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Current status of population and demography of Nicobar crab-eating macaque (*Macaca fascicularis umbrosa*) in the Great Nicobar Biosphere Reserve, Andaman and Nicobar Islands, India

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ABSTRACT

A comprehensive population study of Nicobar-crab eating macaque (*Macaca fascicularis umbrosa* Miller, 1902) was conducted during October 2011 to September 2013, in the Great Nicobar Island. It is estimated that 882 individuals in 29 troops with the group size varied from 18 to 46 individuals (mean ± SD = 30.41 ± 6.91). The abundance of monkey group per km is about 0.23 corresponding with 6.9 individuals per km. The survival rate was high; it was estimated 0.99/individual/year with the mean growth rate of 1.55/individual/year. The mean group size of macaque at Great Nicobar Biosphere Reserve (GNBR) (mean ± SD = 28.92 ± 6.7) varied from macaque groups found in residential areas (mean ± SD = 31.62 ± 7). The population was increased during the period of study. The female-infant ratio was increased, while male ratio was slightly decreased in residential groups rather than groups observed in protected areas.

Key words: Macaque, population size, sex ratio, Great Nicobar Island.

INTRODUCTION

Tropical primates are highly susceptible for continuous degradation of their habitat by human interferences and natural calamities. Habitat loss and degradation of tropical forest are the greatest threats to terrestrial species (Baillie *et al*., 2004). Determination of the impact of disturbance on rare species and adequate data about species-habitat relationship are essential requirements for conservative purposes (Lindenmayer, 1999). The Long-tailed Macaques (*M. fascicularis*) are widely distributed in Southeast Asia including Indo-Malay peninsula, Indonesia, Malaysia, Thailand, Cambodia and Philippines among the other primates (Rodman, 1991; Fooden, 1995). According to Napier & Napier (1967) 21 sub species of *M. fascicularis* found all over the world, however, Fooden's classification system (Fooden, 1995; Brandon-Jones *et al*., 2004) suggests 10 subspecies widespread in Southeast Asia, while India has only one subspecies *M. f. umbrosa* found in the three islands of Nicobar groups namely Katchal, Little Nicobar and Great Nicobar Island (Tikader & Das, 1985). The endemic population of these monkeys is distributed in the undisturbed tropical rainforest, coastal areas, and disturbed revenue or agricultural land and residential areas of these Islands in Nicobar. Previous reports are available in the population of this endemic subspecies by few workers (Molur *et al*., 2003; Umapathy *et al.,* 2003; Sivakumar, 2010; Narasimmarajan & Raghunathan, 2012; Sivaperuman & Venkataraman, 2012). According to Sivakumar (2010) the coastal groups are severely caused by 2004 tsunami due to loss of coastal forest. Narasimmarajan & Raghunathan (2012) revealed that the declined population was recovered considerably. Subsequently the daily activity budget of this species was made by Rajeshkumar *et al.* (2014) in Great Nicobar Island. The present study provides the result of preliminary population survey conducted during October 2011 to September 2013. Comparative study on population was also made between protected area and revenue areas to assess the impact of anthropogenic activities.

Study area

Great Nicobar Island (Figure 1) is located about 06° N of the equator, cover an area of 1045.1 sq. km. It is designated as Great Nicobar Biosphere Reserve (GNBR) one of the 17 Biosphere Reserves in India with 885 sq. km geographical area comprising Campbell Bay National Park in the north and Galathea National Park in the south. In 2013, GNBR was included in the World Network of Biosphere Reserves by International coordinating council of UNESCO under Man and Biosphere Reserve Programme (MAB). 85% of the area in Great Nicobar is declared as protected areas; remaining 15% area is being utilized for agriculture and settlements. Evergreen, mixed evergreen, moist deciduous, lowland swamp, littoral, mangrove, grassland, scrub and degraded forest are the vegetation types of Great Nicobar Island.

