included in any quantitative analysis. Further, the data on amphibians, reptiles, birds and mammals when treated gridwise show a considerable variation. Total number of species per grid varies from 1 to 63; 63 being in and around Campbell Bay. The average number of species per grid is 20.6 with a SD of 12.84.

That there is greatest diversity near Campbell Bay is in itself an indication of higher efforts in this grid (grid no. 37). This is where the project staff were based. Since variance is high a direct ranking of grids by the total number of vertebrate species will not be appropriate. Instead we have attempted to consider the actual deviation from the mean number of species as a measure of diversity for each grid. What we thus get are values which range from -20 to +42. In order to eliminate the symbols, we have used different colours to denote the deviations that are below and above average.

Fig 3.4 shows the result of the above analysis. It is apparent that most of the grids along the coast have above the average number of species. Interior areas are poorer in vertebrates than the coast. While this seems anomalous, such a pattern is quite probable considering the fact that birds comprise much of the vertebrate diversity on GNI. That bird diversity increases with human interference and landscape heterogeneity has been convincingly demonstrated for the Western Ghats (Daniels, *et al*, 1990a&b, 1991, & 1992 and Daniels, 1994 & 1996b).

In order that we eliminated the influence of birds on the patterns of vertebrate diversity, the data on birds was excluded and only that on amphibians, reptiles and mammals were used. The results are given in figure 3.5.

Fig 3.4 Diversity scores for each grid taking amphibians, reptiles, birds and mammals together.

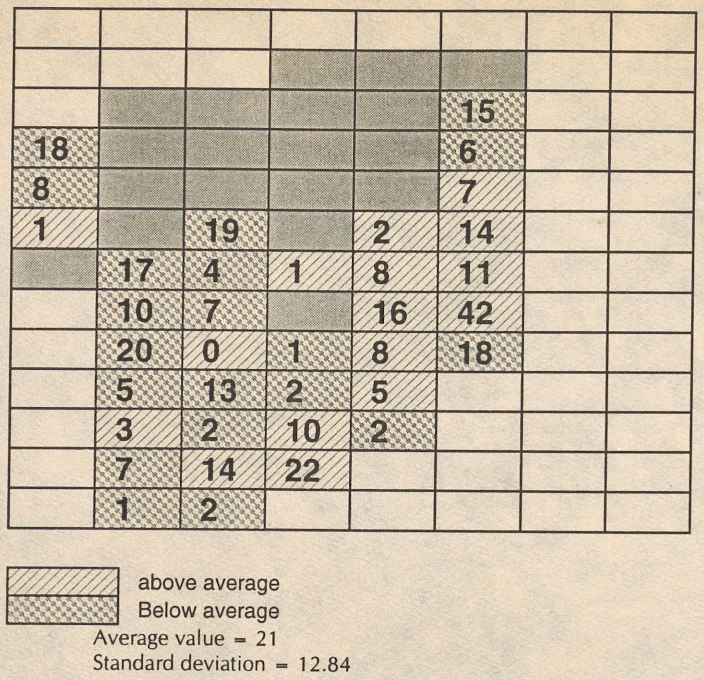
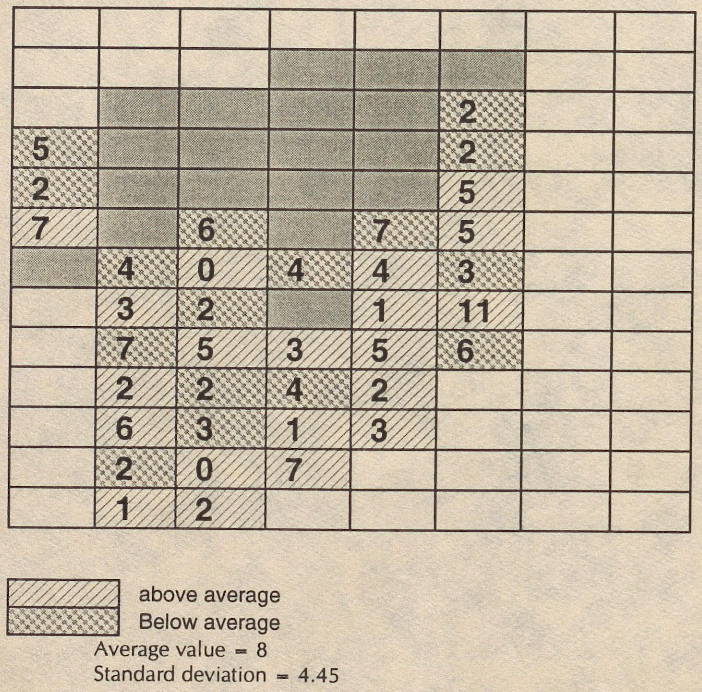


Fig 3.5 Diversity scores for each grid after removing birds



The altered analysis has made some difference. That a few grids in the interior also take values higher than the average becomes apparent. Such a pattern can be explained in two ways.

- First, the nonuniformity of the data as we did not use standard sampling methods.
- Second, the greater habitat heterogenity of the coastal grids leading to a greater vertebrate diversity.

While the first point cannot be ignored at any stage of data analysis, the second seems to be a stronger possibility. If we see the interior grids, they are generally homogeneous with either only forests or some streams and tribal settlements. These tribals (as we will discuss later) are still aboriginal and in small numbers causing very little impact on the forests. The coast on the contrary is heterogeneous. The mosaic of coastal aquatic habitats (including creeks and mangroves), coastal forests (with dense patches of *Pandanus*) and coastal human settlement, creating ponds and other freshwater ecosystems has certainly provided opportunities for many species of vertebrates on GNI. If one still argues against this in the light of sampling biases, we may reiterate with due consideration that, in terms of vertebrate diversity on GNI, the coastal areas are equally important, if not more, as the interior forests. It must also be pointed out here that this pattern has emerged despite keeping fish out of the analysis!

3.2.1. Distribution and diversity of Endemic vertebrates on GNI

Table 3.1 provides information on the endemic vertebrates of GNI. Twenty seven out of 170 species (16.0%) of vertebrates are known to be endemic to the Andaman and Nicobar Islands. Of these the fish *Kramericus smithi*, frogs *Limnonectes shompenorum* and *Polypedates insularis* are so far reported only from the GNI (Menon and Talwar, 1972; Das 1995 & 1996).

Table 3.1 Endemism in vertebrates of GNI

Class	Total no. of species	No. of endemic species	%
Fish	34	1	3.0
Amphibians	13	3	23.0
Reptiles	32	8	25.0
Birds	76	8	10.5
Mammals	15	7	47.0
Total	**170**	**27**	**16.0**

Fig 3.6 Distribution of endemic vertebrates excluding fish

			1	2	3		
	8	7	6	5	1		
2	10	11	12	13	3		
5	19	18	17	16	7		
7	22	1	24	3	7		
32	31	6	5	8	4		
	5	2	35	7	11		
	42	6	5	7	38		
	4	4	3	4			
	7	5	5	3			
	5	8	9				
	4	6					

Figures given in shaded areas are that of numbers of endemic species.

Endemism is highest amongst mammals (47.0%) in the GNI followed by reptiles (25.0%) and amphibians (23.0%). Fig 3.6 suggests that the endemics are fairly widespread with most grids surveyed (20 out of 36) having not less than 5 species. The maximum of 11 species has been reported in and around Campbell Bay. The coastal grids, despite being disturbed considerably, apparently provide habitat for endemic vertebrates as much as the interior forests do. Further, that the single grid with the largest number of endemic vertebrates (11 species) amounts only to less than 50% of all known endemics on GNI, is indication that no grid (and thus habitat) can be exclusively labelled as having very high conservation value. Extensive habitat mosaics seem to be important for conserving the endemic vertebrates on GNI.

