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Distribution of Rhesus Macaques (*Macaca mulatta*) in Bangladesh: Inter-population Variation in Group Size and Composition

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Abstract: In Bangladesh rhesus macaques (*Macaca mulatta*) are found in forested habitats and urban areas. From 2005 to 2010, we investigated the distribution of rhesus macaques throughout the country. Populations were estimated by line transect, point sampling and direct counting. A total of 37 groups in 16 localities were recorded in urban areas. Overall, group size in urban areas ranged from 22 to 91 individuals, with a mean of 41.3 ± 16.7 . Rhesus macaques in urban areas were found mostly near Hindu communities. Nearly five times as many groups ($n=176$) of rhesus were observed in the forested habitats of the country. Overall group size in natural habitats varied from 10 to 78 individuals, with a mean of 30.2 ± 10.9 . Of the natural habitats, the northeast rainforests were found to support the largest groups (38.9 ± 10.3 , $n=49$), while smaller groups were found in the central deciduous forests (19.3 ± 4.7 , $n=18$). The adult sex ratio was higher (1 male to 2.86 females) and the ratio between adult and non-adult (immature) was lower (1 adult to 1.70 non-adults) in natural habitats than was found for the populations in urban areas (1 male to 1.93 females, and 1 adult to 2.11 non-adults). In urban areas, the human-monkey conflict is increasing as competition for resources intensifies.

Key words: Rhesus macaque; *Macaca mulatta*; distribution; population; group size; Bangladesh

Introduction

Bangladesh lies between 20°30' and 26°45'N and 88°01' and 92°41'E. It has an area of 147,570 km² and supports about 160 million people. The country largely comprises the flat deltaic and alluvial deposits of the rivers Ganges, Meghna and Brahmaputra and their tributaries. Hill ranges are found in the northeastern and southeastern parts of the country. April and May are typically hot and followed by the monsoon season in June and July. Winter (November–March) is typically cool and dry. At present about 6% of the country is covered by three types of forest: a) semi-evergreen and evergreen forest in the northeast and southeast hill tracts; b) moist deciduous forest in the central region; and c) the Sundarbans mangrove forest in the southwest. Many tea gardens in the northeast support an abundant population of rhesus macaques (*Macaca mulatta*). Urban areas are densely populated with multistoried buildings. In some urban areas, it is the temples and shrines that are particularly occupied by the monkeys.

Seven species (14 subspecies) of macaques are known in South Asia (Molur *et al.* 2003), and five of them are found in Bangladesh. *Macaca nemestrina*, *M. fascicularis*,

M. arctoides, and *M. assamensis* occur only in the north-eastern and southeastern hill areas. The rhesus macaques are distributed throughout the country. They are synanthropic, thriving in human-altered environments, including urban areas, and play a significant role in the culture and traditions of some communities. Rhesus macaques are non-seasonal breeders and, although some have labeled them “weed species” in recognition of their ability to live in densely populated urban areas (Teas *et al.* 1980; Richard *et al.* 1989; Southwick *et al.* 2005) we recognize this adaptive characteristic as an evolutionary strategy that has allowed this macaque to be among the most widely distributed and successful primates in the world.

Primate populations are being reduced or eliminated in many parts of the world due to habitat destruction, competition for food and space, bushmeat hunting, biomedical research, and the pet trade (Wolfheim 1983; Mittermeier 1986). Published data detailing the distribution and population composition of rhesus macaques in Bangladesh is very limited (Green 1978, Gittins 1980), and largely limited incidental or discontinuous observations in the early 80's (Khan and Ahsan 1981). Intensive surveys, which covered 17 primate habitats in the

northeastern and southeastern part of the country, were later conducted by Feeroz and colleagues in the late 1990s (Feeroz *et al.* 1995; Feeroz 2001). The present study aims to describe the current distribution of rhesus macaques in Bangladesh and to discuss the variations in group size and composition among populations in relation to habitat diversity and commensality.

Methods

We conducted 75 field surveys between 2005 and 2010, including 14 field surveys in the northeast, 15 in the south-east, and five in the central part of the country, as well as 15 in the Sundarbans mangrove forests and 26 in urban areas. Three to four days were spent in each field survey, comprising a total of 240 days. Three to five permanent line transects were set at each forest site (Feeroz 2001; Hasan 2003, 2007, 2010). In total, approximately 60% of the forested areas in the country were surveyed in this study. Generally, line transects with modification were used to survey populations in forested areas. Since it was very difficult to perform line transect surveys in the mangrove swamps of the Sundarbans, point sampling was used. In urban areas, total counts were used to survey populations. Double counting was avoided by identifying social groups; comparing group size, composition and visible markings of members (injury, abnormalities or other characteristic morphology). At the same time local people were interviewed regarding their religion, culture and attitude toward the monkeys.