MATERIALS AND METHODS

Population and behavioral ecology of Nicobar crab-eating macaque were studied in Great Nicobar Island for the period of three years from 2011 to 2013. Line

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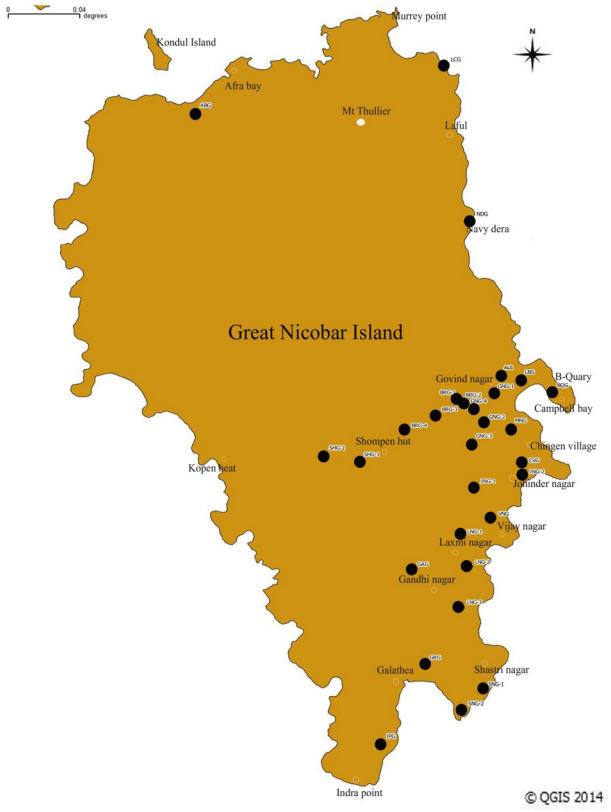


Figure 1. Map shows study area and location of Nicobar crab-eating macaque troops (Black dots) in Great Nicobar Island.

transact method was adopted based on Burnham *et al.* (1980) and NRC (1981) by random walk sampling on foot through the tracking routes and trails in the rainforest. Macaque group was frequently observed by direct sight sometimes vocal calls ensure that the places were occupied in dense evergreen forest. The located troops were continually followed and observed until the troop was reliable count. In order to obtain accurate data the procedure was repeated until ensuring the number of individuals and exact location of group presence in the study site.

Individuals were classified based on their morphological differences: adult (male or either female), sub adults, juveniles and infants, based on the method followed by Napier & Napier (1967). Observed group was marked by adult dominant males in their hierarchy and also their exact GPS location was noticed using GARMIN 12 Channel GPS. Local people, field assistants and forest officials were interviewed for the identification of exact location of troops. Macaque troops were observed from dawn to dusk and the data were collected. 32 transacts, covering a distance of 128.5 km were laid and estimated the numerical abundance of macaques in groups sighted per km. According to Fittinghoff (1972), the demographic data, group size and age-sex class of each individual was collected from 10 troops (Table 1) of which 6 troops were observed continuously in GNBR and 4 troops were observed outside the reserve area to examine the significant changes in their population structure and group composition between protected and residential areas. It was calculated by basic nonparametric statistical methods. Chi-square test was used to evaluate the significant changes between the protected and residential population. The birth rate, survival rate and growth rate were estimated based on methods described by Caughley (1977) and NRC (1981). The birth rate (b) is estimated by the formula $b = I_t / F_t$ where I_t = total number of infants born in 1 year and F_t = total number of females observed throughout one year. Disappearance of animals in the consecutive census was considered as death. The entire troop was carefully monitored to consider the disappearance. Growth rate was calculated by $\lambda = N_t + 1 / N_t$ where N_t is the number of individual in a population at time t. When λ is >1 the population has increased from the period t to t+1, When λ is <1 the population has decreased, and λ=1, the population has constant (NRC, 1981). Mann-Whitney *U*- test were used

Table 1. Population structure and Group composition of Nicobar crab-eating macaque troops in Great Nicobar Island.

Location	Troop name	Adult		Total no. of adult	Immature			Total no. individuals
		Male	Female		Sub adult	Juvenile	Infant	
GNBR (EWR) 16th km	BRG-3*	7	9	16	6	2	2	26
Shompen hut 25.5th km (EWR)	SHG-1*	9	11	20	9	2	2	33
Laful creek	LCG*	4	6	10	4	4	1	19
Afra bay	ABG*	8	9	17	6	2	1	26
Govind nagar (EWR) 6th km	GNG-1#	13	16	29	12	6	4	51
B-Quary beach	BQG#	11	15	26	8	6	6	46
Chingen village (NSR) 7th km	CVG#	8	12	20	6	6	2	34
Johinder nagar (NSR) 15th km	JNG-1#	7	8	15	11	2	2	30
Laxmi nagar (NSR) 21st km	LNG-1*	4	8	12	7	5	1	25
Gandhi nagar (NSR) 27th km	GAG*	9	9	18	5	4	1	28
Total		80	103	183	74	39	22	318

* Troops located in protected areas (GNBR) # Troops located in revenue/residential areas EWR- East west road NSR-North south road

to test for whether protected and residential troops differed in group size. This analysis was done by using Social science statistics calculator. Statistical significance was set at $P < 0.05$.