3.2.2. Distribution of Habitat Specialists

With the exception of the introduced inland fish and certain birds like the Pond heron (*Ardeola grayii*), Cattle egret (*Bubulcus ibis*) and pigeon (*Columba livia*) which are more or less specialized users of human transformed habitats, most vertebrates on GNI survived historically in either dense forests or coastal habitats.

Non-migratory species of fish in creeks, backwaters and tidal river mouths are specialized habitat users. These habitats are subject to fluctuations in water level, temperature and salinity throughout the year.

Megapodes (*Megapodius nicobariensis*) are habitat specialists. That they are restricted in range to the coastal parts of GNI is evidence adequate to support this presumption (see Sankaran, 1995a). Other species of birds that might be considered as habitat specialists are the Nicobar pigeon (*Caloenas nicobarica*) and the pitta (*Pitta sordida*) which prefer shaded floors within dense forests. Swiftlets (*Collacalia spp*) are specialized users of caves. Most caves on GNI which are active are along the coast. (For detailed discussion on cave swiftlets please see Sankaran, 1995b).

Assigning conservation value to the grids of GNI based on the presence of habitat specialists does not appear to be logical. Both inland and coastal habitats are equally important, in that they have a comparable set of vertebrates. To classify these into strictly specialists and generalists is not possible considering the range of each species on GNI. Broadly speaking, terrestial habitat specialists are largerly forest dwelling and aquatic specialists are coastal on GNI.

3.2.3. Endangered species

In lieu of detailed population and ecological studies, categorising species on GNI as endangered is premature. Going by what has been listed as endangered species in the Indian Wildlife Act, 1972 as well as CITES appendices, we may only consider the following 3 species of reptiles viz., *Crocodylus porosus, Varanus salvator* and *Python reticulatus* as endangered.

Interestingly, the former two are inhabitats of coastal habitats. *Varanus salvator* can also be seen in the interior parts of the island (see fig. 3.2). *Python reticulatus* which is more a forest inhabitant (at least the larger individuals as reported by the local settlers) frequently enters human habitation to prey on domestic chicken. Thus, in a sense, the 3 endangered species of vertebrates on GNI are equally distributed amongst the 2 major habitat types viz., inland forests and coastal aquatic habitats.

3.3. Habitat degradation brought about by humans

In Section 2.0 the format for collecting information on human interference and habitat quality was presented as table 2.4. Analysis of the data thus collected has been presented in this section in figure 3.7. The details of distribution of the various habitat attributes given in the figure are discussed below.

The GNI has a total area of 1045 km^2 with a coastline of 213 km. The human population consists of 536 tribals (Shompen and Nicobarese) and 6295 settlers/officials from the mainland (Sankaran, 1995a). Whereas the Shompens numbering around 200 (Daniels, 1996a) are still existing as nomadic hunter-gatherers. The Nicobarese have taken to settled agriculture. But for the occasional fires that they start, Shompens generally do not cause any adverse impact on the natural habitats of GNI.

Nicobarese practising agriculture grow coconut, betelnut, bananas and a variety of root and vegetable crops. Small areas around their settlements are cleared for this purpose. The impact by Nicobarese on GNI is also not really considerable.

Human settlement along the coast is of mainland immigrants. Essentially the 6000 and odd settlers are concentrated here. The impact of these settlers is rather adverse. Due to unplanned agriculture, the coastal areas are greatly damaged between Campbell Bay and Galathea. Settlers practising agriculture here are largely of those who have immigrated from Punjab and Bihar (Ranchi). Their forms of agriculture is not compatible with rainforests and coastal habitats. For instance dense formations of *Pandanus* (fruits of which are a staple diet to the native islanders) naturally protect the shoreline. These are destroyed using fire by the settlers and in many places replaced with casuarina on GNI. The *Pandanus* also play a key role in creating small freshwater swamps a few meters away from the shoreline on the island.

3.3.1. Roads

Major impact on the natural habitats of GNI are those brought about by laying roads since the early 1960s. Starting with the two roads viz., the east-west road that cuts the GNI into 2 halves and the longer coastal north-south road that links Campbell Bay with Pygmalion Point, considerable habitat degradation has been brought about. The impact of roads has been the greatest along the coast leading to coastal degradation by way of shoreline erosion, loss of littoral forests and removal of sand and dead coral.

3.3.2. Tribal Development Schemes

Government initiatives to help the tribals have led to undue habitat transformation. Towards the end of the east-west road we find the Shompen Hut. This centre which was meant to provide basic services such as medical treatment and food rations is currently mostly abandoned by the Shompens. The residing staff are creating local damage to forests and the freshwater sources.

The agriculture department's initiative in clearing forests and planting betelnut for the tribals has also been a failure. While large stretches of forests between Galathea and Pygmalion Point have been cleared and planted densely with betelnut, the plantations are not visited by the tribals. Settlers from Ranchi are known to periodically harvest the nuts.

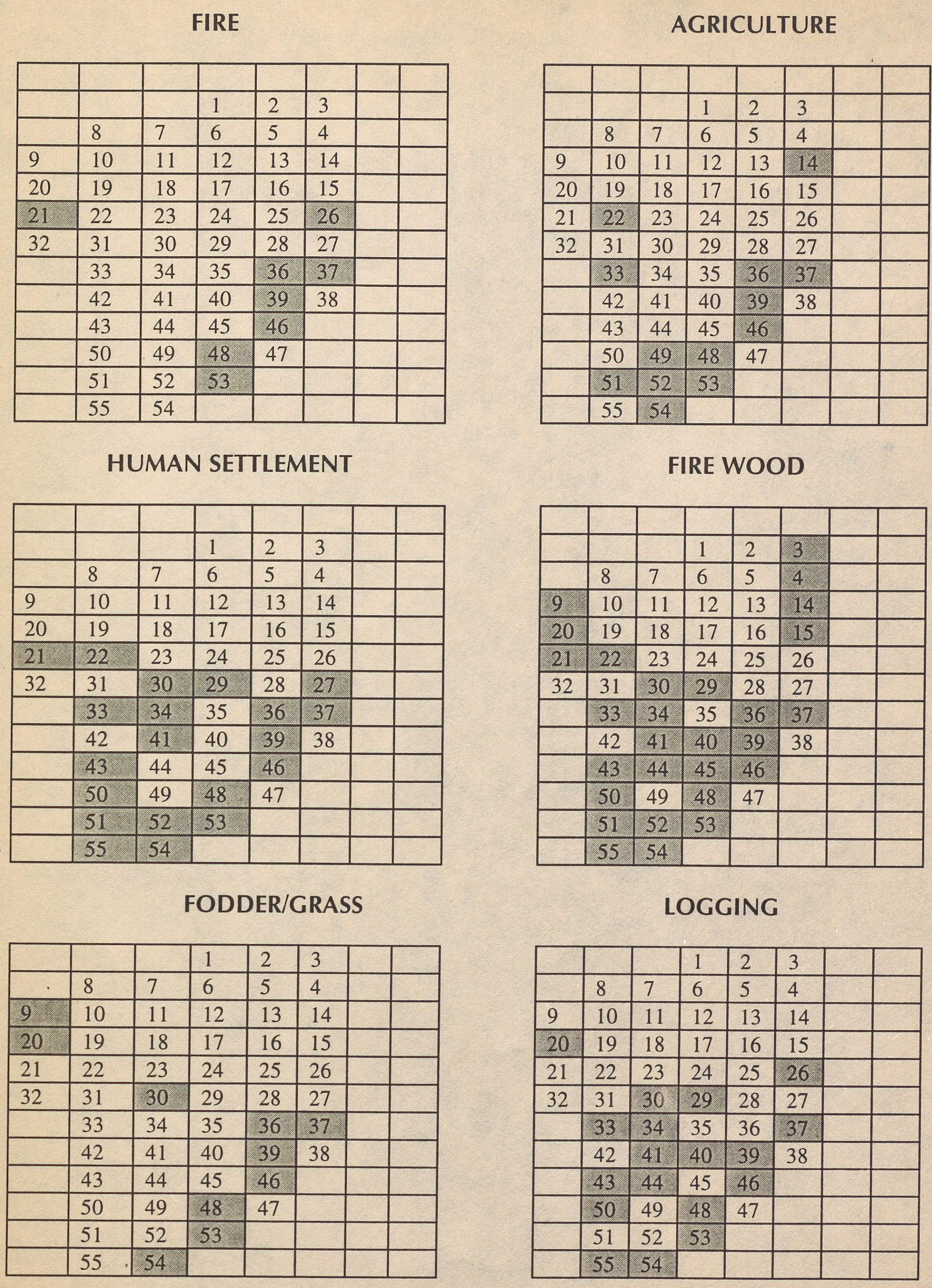
3.3.3. Logging and extraction of nontimber forest products