GPS coordinates were noted whenever any group of rhesus macaques was found. Group size and composition were recorded for each group. Group size and composition were verified by repeating the survey at a different time of the day and in different months. We initially used six age-sex classes to characterize macaques: adult male, adult female, sub-adult male, sub-adult female, juvenile and infant. However, it proved very difficult to distinguish sub-adult from juvenile's age-sex in forested areas. Thus, we changed our classification to recognize three classes: adult male, adult female and non-adult (rest of the member of the group as a single category). Vegetation types were categorized as semi-evergreen forest, evergreen forest, deciduous forest, mangrove forest, plantation, tea garden and scrub forest (which include crop fields, scrub-bushes, and bamboo thickets). Urban areas were further categorized into frequent provisioning areas (regular, typically daily or nearly daily) and infrequent provisioning areas (less than once per month).

Results

Rhesus macaque populations in Bangladesh can be divided into two major categories: 1) those living close to human settlements (generally known as urban monkeys); and 2) those living in forested habitats. Mean group size was larger among urban monkeys ($t=2.08$, $p < 0.05$).

A total of 37 groups of rhesus macaques were identified among 16 urban populations. All these populations were

geographically isolated from each other by 30 to 300 km apart (Fig. 1). The number of groups identified at the urban sites varied from one to five. In urban settings the total population size ranged from 55 to 260 individuals (mean 95.5 ± 62.3 , $n=16$) with individual group sizes varying from 22 to 90 individuals (mean 41.3 ± 16.7). In urban areas adult males and adult females comprised 11% and 21% of the populations, respectively, while non-adults comprised 68% of the population (Fig. 2). The average ratio between adult males and adult females was 1:1.93. The average ratio between adults and non-adults was 1: 2.11 (Table 1).

In all, 176 groups were identified in natural habitats. Among these groups 49 were identified in the northeastern region, 68 in the southeastern region, 18 in the central region and 41 in the Sundarbans (southwestern) (Fig. 1). Group size of rhesus macaques in forested habitats varied from 10 to 78 (mean 30.2 ± 10.9 , $n=176$) individuals. Among forested sites, the rainforests of the northeastern region supported the largest mean group size (38.9 ± 10.3 , $n=49$), while the smallest mean group size was observed in the central deciduous forests (19.3 ± 5.5 , $n=18$) (Fig. 3). The adult sex ratio was higher (1 male to 2.86 females) while the ratio between adult and non-adults (immatures) was lower (adult:non-adult=1:1.70 in natural habitat) than that of the population in urban areas (1 male to 1.93 females and adult:non-adult=1:2.11) (Table 2). Mean group size of rhesus macaques living in urban areas was significantly larger than that of forested areas ($t=2.08$, $p < 0.05$).

A significant variation ($t=6.7$, $p < 0.05$) in group size was also observed among the forested rhesus groups occurring in different habitats—semi-evergreen forest, evergreen forest, deciduous forest, mangrove forest, planted forest, tea garden and scrub forests.

Frequent provisioning was found in seven of the 16 urban sites: Sadhana, Dhamrai, Bormi, Chashnipeer, Syed Jahan, Charmuguria and Chandpur. In these frequently provisioned areas group size ranged from 30 to 90 individuals with a mean group size of 57.85 ± 16.84 . In infrequently provisioned areas, group size ranged from 22 to 57 individuals with a mean group size of 32.33 ± 7.17 . Group size was significantly larger in the sites where the monkeys were frequently provisioned ($t=5.42$, $p < 0.05$).

Discussion

Bangladesh is a densely populated, developing country. At the time of writing this, about 6% of the land area of the country was covered by forests (Gain 2002). Due to increases in human populations and rapid urbanization, the existing forested areas are still facing continuous threats of degradation. In addition to this, human population pressures have accelerated the fragmentation of wildlife habitats, including those of rhesus macaques (Hasan 2003, 2010). Although few data on rhesus ranging patterns are available, research at Lawachara National Park (Feeroz 1999) indicates that a group can range over 5 km², and adult males in the population