RESULTS AND DISCUSSION

Based on the survey conducted, a total of 29 groups comprising 882 individuals of macaque were observed in 2012 and 2013 of which 10 groups (Table 1) were selected to study demographic variation and population difference for three year. Each group differed in size ranging from 18 to 46 individuals. LNG-2 group has the highest number of macaque while the LCG group has the least number of individuals during the study period. Majority of the troops have the mean size of less than 30 individuals. The overall mean size ± SD was estimated as 30.41 ± 6.91 individuals, the mean size of groups living in protected areas were 28.92 (SD = 6.7; N=13) and in the residential areas it was 31.62 (SD = 7.0; N=16) was also estimated although the troop size in protected and residential areas differed statistically (Mann-Whitney U=22, P<0.05). The total number of individuals in the macaque groups found in protected and residential area's preferences differed across the two years ($\chi 2$=0.02017, df =1, p< 0.006). The troop size in the entire groups was gradually increased from 2012 to 2013 (Table 2). The majority of groups were recorded from residential area than protected area. It indicates that the food availability was reduced in interior forest while the residential areas have much more increased by agriculture, coconut farms and human settlements.

Adult-Immature ratio (1:0.64; 1:0.73), Male-Female ratio (0.80:1; 0.77:1), Female-Infant ratio (6.53:1; 4.68:1) was considerably increased from 2012 to 2013 (Figure 3). Significant variations were observed in the Adult-Immature ratio, Male-Female ratio and Female -Infant ratio obtained in protected areas (1:0.63; 0.68:1), (0.81:1; 0.78:1), (9.6:1; 6.5:1) and residential areas (1:0.65; 1:0.78), (0.8:1; 0.76:1), (5:1; 3.6:1) in 2012, 2013 respectively (Figure 4). The percentage of male (25%), Female (33%), sub adult (23%) in the year 2013 was marginally reduced from previous year i.e., 2012 from 27%, 34%, 24% respectively. While, in 2013 the juvenile (12%) and infant (7%) percentage was increased from 10% and 5% respectively recorded during 2012 (Figure 2). Comparison between the adult and immature ratio was quite significant, where immature ratio was less than adult ratio.

Table 2. Yearly variations in troop size of Nicobar crab-eating macaque.

Troop name	Troop size		Mean
	2012	2013	
BRG-3	24	26	25.0
SHG-1	28	33	44.5
LCG	18	19	18.5
ABG	21	26	23.5
GNG-1	45	51	48.0
BQG	42	46	44.0
CVG	32	34	33.0
JNG-1	30	30	30.0
LNG-1	24	25	24.5
GAG	27	28	27.5
Total	291	318	31.85

Table 3. Survival rate of all the age/sex class for each troop for two years.

Troop name	Total animal monitored	Deaths recorded	Survival rate
BRG-3	50	0	-
SHG-1	61	2	0.97
LCG	37	2	0.95
ABG	47	0	-
GNG-1	96	0	-
BQG	88	0	-
CVG	66	0	-
JNG-1	60	1	0.98
LNG-1	49	0	-
GAG	55	1	0.98
Total	609	6	0.99