Pande *et al* (1991) have briefly discussed the status of GNI in their report. They have stated that 85% of the island's forest is 'pristine'. This is certainly an over-statement. Logging, both licenced(?) and illegal, goes on all over GNI currently (see fig 3.7). Further, collection of dead wood in truck loads is fairly common. The process of cutting dead trees and sawing them to barrel-sized logs which are then rolled down to hit the roads is quite destructive to smaller plants. Other forms of extraction by settlers is collection of firewood, cane and wild betel leaves.

3.3.4. Poaching

Poaching is rampant. Three kinds of poachers exploit the GNI. The Nicobarese and Shompens hunt wild pigs and megapodes (see Sankaran, 1995a). There are Thai poachers who visit the island to collect crocodiles. These foreign poachers are quite destructive. Since they mingle with the Nicobarese, the exact area of operation is not clearly traceable. We also have information that the rare Malayan box turtle (*Cuora amboinensis*) is regularly poached on GNI.

Fig 3.7 Distribution of important habitats and the various human impacts on GNI



HUNTING

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

CATTLE/GOAT

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

TALL TREES

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

DENSE VEGETATION

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
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	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

OPEN VEGETATION

			1	2	3		
	8	7	6	5	4		
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20	19	18	17	16	15		
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32	31	30	29	28	27		
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	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

METAL ROADS

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Fig 3.7 (Contd.)

SWAMPS

			1	2	**3**		
	8	7	6	5	**4**		
9	10	11	12	13	**14**		
20	19	18	17	16	**15**		
21	**22**	23	24	**25**	**26**		
32	31	**30**	**29**	28	**27**		
	33	**34**	35	**36**	**37**		
	42	41	**40**	**39**	38		
	43	**44**	**45**	**46**			
	50	**49**	**48**	47			
	51	52	**53**				
	55	**54**					

COMMUNAL BIRD ROOSTS

			1	2	**3**		
	8	7	6	5	**4**		
9	10	11	12	13	**14**		
20	19	18	17	16	**15**		
21	**22**	23	24	**25**	**26**		
32	31	**30**	**29**	28	**27**		
	33	**34**	35	**36**	**37**		
	42	**41**	**40**	**39**	38		
	43	**44**	**45**	**46**			
	50	49	**48**	47			
	51	**52**	**53**				
	55	**54**					

TURTLE BREEDING

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	**26**		
32	31	30	29	28	**27**		
	33	34	35	36	37		
	42	**41**	**40**	39	38		
	43	44	45	**46**			
	50	49	**48**	47			
	51	**52**	**53**				
	55	**54**					

SEA SNAKE HABITAT

			1	2	3		
	8	7	6	5	**4**		
9	10	11	12	13	**14**		
20	19	18	17	16	**15**		
21	**22**	23	24	25	**26**		
32	31	30	29	28	**27**		
	33	34	35	36	**37**		
	42	41	40	**39**	38		
	43	44	45	**46**			
	50	49	**48**	47			
	51	**52**	**53**				
	55	**54**					

FISHING

			1	2	**3**		
	8	7	6	5	**4**		
9	10	11	12	13	**14**		
20	19	18	17	16	**15**		
21	**22**	23	24	25	**26**		
32.	31	30	**29**	28	**27**		
	33	**34**	35	36	**37**		
	42	**41**	**40**	**39**	38		
	43	**44**	**45**	**46**			
	50	**49**	**48**	47			
	51	**52**	**53**				
	55	**54**					

SAND MINING

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	**29**	28	27		
	33	34	35	36	**37**		
	42	41	40	**39**	38		
	43	44	45	**46**			
	50	49	**48**	47			
	51	52	**53**				
	55	54					

Fig 3.7 (Contd.)

ROCK QUARRYING

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

OTHERS

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
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Fig 3.7 (Contd.)

Settlers also poach on GNI. Illegally harvesting edible-nest swiftlet nests from caves is frequent (also see Sankaran, 1995b). Wildlife-settlers conflict on GNI is often detrimental. Pythons which are known to visit chicken roosts within settler's habitation are at once killed. A number of such encounters leading to killing pythons were reported during our study. During the rains 10-15 pythons are thus killed per month.

3.3.5. Domesticated animals

Besides directly impacting natural areas, humans have had several indirect influences on habitats in GNI. Cattle and goats are common within settled areas. These freely graze in the forests. A fairly large population of abandoned cattle now in a semi-wild state is frequently seen roaming about the southern parts of the GNI. Considering the fact that the island's forests have not experienced the influence of grazing herbivores in the past, cattle and goat can be a serious problem in the ecosystem. Further the many free-ranging dogs and cats maintained by the settlers can have adverse effects on terrestrial fauna.

3.3.6. Habitats of special significance

In order to assess the human impact on specialized habitats, we also mapped areas where sea turtles breed, birds roost communally and sea snakes abound. These are shown in Fig. 3.7. In Galathea, close to 300 leatherback turtles (*Dermochelys coriacea*) breed annually. While these are being 'protected', local tourists disturb them considerably at the time of laying. Visitors are known to even ride on the backs of these huge reptiles when they arrive on the beach (Dutta, 1996).

Many species of birds, especially fruit pigeons, parakeets, herons and others roost communally in many parts of the island. Such roosts can be easy targets of poaching. Very little information on sea snakes could be obtained directly during the study. What has been provided in Fig 3.7 is largely secondary information from local fishermen and knowledgable settlers.

3.3.7. Assessing habitat quality

Based on the information presented in Fig. 3.7 a kind of habitat quality score was given to each grid. Attributes such as tall trees, dense forests, swamps, communal bird roosts, turtle breeding areas and sea snake habitats were given a positive score of '2' each. All other attributes that are results of human interference were scored as '-1' each. Once such scores were given to the different attributes within a grid, the total habitat score of the grid was taken to be the sum of individual scores. The sums of scores range from 'negative' to 'positive'. The higher the negative sum it must be inferred that the concerned grid has the most deteriorated habitats. Similarly the grid taking the highest positive sum which in theory can be as high as 12, has the best preserved habitats.

Fig. 3.8 summarizes the results of this analysis. By and large it seems that the habitat degradation resulting from human influences is greater along the coastal areas and the major roads in the southern half of the island. Habitat degradation due to humans is considerably less along the northern and western coasts of GNI.

Fig. 3.8 Assessment of habitat quality gridwise based on the human impact

					4		
					7		
2					5		
7					7		
4	5			7	9		
		2	1		9		
	4	3		1	0		
		3	6	-2			
	7	3	4	1			
	7	3	1				
	5	3	1				
		4					

Note: Higher the positive score, better the quality is.

3.4. Habitat requirements of lower vertebrates

Fish, amphibians and reptiles are considered as lower vertebrates. These are poikilotherms ('cold blooded'). They are hence very sensitive to even slight changes in their local environment. Conservationists are of the opinion that the patterns of distribution of lower vertebrates tell us a lot more about environmental health (at an early stage of damage) than higher vertebrates (Blaustein and Wake, 1990). These animals which also have limited powers of dispersal tend to show unique adaptaions to insular conditions. It is therefore important to study their habitat requirement on GNI.