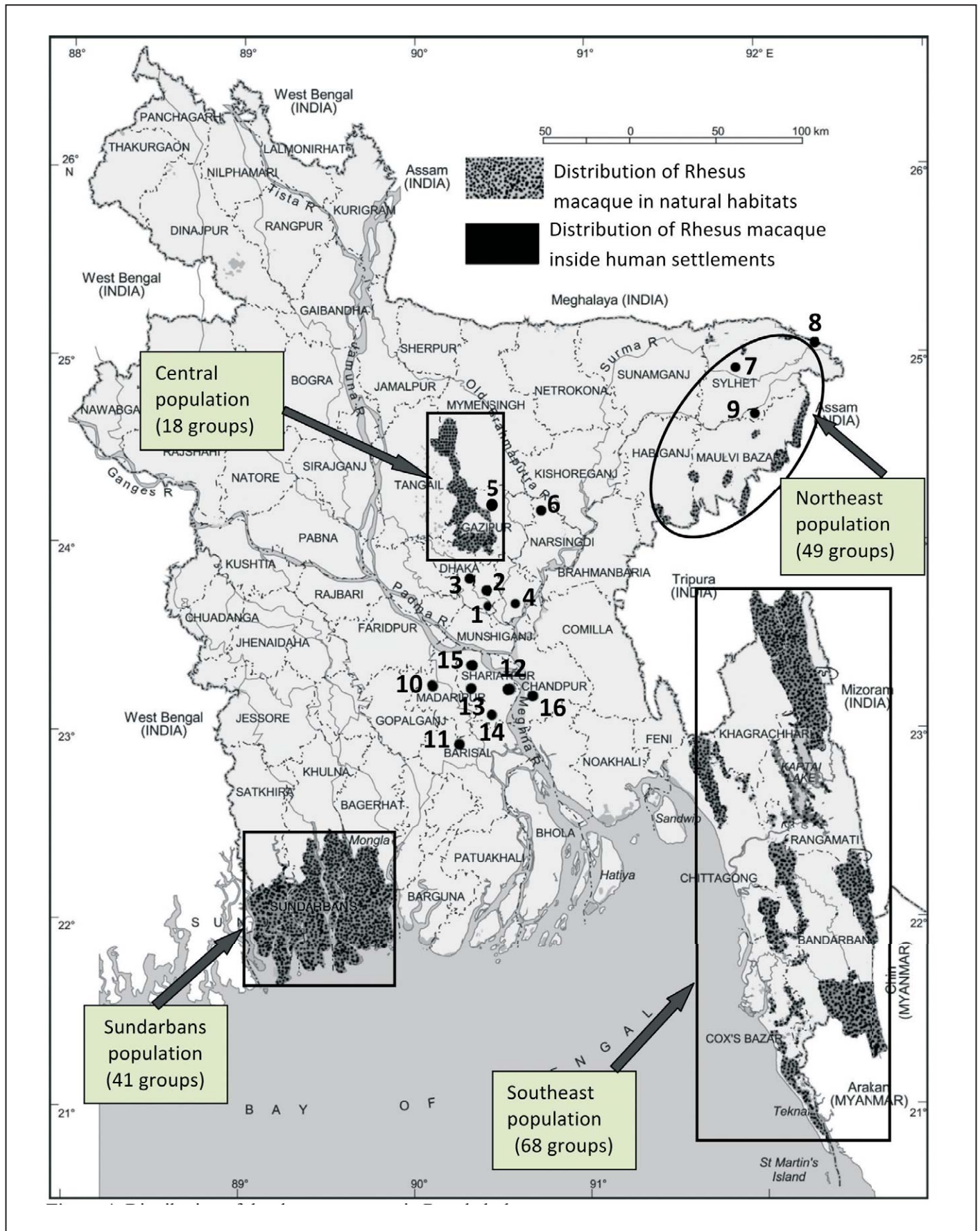


Figure 1. Distribution of the rhesus macaque in Bangladesh. Note: 1- Old Dhaka (4 groups), 2- Dhaka cantonment (3 groups), 3- Dhamrai (2 groups), 4- Narayanganj (2 groups), 5- Bormi (2 groups), 6- Rampur (3 groups), 7- Sylhet town (5 groups), 8- Jointapur (3 groups), 9- Fenchuganj (1 group), 10- Charmuguria (3 groups), 11- Wazirpur (3 groups), 12- Nandanshar (1 group), 13- Kartikpur (1 group), 14- Kolargaon (1 group), 15- Naria (1 group), 16- Chandpur (2 groups).

can move about 10 km in three days, which indicates that adult males may travel about 20 km even in a fragmented habitat. In this situation we considered 40 km as the separator distance between two populations of rhesus macaque in Bangladesh. Koganezawa (1995) considered 15 km as the separator distance between the two populations of Japanese macaque, while several studies recorded male migration of more than 45 km in this species (Yoshimi and Takasaki 2003). Population genetic studies of Japanese macaques suggest that groups geographically separated by more than 100 km are genetically distinct from each other (Nozawa *et al.* 1996).