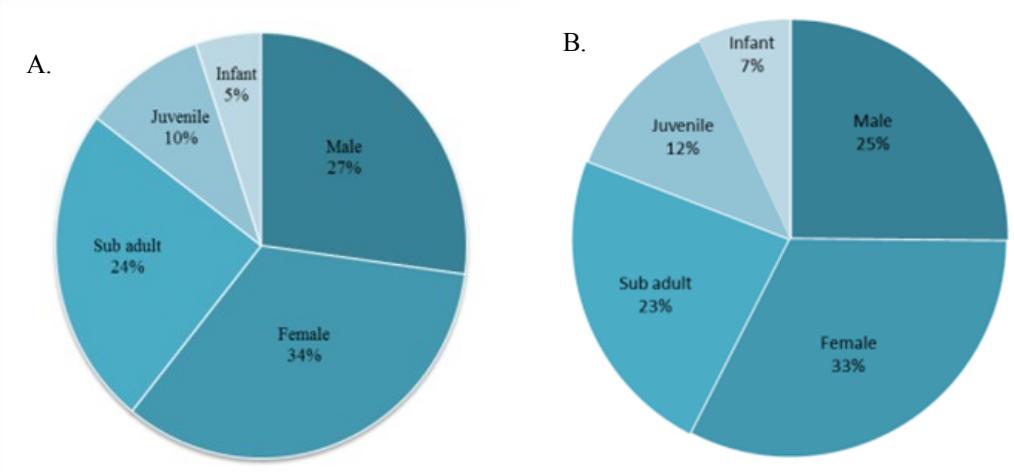
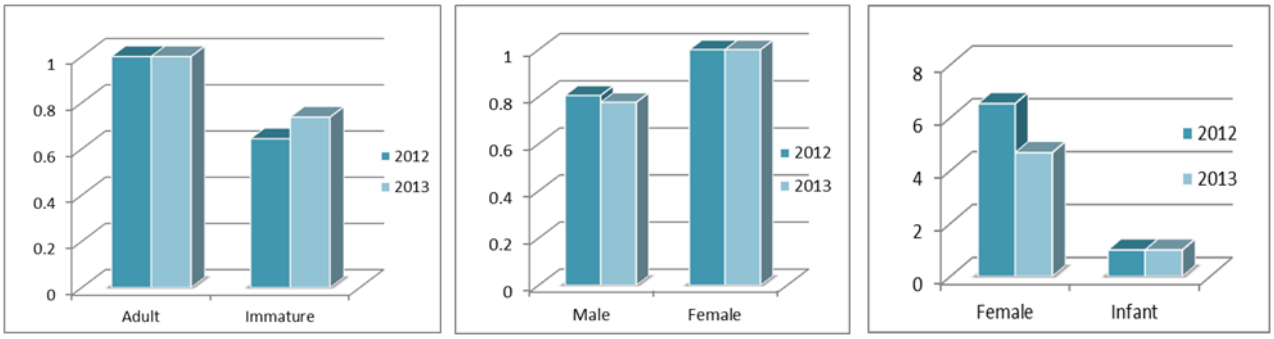
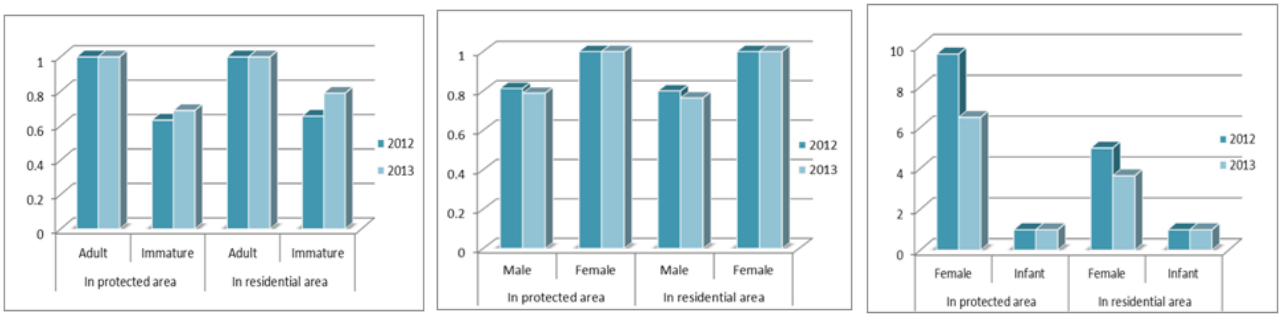


Figure 2. Percentage of group individuals; A. 2012, B. 2013.



A. B. C.

Figure 3. Differences in age-sex ratio from Great Nicobar Island; A. Adult-Immature ratio, B. Male-Female ratio, C. Female-Infant ratio.



A. B. C.

Figure 4. Ratio between group individuals in protected *vs* residential areas; A. Adult-Immature ratio, B. Male-Female ratio, C. Female-Infant ratio.