3.4.1. Fish

Although the GNI is uniquely endowed with perennial sources of freshwater, its only a few species of amphibians that seem to utilize this habitat. The island situation has effectively prevented the existence of primary freshwater species of fish. As of now we only know of introduced freshwater fish on GNI.

As many as 34 species of estuarine/marine fishes are reported from the inland waters of GNI (see Appendix I). How far upstream these fish naturally colonise is not fully understood. As mentioned earlier, the only fish upstream was the rice fish (*Oryzias melastigma*). This fish according to Talwar and Jhingran (1991) was accidentally introduced in the Andamans along with Rohu fingerlings. Rohu (*Labeo rohita*) has not been reported from GNI. How exactly the rice fish reached there is not clear. In the absence of native freshwater fish, the rice fish seems to have spread all over the island.

Observations on live fish were made only where the water was shallow and clear. Close to the sea in the larger creeks we often found *Liza* spp and *Ophielioteris aporos*. The latter prefers brackish waters with fallen logs, rocks and other natural hiding places. Within small pools of clear fresh water behind *Pandanus* patches, though close to the sea, were a number of *Ophiocara porocephala*. Interestingly this habitat was shared by young frogs (*Rana erythraea*).

3.4.2. Amphibians

Very little information is available on the habitat requirement of amphibians on GNI. Except *Bufo camortensis* that was observed breeding in brackish water, we did not observe breeding in amphibians during the study. *Limnonectes cancrivora* is known to inhabitat mangrove habitats elsewhere. We have not observed this in GNI although the species exists here.

The largest frog on GNI is the recently described *Limnonectes shompenorum*. This frog was collected from forest floors in the night according to the author who first described it. The stomach contents has indicated that the frog feeds on smaller frogs besides large beetles and cockroaches (Das, 1996). *L. shompenorum* is apparently a litter frog inhabiting the forest floor.

Other species of frog inhabiting litter are *Rana nicobariensis* and *Microhyla heymonsi*. The latter was seen frequently under leaves on forest floors during our study. Their breeding habitats are however, not known.

Das (1995) has reported collecting many examples of the tree frog *Polypedates insularis* away from streams within rainforests. These tree frogs were on low plants above ground. In one case a pair, reported as breeding, was collected by Das from a small pool of freshwater with submerged and emergent plants. He has reported that in this pool there were also *Bufo melanostictus, Rana chalconota* and *Microhyla heymonsi*. Das considers the above 3 species being sympatric with the forest floor amphibian *R. nicobariensis*.

During our studies most of these amphibians were observed within or close to human habitation. These species seem to prefer stagnant freshwater in agricultural areas adjacent to the forests. Both species of *Bufo* were also seen within Campbell Bay around buildings. The distribution of amphibians on GNI is apparently subject to the availability of rainwater pools and stagnant sources of freshwater. Freshwater swamps within forests are thus important habitats in this regard.

3.4.3. Reptiles

Many species of reptiles were found using the coastal habitats. Creeks with mangroves were inhabited by *Varauns salvator* and *Crocodylus porosus,* both endangered species. Others such as the gecko *Cyrtodactylus* sp and dogfaced watersnake *Cerberus rhynchops* were frequently seen within mangrove areas. The gecko is seen on stems of tall trees, including coconut, during the daytime.

The single record of the snake *Xenopeltis unicolor* was based on a road kill. *Dendrelaphis humayuni* was also frequenly seen dead on roads. These snakes probably bask on roads.

Bungarus sp was once recorded inside interior forests in Galathea and on another occasion closer to the beach within littoral forests. *Python reticulatus* and *Elaphe flavolineata* were both recorded within agricultural areas.

As discussed earlier, much of the reptilian fauna of GNI is comprised of skinks. While *Dasia* spp are seen on roadside trees, *Mabuya* and *Lipinia* are litter species. Ground skinks are most active in the litter within forests. Interestingly, juvenile stages of the arboreal skink *Dasia* spp, can also be seen in litter taking shelter within or under fallen logs. Garden lizards (*Bronchocela* spp) are seen on roadside trees, fences and posts. *Hemidactylus frenatus* is seen inside both modern houses and traditional wood and thatch huts.

3.5. Habitat and Communities of Sea snakes

Very little is known of the occurrence and habitat requirement of sea snakes in the Andaman and Nicobar Islands. This is particularly felt when GNI is considered. While proposing the project it was felt necessary to assess populations of sea snakes on GNI. There were also unpublished reports of sea snakes libernating on low trees such as *Pandanus* on certain islands (Satish Bhaskar and H. Das, pers. commn.). The significance of such behaviour is not understood. These were reasons for laying emphasis on a study of sea snakes although they are not inland vertebrates.

During the 3 year study, sea snakes were seen in the coastal waters on several occasions. At least 2 species occur here. One was confirmed as belonging to *Laticauda* sp by collecting a sloughed skin from the reef. The other could not be identified. In Fig. 3.2, the distribution of sea snakes on GNI has been presented.

All observations were made during the daytime close to the coast in the sea. We have not come across sea snakes entering forests or resting in arboreal situations.

Under captive conditions, sea snakes refuse to feed on anything provided and tend to starve to death (Daniels, pers. observ.).

4. SUMMARY AND RECOMMENDATIONS

A three year project sponsored by the Ministry of Environment and Forests, Government of India was taken up to study the patterns of distribution and diversity of vertebrates on the Great Nicobar Island (GNI). The study proceeded by dividing the island into 55 equal sized grids. These grids were 5 km X 5 km in size. Sixty five per cent of the grids were surveyed during an effective period of 460 days spent on GNI. The northern portions could not be satisfactorily covered due to logistic constraints.

120 species of vertebrates amounting to 71% of the 170 known vertebrates on GNI were recorded during the 3 year study. These included 14 species of fish, 8 amphibians, 22 reptiles, 67 birds and 9 mammals. The distribution of each of these 120 vertebrates, excluding the fish are mapped and presented.

Primary freshwater fishes on GNI are few. All species of fish naturally residing in creeks and other stagnant freshwater pools are estuarine or marine. There is a predominance of Gobioid fish amongst those inland. The single record of *Apogon thermalis* is a first report of this species from Andaman and Nicobar Islands.

Bufo camortensis and *Microhyla heymonsi* are amongst the most widespread amphibians on GNI. These have adapted to living within human habitation.

Skinks, *Mabuya rudis* and *Lipinia macrotympanum* are widespread on the island. Other common reptiles are *Varanus salvator* and *Dendrelaphis humayuni*. Reptiles seem to be the most widespread and frequently encountered vertebrates on GNI. They form an important component of the island ecosystem playing the roles of top predators (*Crocodylus porosus* and *Python reticulatus*), scavengers (*Varanus salvator*) and prey (most lizards and smaller snakes).

Birds on GNI are widespread. The avifauna is characterized by a predominance of non-passerines (75%). About 30% of the avifauna is of species that would normally depend on lower vertebrates for their food. Strictly insectivorous birds are scarce on GNI. The large hawk cuckoo (*Cuculus sparverioides*) is being reported for the first time in the Andaman and Nicobar Islands.

Mammalian diversity is largely contributed by rodents and bats. The most widespread mammals are nevertheless *Macaca umbrosa* and *Tupaia nicobarica*. The study reports the possible occurrence of the arboreal cat *Felis marmorata* on GNI.

16% of all vertebrates known from GNI are endemic to Andaman and Nicobar Islands. Of these mammals contain the maximum (47%) endemic species relative to their faunal size. 25% of the reptilian species and 23% of the amphibian species on GNI are of endemic to the Andaman and Nicobar Islands. Endemism is least amongst birds (10.5%) and fish (3%).