Birth rate

Natality or Birth rate among the different troops was calculated and compared between the two years (Table 4). A total of 37 infants were born in the entire study period out of 201 adult females observed, among 10 troops giving the mean birth rate of 0.26 infants/adult female/year. In 2013, the birth rate was higher (0.21 infants/adult female/year) when compared to 2012 where it was estimated 0.15 infants/adult female/year. B-Quary troop (BQG) had the high mean birth rate (0.39 infants/adult female/year) than other troops while the low birth rate was (0.06 infants/adult female/year) observed in the ABG troop (Afra Bay). The mean birth rate of residential troops (0.35 infants/adult female/year) was higher than protected troops (0.18 infants/adult female/year).

Survival rate

Table 3 shows the survival rate of all age sex classes together in 10 troops and was calculated as 0.99/individual/year. In our study period six individuals were disappeared including five adults and one immature. Survival rate was lower in troops found in protected areas (0.983/individual/year) than residential troops (0.996/individual/year). It indicates macaque were found in protected areas are managing to survive. In total, four troops having disappearance or deaths were occurred while the other six troops, no deaths were recorded during the entire study period. Among these four troops the least survival rate (0.95/individual/year) was observed in Laful creek troop with two disappearances compared to the other three troops. The adult survival rate (0.986/individual/year) was less than immature survival rate (0.995/individual/year). The results indicate that the high rate of immature survival remarkably shows responsiveness of adult over immature.

Growth rate

The total growth rate was estimated over the study period from 10 troops also observed in each year (Table 4). The total mean growth rate is 1.55/individual/year. Significantly in 2012, the total mean growth rate of all troops (1.04/individual/year) was marginally higher than 2013 (1.03/individual/year). There were a least differences in growth rate among different troops. The highest mean growth rate was estimated in Laful creek group (1.59/individual/year). The growth rate was slightly decreased in six troops out of 10 troops monitored.

The quantitative information on the population estimation and demographic variables provide in assessing the status and effects in management perspectives (Kyes *et al*., 1998). In Great Nicobar Island, the macaque population density (47.61 individual/km^2) was lower when compared to the other reported island population in Southeast Asia such as Pulau penutjang off of Java in Indonesia (400 indiv./km^2), Sumatra (55 indiv./km^2), Bali (1111 indiv./km^2), Hong Kong (326 indiv./km^2) and Singapore (only in the Nature Reserves) (28.2 indiv./km^2) as reported by Sha *et al*. (2009). In Great Nicobar the population was recovered and increased considerably after tsunami 2004 as per earlier reports (Narasimmarajan & Raghunathan, 2012). The present study, the estimation of

Table 4. Yearly growth rate & birth rate among different troops

Troop name	Growth Rate per capita			Birth Rate		
	2012	2013	Mean	2012	2013	Mean
BRG-3	1.04	1.04	1.56	0.13	0.22	0.24
SHG-1	1.04	1.03	1.56	0	0.18	0.09
LCG	1.06	1.05	1.59	0	0.17	0.08
ABG	1.05	1.04	1.57	0	0.11	0.06
GNG-1	1.02	1.02	1.53	0.13	0.25	0.26
BQG	1.02	1.02	1.53	0.19	0.4	0.39
CVG	1.03	1.03	1.55	0.3	0.17	0.38
JNG-1	1.03	1.03	1.55	0.22	0.25	0.35
LNG-1	1.04	1.04	1.56	0.29	0.13	0.35
GAG	1.04	1.04	1.56	0.22	0.11	0.28
Mean	1.04	1.03	1.55	0.15	0.21	0.26

size, birth rate and survival rate indicates that the macaque population is in fair to good health. On the other hand growth rate was slightly decreased, indicating that the macaque population may decrease in near future. Remarkably immature survival rate was higher than adult which indicates that the adult are defensive over immature against predation. The mean birth rate was increased especially in residential areas the birth rate was higher than protected areas. According to Van Noordwijk & Van Schaik (1999) high food availability leads to higher birth. Hence the food sources impact on birth rates. Likewise, this result shows that the food availability was higher in residential areas than protected areas. Habitat quality is also effective in reproduction and birth possibly depends on seasonality of fruit bearing plants and food availability. Overall adult-immature ratio and female-infant ratio was changed. It indicates the number of females for producing offspring was considerably increased due to the lower number of females over infants. At the same time the number of males was reduced over females. This result shows competition for reproduction and mating between the males may possibly reduce. The entire individual ratio was higher in residential areas than protected areas, it indicate that the residential areas are highly preferred for survival due to food availability than protected areas.