Patterns of distribution of vertebrate diversity and endemic species on GNI does not indicate localizations. From our studies it has emerged that coastal habitats are as rich, if not richer, in both vertebrate species and endemics as the rainforests on GNI. All three species of endangered animals on GNI are reptiles. They are equally distributed amongst interior forests and coastal habitats. Habitat specialization does not seem to finely seggregate the vertebrates of GNI.

Human impact is widespread on GNI. The coastal areas are the most adversely affected. Conservation efforts need to be immediately directed to the coasts of GNI. Habitat destruction by settlers need to be curbed.

The coastal aquatic habitats are rich in vertebrates, especially fish. That of all the species recorded for the first time during this study more than 50% are fish, suggests the diversity amongst fishes. There seems to be a lot more to be explored in these habitats.

Although the GNI is endowed with perennial rivers, they do not offer habitat to many species of vertebrates. Inland swamps and freshwater pools (both natural and manmade) are more important for the survival of fish as well as amphibians.

Amongst reptiles, lizards show some habitat specificity. Snakes however are generalist habitat users, often encountered on roads and other human transformed habitats.

Sea snakes are frequently observed in the coastal waters of GNI. Their dependence on the island ecosystem needs more careful investigation.

The GNI is certainly a refuge for lower vertebrates including fish, amphibians and reptiles. Conservation efforts should pay adequate attention to this.

Finally, this study has only highlighted certain broad patterns of vertebrate distribution on GNI based on a rather partial coverage of the islands' total area. Future studies should add to this, especially by surveying the hilly and remote northern-central portions. The coasts of GNI should be recognised as 'hot-spots' of vertebrate diversity.

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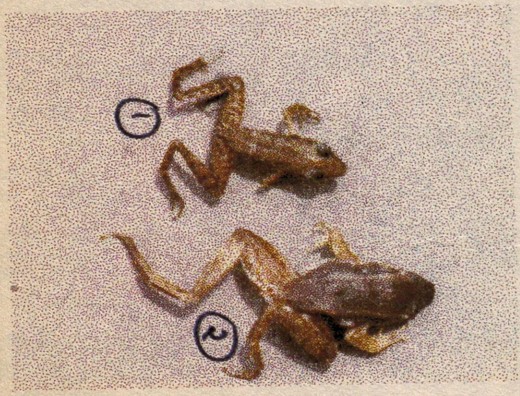
PLATES

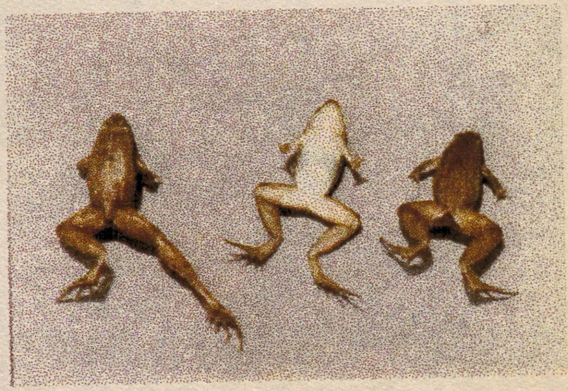
Limnonectes shompenorum

Limnonectes cancrivora

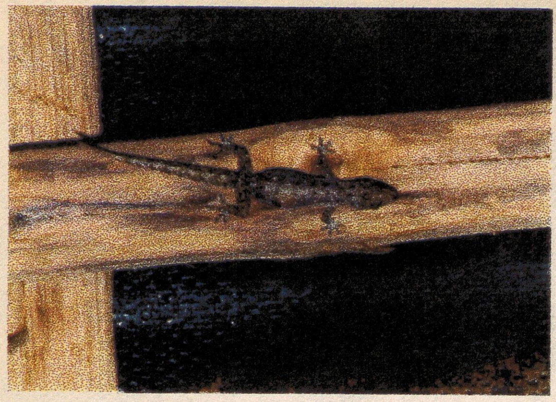
Polypedates insularis



Rana nicobariensis (1)
Rana erythraea (2)

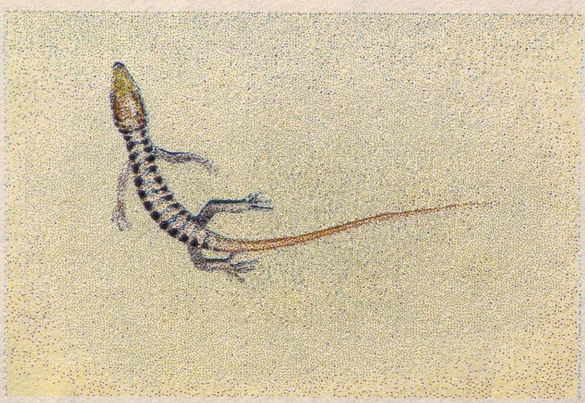


Microhyla heymonsi

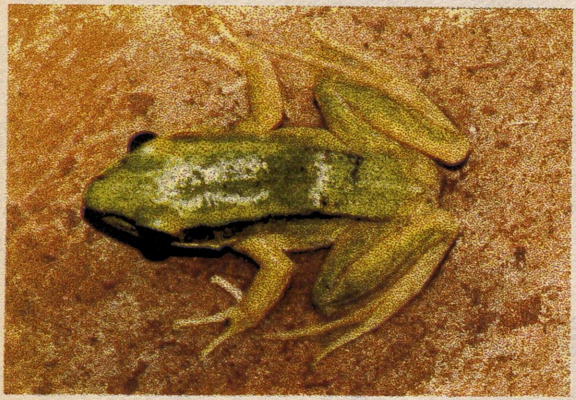


Hemidactylus frenatus

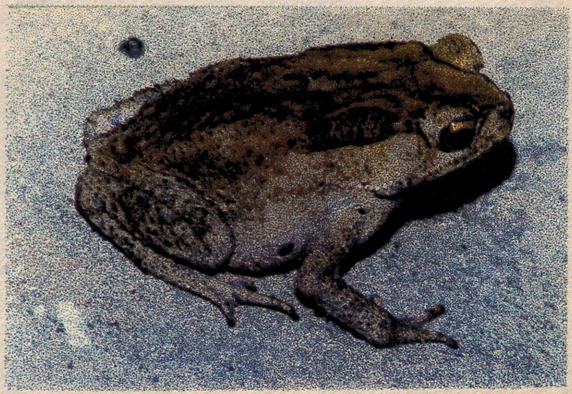
Dasia olivacea



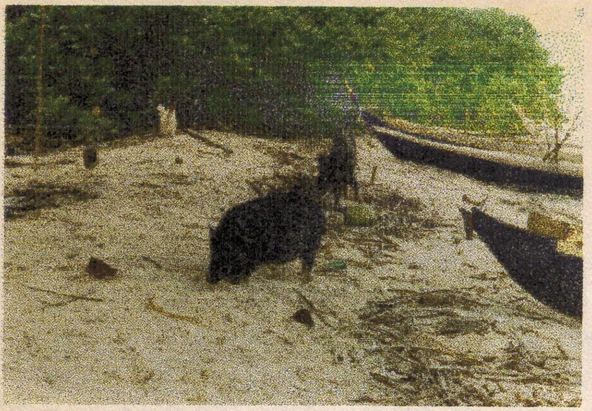
Dasia sp (juvenile)



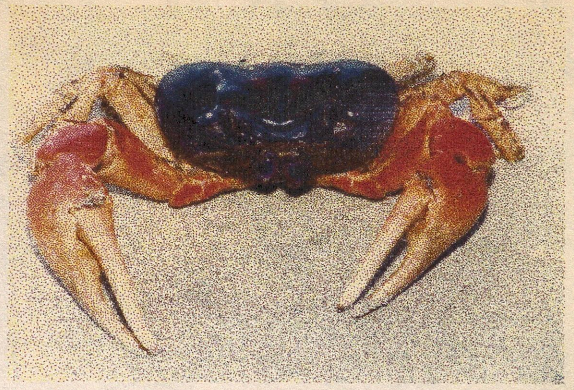
Rana chalconota



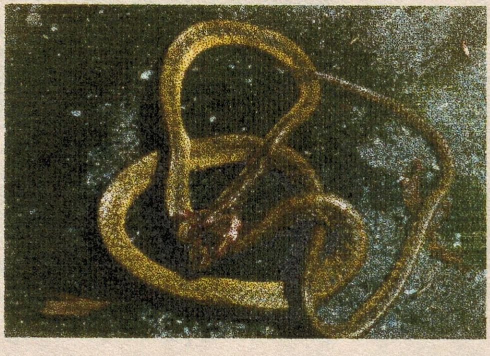
Bufo camortensis



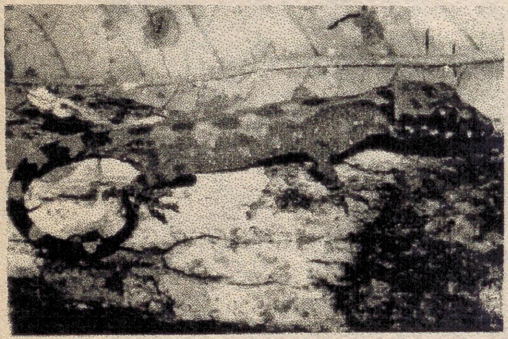
Semi-wild pigs in
Nicobarese village



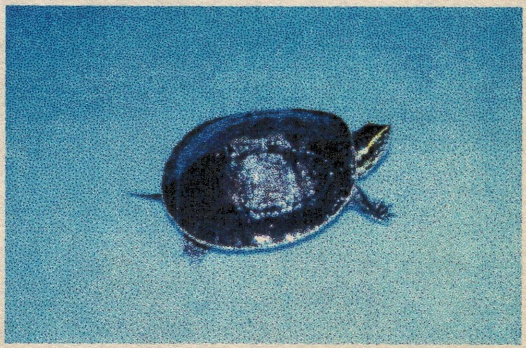
Shore crab: a source
of food to the macaque
and wild pigs



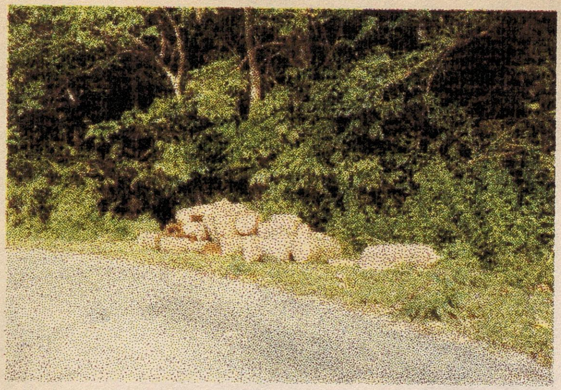
Boiga ochracea killed by
road maintenence workers



Cyrtodactylus sp



Cuora amboinensis (juvenile)



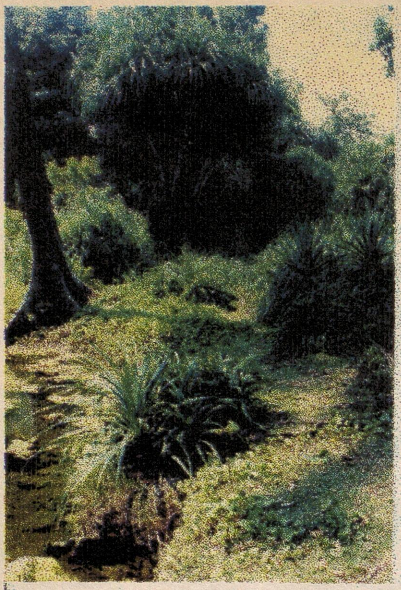
Deadwood cut and ready
for transport

Abandoned betelnut plantation

Cyathea formation on GNI

Sampling fish in creeks

Roadside landslip



Freshwater pool
sheltered by *Pandanus*

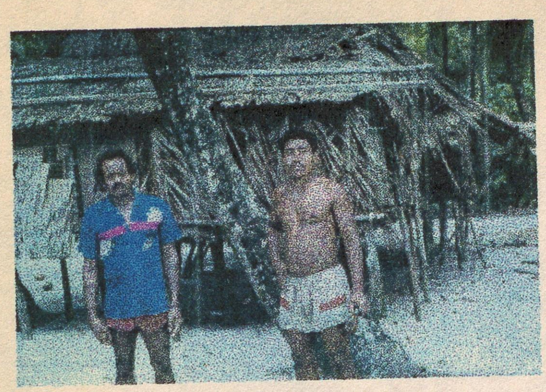
Casuarina replacing
Pandanus on beach

Encroachment by settlers

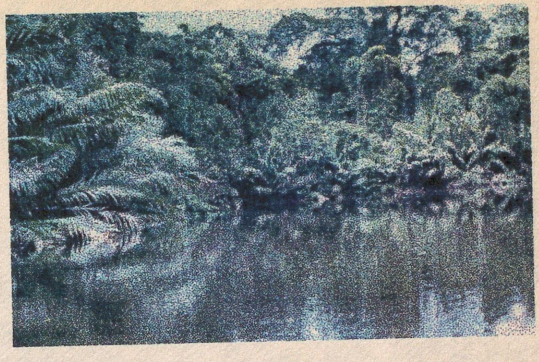
Invasion of weeds
along the roads

Burnt patch of *Pandanus*

Natural stands of
Pandanus bordering the beach



Nicobarese men in village



Riverine forest with *Nypa fruticans*

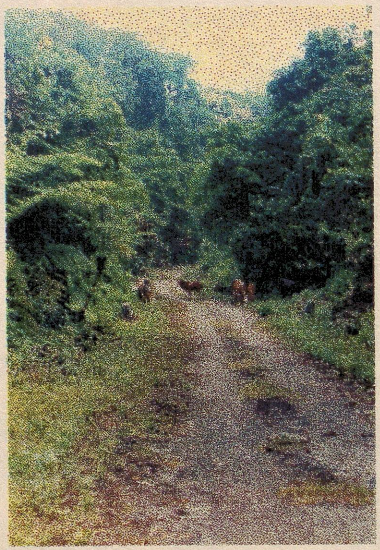
Sampling along the river by boat

Shompen with spear

Dense mangrove along creek

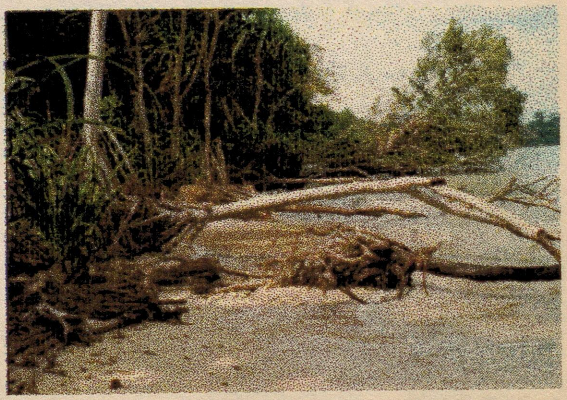
Galathea river: note
Nypa fruticans formation