Threats and its conservation

Anthropogenic disturbances in Great Nicobar Island

Anthropogenic pressure was observed outside the reserve forest. No evidence of hunting and poaching was recorded in reserve forest and other protected areas. Dogs were used by farmers to chase and kill the monkeys while raiding cropland and coconut farms were observed outside the reserve forest and near residents during the study period. Besides, hunting and trapping wild fauna like Wild boar, Saltwater Crocodile, Reticulated python, Water monitor lizard, Malayan box turtle, pigeons and other birds by local inhabitants were noticed in few occasions. Farmers are using nylon traps to control monkeys against crop raiding. Also some local people are using traps called '*fanda*' (in Hindi) for illegal hunting of wild boar *Sus scrofa nicobaricus* and placing traps in forest areas, turns fatal to monkeys while moving and playing. Some farmers fixing sharp iron materials in each coconut tree to save the crop from monkeys. Such iron materials are harmful for monkeys while climbing coconut trees it may cause injuries.

According to Wheatley (1999), long-tailed macaques well adapted when they change their environment. Moreover, they frequently visit nearby human settlement areas where the food source is available and more attractiveness to human and human made environments (Sha *et al*., 2009; Fuentes *et al*., 2008; Karimullah & Shahrul, 2011). The present study reveals that the Nicobar long-tailed macaques regularly visit residential area where the human food source is available. Sometimes monkeys were engaged to feed the substance garbage from dumping sites. Few monkeys engulf the plastic and rotten food materials which indicate that lack of suffered food from forest (Figure 5). It may cause diseases and deaths in their communities. Likewise skin disease and injuries in some individuals were noticed during the study period. Macaques are sometimes resting, playing low traffic road of Great Nicobar, however monkeys often injured and even killed by transient vehicles while crossing road. Previously several observations of disability were made in Nicobar Long-tailed macaques (Rajeshkumar *et al*., 2014). The vehicular movement in north-south road for the construction of new road may cause threats to primate communities and also to the other threatened fauna. Speed limitation for vehicular movement shall reduce road kills of monkeys and other wild animals.

Figure 5. Nicobar crab-eating macaques feeding in garbage dumping sites & consumes plastics, rotten food items.

Agricultural encroachment resulted in the loss of important forest habitats. Extension of agriculture land leads to the habitat destruction on flora and fauna is the major threats. The non-human primates are suffering due to the intensive agriculture (Pirta *et al.,* 1990). The continuous forest areas are getting fragmented due to unplanned human activity and pressure (Gaston *et al*., 1983). According to Umapathy *et al*. (2003) continuous habitat loss can result in forest fragmentation and also groups even within a single island may become isolated. Similarly in Western Ghats the Lion-tailed macaque (*M. silenus*) population was reduced due to continuous rain forests fragmentation (Kumar *et al*., 1995; Singh *et al*., 1997, 2000, 2002). The present study revealed that the conflict between humans and non-human primates were raised due to competition of food and shelter, and ultimately it eradicates latter. Most of the sleeping sites located in forest cover nearer to agriculture land. In Great Nicobar forest covers continuously logged for agriculture (Figure 6) it will increase human-monkey conflict due to crop raiding activity of macaques when food shortage occurs in their territory. Logging of protected forest should be monitored regularly and it may address this issue. The long term field studies are essential for non-human primate conservation (Southwick & Siddiqi, 1988; Vogel, 1977). Likewise, regular population census, feeding and other behaviour studies can be helpful for further conservation and management. *In situ* and *ex situ* conservational methods can be used to protect natural habitat. Great Nicobar Island has major protected areas, but the monkey population was higher in residential areas than protected areas. According to Sivakumar (2010), the declaration of Community Reserve in Nicobar Islands has to enhance protection from threatening activities against Long-tailed macaques. Introduced food plants and increase plantation in coastal areas and other protected areas can be helpful for conservation of non-human primate in the Great Nicobar Island.

Figure 6. Habitat loss of rainforest, logging for Island development & agriculture practices in Great Nicobar Island.

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