Sunset in Pygmalion Point



Feral cattle grazing

Shompen hut: note
dense forests surrounding



Beach erosion

APPENDIX

APPENDIX I

LIST OF INLAND VERTEBRATES HITHERTO RECORDED ON GREAT NICOBAR ISLAND

	FISH
1	*Megalops cyprinoides*[23]
2	*Anguilla bicolor*[2]
3	*Heteropneustes fossilis*[23]
4	*Oryzias melastigma*[2]
5	*Syngnathus spicifer*
6	*Platycephalus indicus*
7	*Apogon thermalis*[23]
8	*Ambassis commersoni*[2]
9	*Ambassis gymnocephalus*
10	*Terapon theraps*[23]
11	*Gazza minuta*
12	*Leiognathus equulus*[2]
13	*Lutjanus argentimaculatus*[23]
14	*Gerres oblongus*
15	*Monodactylus argenteus*
16	*Toxotes jaculator*[2]
17	*Liza macrolepis*
18	*Liza melinoptera*
19	*Valamugil buchanani*[23]
20	*Valamugil cunnesius*
21	*Salarius fasciatus*
22	*Callogobius hasselti*
23	*Stigmatogobius romeri*
24	*Periophthalmus koelreuteri*
25	*Butis gymnopomus*
26	*Eleotris fusca*
27	*Eleotris andamanensis*
28	*Bunaka gyrinoides*
29	*Kramericus smithi*[1]
30	*Ophieleotris aporos*[2]
31	*Ophiocara porocephala*[2]
32	*Quisquilius eugenius*
33	*Channa sp*[23]
34	*Chelonodon fluviatilis*

[1] Endemic to A&N Islands.
[2] Recorded during present study.
[3] Reported for first time on GN Islands.
[4] Unconfirmed reports during the present study.

	AMPHIBIANS
35	*Bufo melanostictus*
36	*Bufo camortensis*[12]
37	*Microhyla heymonsi*[2]
38	*Limnonectes cancrivora*[2]
39	*Limnonectes doriae*
40	*Limnonectes limnocharis*
41	*Limnonectes shompenorum*[12]
42	*Limnonectes macrodon*
43	*Rana erythraea*[2]
44	*Rana nicobariensis*[2]
45	*Rana chalconota*[2]
46	*Polypedates leucomystax*
47	*Polypedates insularis*[12]
	REPTILES
48	*Crocodylus porosus*[2]
49	*Cuora amboinensis*[2]
50	*Cnemaspis kandiana*
51	*Hemiphyllodactylus typus*
52	*Platyurus platyurus*
53	*Gecko gecko*
54	*Cyrtodactylus sp*[12]
55	*Hemidactylus frenatus*[2]
56	*Phelsuma andamanense*[14]
57	*Bronchocela cristatella*[2]
58	*Bronchocela danieli*[12]
59	*Dasia nicobariensis*[1]
60	*Dasia olivacea*[2]
61	*Mabuya rudis*[2]
62	*Mabuya rugifera*[2]
63	*Scincella macrotis*[1]
64	*Lipinia macrotympanum*[12]
65	*Dibamus lencurus*
66	*Varanus salvator*[2]
67	*Xenopeltis unicolor*[2]
68	*Python reticulatus*[2]
69	*Boiga dendrophila*
70	*Boiga ochracea*[2]
71	*Cerberus rhynchops*[2]

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[4] Unconfirmed reports during the present study.

72	*Dendrelaphis humayuni*[1,2]
73	*Dendrelaphis pictus*
74	*Elaphe flavolineata*[2]
75	*Xenochropis melanzostus*[1,2]
76	*Xenochropis trianguligerus*
77	*Bungarus sp*[2,3]
78	*Laticauda sp*[2]
79	*Trimeresurus sp*[4]
	BIRDS
80	*Ardea purpurea*[2]
81	*Butorides striatus*[2]
82	*Ardeola grayii*[2]
83	*Bubulcus ibis*[2]
84	*Egretta alba*[2]
85	*Egretta intermedia*[2]
86	*Egretta sacra*[2]
87	*Gorsachius melanolophus*
88	*Ixobrychus cinnamomeus*[2]
89	*Ixobrychus sinensis*
90	*Accipiter butleri*[1,2]
91	*Accipiter soloensis*
92	*Haliaeetus leucogaster*[2]
93	*Spilornis minimus*[1,2]
94	*Megapodius nicobariensis*[1,2]
95	*Amaurornis phoenicurus*[2]
96	*Pluvialis squatarola*[2]
97	*Pluvialis dominica*
98	*Charadrius mongolus*[2]
99	*Numenius phaeopus*[2]
100	*Tringa totanus*
101	*Tringa ochropus*[2]
102	*Tringa terek*[4]
103	*Tringa hypoleucos*[2]
104	*Arenaria interpres*[4]
105	*Capella stenura*[2]
106	*Scolopax rusticola*[4]
107	*Calidris minutus*[4]
108	*Dromas ardeola*[2]
109	*Sterna sumatrana*[2]
110	*Anous stolidus*[4]

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[2] Recorded during present study.
[3] Reported for first time on GN Islands.
[4] Unconfirmed reports during the present study.

111	*Treron pompadora*[2]
112	*Ducula aenea*[2]
113	*Ducula bicolor*[2]
114	*Columba livia*[2]
115	*Columba palumboides*[14]
116	*Macropygia rufipennis*[12]
117	*Chalcophaps indica*[2]
118	*Caloenas nicobarica*[2]
119	*Psittacula caniceps*[12]
120	*Psittacula longicauda*[2]
121	*Loriculus vernalis*[4]
122	*Cuculus sparverioides*[23]
123	*Cuculus saturatus*
124	*Eudynamys scolopacea*[2]
125	*Centropus sp*[4]
126	*Otus scops*[2]
127	*Ninox affinis*[12]
128	*Collocalia fuciphaga*[2]
129	*Collocalia esculenta*[2]
130	*Alcedo atthis*[2]
131	*Ceyx erithacus*[4]
132	*Pelargopsis capensis*[2]
133	*Halcyon chloris*[2]
134	*Halcyon pileata*
135	*Merops philippinus*[2]
136	*Pitta sordida*[2]
137	*Hirundo rustica*[2]
138	*Lanius cristatus*[2]
139	*Oriolus chinensis*[2]
140	*Dicrurus paradiseus*[2]
141	*Dicrurus andamanensis*[123]
142	*Aplonis panayensis*[2]
143	*Gracula religiosa*[2]
144	*Coracina nigra*
145	*Rhinomyias brunneata*[2]
146	*Muscicapa latirostris*[23]
147	*Terpsiphone paradisi*
148	*Monarcha azurea*[2]
149	*Phylloscopus tenellipes*[4]

[1] Endemic to A&N Islands.
[2] Recorded during present study.
[3] Reported for first time on GN Islands.
[4] Unconfirmed reports during the present study.

150	*Anthus cervinus*[2,3]
151	*Motacilla flava*[4]
152	*Motacilla caspica*[2]
153	*Nectarinia jugularis*[2]
154	*Aethopyga siparaja*[2]
155	*Zosterops palpebrosa*[2]
	MAMMALS
156	*Macaca umbrosa*[1,2]
157	*Tupaia nicobarica*[1,2]
158	*Crocidura nicobarica*[1]
159	*Felis spp*[2]
160	*Sus scrofa*[2]
161	*Pteropus melanotus*[4]
162	*Pteropus faunulus*[1]
163	*Taphozous saccolaimus*
164	*Hipposideros ater*
165	*Pipistrellus camortae*[1,4]
166	*Pipistrellus coromandra*[4]
167	*Pipistrellus sp*
168	*Rattus rattus*[2]
169	*Rattus pulliventer*[1,4]
170	*Rattus burrescens*[1]

[1] Endemic to A&N Islands.
[2] Recorded during present study.
[3] Reported for first time on GN Islands.
[4] Unconfirmed reports during the present study.

APPENDIX II

Place names corresponding to the grids on GNI

Grid No.	Name of the Place
3	Murray Point
4	Trinket
5,6,7	Campbell Bay NP
9	Dogmar River
10 - 13	Campbell Bay NP
14	Lau foul
15	Navy Dehra
16	Alou Plot
17 - 20	Campbell Bay NP
21	Kopen Hut
22	Campbell Bay NP
26	Javu Nallah
27	Laxman Beach/Tonghi Nallah
28	Gobind Nagar
29	Saithan Pahad
30	Schompen Hut
33	Kochin Town
34,35	Galathea NP
36	Air port
37	Campbell Bay
38	Maggar Nallah
39	Vijay Nagar/Laxmi Nagar
40,41	Galathea NP
42	Pillow Babhi
43	Inhilonol
45	Galathea NP
46	Gandhi Nagar
48	Shastri Nagar
49	Galathea NP
50	Pillow Bucca
51	Pillow Bha
52	Shingam Basti
53	Galathea
55	Pygmalion Point

Appendix III

List of vertebrates recorded from the core zone of GNBR during the study

	Campbell Bay NP	Galathea NP	Total
Amphibians	*Bufo camortensis* *Microhyla heymonsi* *Rana erythraea*	*Bufo camortensis* *Limnonectes cancrivora*	4
Reptiles	*Mabuya rudis* *Lipinia macrotympanun* *Varanus salvator*	*Crocodylus porosus* *Cuora amboinensis* *Cyrtodactylus sp* *Mabuya rudis* *Lipinia macrotympanun* *Varanus salvator* *Dendrelaphis humayuni* *Bungarus sp.*	8
Birds	*Megapodius nicobariensis* *Ducula aenea* *Macropygia rufipennis* *Psittacula longicauda* *Gracula religiosa* *Rhinomyias brunneata* *Nectarinia jugularis*	*Ardeola grayii* *Bubulcus ibis* *Egretta alba* *Egretta intermedia* *Egretta sacra* *Haliaeetus leucogaster* *Megapodius nicobariensis* *Amaurornis phoenicurus* *Charadrius mongolus* *Numenius phaeopus* *Tringa terek* *Tringa hypoleucos* *Treron pompadora* *Ducula aenea* *Columba livia* *Colimba palumboides* *Macropygia rufipennis* *Psittacula caniceps* *Psittacula longicauda* *Eudynamys scolopacea* *Pelargopsis capensis* *Dicrurus paradiseus* *Aplonis panayensis* *Gracula religiosa* *Rhinomyias brunneata* *Monarcha azurea* *Motacilla caspica* *Nectarinia jugularis*	28
Mammals	*Macaca umbrosa* *Tupaia nicobarica*	*Macaca umbrosa* *Tupaia nicobarica* *Felis spp* *Pteropus spp* *Rattus rattus*	5

APPENDIX IV

Distribution maps of all the vertebrates of GNI recorded during the study excluding the fish

AMPHIBIANS

Bufo camortensis

			1	2	3		
	8	7	6	5	**4**		
9	10	11	12	13	14		
20	19	18	17	16	**15**		
21	22	23	24	25	**26**		
32	31	**30**	**29**	**28**	27		
	33	34	35	**36**	**37**		
	42	**41**	**40**	**39**	38		
	43	44	45	46			
	50	49	48	**47**			
	51	52	**53**				
	55	54					

Microhyla heymonsi

			1	2	3		
	8	7	6	5	**4**		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	**26**		
32	**31**	30	29	**28**	27		
	33	34	35	**36**	**37**		
	42	41	40	39	38		
	43	44	45	**46**			
	50	49	48	**47**			
	51	52	53				
	55	54					

Limnonectes cancrivora

			1	2	3		
	8	7	6	5	**4**		
9	10	11	12	13	14		
20	19	18	17	16	**15**		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	**41**	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Limnonectes shompenorum

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	**28**	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Rana erythraea

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	**28**	27		
	33	34	35	36	**37**		
	42	41	40	39	38		
	43	44	45	46			
	50	49	**48**	**47**			
	51	52	53				
	55	54					

Rana nicobariensis

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	**26**		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	**39**	38		
	43	44	45	46			
	50	49	48	47			
	51	52	**53**				
	55	54					

Rana chalconota

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Polypedates insularis

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

REPTILES

Lipinia macrotympanum

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Bronchocela cristatella

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Bronchocela danieli

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Mabuya rudis

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	47			
	51	52	53				
	55	54					

Varanus salvator

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	**15**		
21	22	23	24	25	**26**		
32	31	30	29	**28**	**27**		
	33	**34**	35	**36**	**37**		
	42	**41**	**40**	39	38		
	43	44	**45**	**46**			
	50	**49**	**48**	**47**			
	51	52	**53**				
	55	**54**					

Cyrtodactylus sp

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	**14**		
20	19	18	17	16	**15**		
21	22	23	24	25	**26**		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	**41**	40	39	38		
	43	44	45	46			
	50	49	48	**47**			
	51	**52**	**53**				
	55	54					

Dasia spp

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	**37**		
	42	41	40	39	38		
	43	44	45	46			
	50	49	48	**47**			
	51	52	**53**				
	55	54					

Crocodylus porosus

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	**15**		
21	22	23	24	25	**26**		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	**41**	40	39	**38**		
	43	44	45	46			
	50	49	**48**	**47**			
	51	52	53				
	55	54					

Xenopeltis unicolor

			1	2	3		
	8	7	6	5	4		
9	10	11	12	13	14		
20	19	18	17	16	15		
21	22	23	24	25	26		
32	31	30	29	28	27		
	33	34	35	36	37		
	42	41	40	39	38		
	43	44	45	**46**			
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Laticauda spp

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Dendrelaphis humayuni

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Python reticulatus

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Elaphe flavolineata

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Cerberus rhynchops

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Hemidactylus frenatus

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Cuora amboinensis

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Mabuya rugifera

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Bungarus sp

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Xenochropis melanzostus & *Boiga ochracea* (47)

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BIRDS

Aplonis panayensis

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Psittacula longicauda

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Dicrurus paradiseus

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Oriolus chinensis

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Aethopyga siparaja

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Psittacula caniceps

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Gracula religiosa

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Eudynamys scolopacea

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Haliaeetus leucogaster

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Ducula bicolor

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Ducula aenea

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Ninox affinis

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Tringa hypoleucos

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Scolopax rusticola

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Rhinomyias brunneata

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Egretta sacra

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Monarcha azurea

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Macropygia rufipennis

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Lanius cristatus

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Spilornis minimus

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Pluvialis squatarola

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Ardea purpurea

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Egretta alba

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Columba livia

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Accipiter butleri

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Ixobrychus cinnamomeus

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Capella stenura

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Ardeola grayii

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Alcedo atthis

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Egretta intermedia

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Numenius phaeopus

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Charadrius mongolus

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Treron pompadora

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Muscicapa latirostris

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Cuculus sparverioides

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Spilornis minimus

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Dicrurus andamanensis

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Motacilla caspica

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Megapodius nicobariensis

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Nectarinia jugularis

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Pelargopsis capensis

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Chalcophaps indica

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Sterna sumatrana

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Tringa ochropus

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Loriculus vernalis

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Butorides striatus

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Calidris minutus

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Collocalia fuciphaga

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Dromas ardeola

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Hirundo rustica

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Ceyx erithacus

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Caloenas nicobarica

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Amaurornis phoenicurus

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Centropus sp

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Anous stolidus

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Collacalia esculenta

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Tringa terek

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Arenaria interpres

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Otus scops

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Columba palumboides

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Bubulcus ibis

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Anthus cervinus

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Motacilla flava

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Halcyon chloris

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Merops philippinus

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Phylloscopus tenellipes

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Zosterops palpebrosa

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Pitta sordida

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MAMMALS

Macaca umbrosa

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Tupaia nicobarica

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Sus scrofa

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Bats (unidentified)

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Rattus rattus

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Felis domesticus

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Pteropus sp

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Felis marmorata

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Pipistrellus sp

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