However, from the ecological point of view, several factors may affect male migration, including geographical barriers such as large rivers, large human settlements, and discontinuous habitat.

The largest population and the largest group sizes of rhesus in urban areas were recorded at Charmuguria in the Madaripur district. Due to provisioning by the Government between 2006 and 2009 (Fig. 4), the rhesus population increased very quickly and expanded to Madaripur town, 10 km away from Charmuguria. An abrupt end to provisioning in 2009 led to food scarcity, which subsequently resulted in

Table 1. Rhesus population inside human settlements in Bangladesh.

| Urban population | | Population size | No. of groups | Mean group size | Range | AM:AF | AD:NAD |
|----------------------|---------------------------|-----------------|---------------|-----------------|-------|--------|--------|
| Location | GPS coordination | | | | | | |
| Old Dhaka | 23°42.192' N, 90°25.477'E | 159 | 4 | 39.8±13.8 | 26–59 | 1:2.07 | 1:2.70 |
| Dhaka cantonment | 23°49.069'N, 90°24.242'E | 92 | 3 | 30.7±5.8 | 24–35 | 1:1.80 | 1:2.29 |
| Dhamrai | 23°55.056'N, 90°12.637'E | 103 | 2 | 51.5±4.9 | 48–55 | 1:2.22 | 1:2.55 |
| Narayanganj | 23°36.903'N, 90°30.716'E | 55 | 2 | 27.5±3.5 | 25–30 | 1:2.20 | 1:2.44 |
| Bormi | 24°14.669'N, 90°31.301'E | 102 | 2 | 51.0±5.6 | 47–55 | 1:2.00 | 1:2.09 |
| Rampur | 24°14.226'N, 90°43.250'E | 81 | 3 | 27.0±3.0 | 24–30 | 1:2.00 | 1:2.38 |
| Sylhet town | 24°54.314'N, 91°52.418'E | 260 | 5 | 52.0±24.6 | 31–84 | 1:1.97 | 1:2.02 |
| Jointapur | 25°05.930'N, 92°07.768'E | 93 | 3 | 31.0±9.5 | 22–41 | 1:1.83 | 1:1.82 |
| Fenchuganj | 24°39.543'N, 91°58.553'E | 57 | 1 | 57.0 | 57 | 1:1.83 | 1:2.35 |
| Charmuguria | 23°10.249'N, 90°10.036'E | 210 | 3 | 70.0±20.0 | 50–90 | 1:1.88 | 1:2.04 |
| Wazirpur | 22°49.261'N, 90°15.037'E | 98 | 3 | 32.7±3.8 | 30–37 | 1:1.93 | 1:1.23 |
| Nandanshar | 23°17.868'N, 90°28.633'E | 33 | 1 | 33.0 | 33 | 1:1.80 | 1:1.36 |
| Kartikpur | 23°17.732'N, 90°28.737'E | 36 | 1 | 36.0 | 36 | 1:2.00 | 1:2.00 |
| Kolargaon | 23°16.276'N, 90°28.608'E | 30 | 1 | 30.0 | 30 | 1:1.67 | 1:2.75 |
| Naria | 23°18.317'N, 90°24.713'E | 36 | 1 | 36.0 | 36 | 1:1.80 | 1:1.57 |
| Chandpur | 23°13.696'N, 90°38.543'E | 83 | 2 | 41.5±9.2 | 35–48 | 1:1.75 | 1:2.77 |
| Total/Overall | 95.5±62.3 | 1528 | 37 | 41.3±16.7 | 22–90 | 1:1.93 | 1:2.11 |

Note: AM=Adult male, AF=Adult female, AD=Adult and NAD=Non-adult.

Table 2. Rhesus populations in forested habitats of Bangladesh.

| Population | Population size | No. of groups | Mean group size | Range | Adult male: Adult female | Adult: Immature* |
|--|-----------------|---------------|-----------------|-------|--------------------------|------------------|
| North East (NE) (Satchari, WBFR, Rema-Kalenga, Adampur, Borolekha, Juri, Harinchara, Khadimnagar and Tea gardens) | 1909 | 49 | 38.9±10.3 | 26–78 | 1:3.43 | 1:1.36 |
| South East (SE) (Sitakunda, Hazarikhil, Fashiakhali, Himchari, Kaptai, Rangamati, Bandarban and Khagrachari Hill Tracts) | 2091 | 68 | 30.8±9.8 | 20–52 | 1:2.61 | 1:1.85 |
| Central (Bhawal and Madhupur deciduous forest) | 347 | 18 | 19.3±4.7 | 10–26 | 1:2.56 | 1:1.93 |
| Sundarbans | 966 | 41 | 23.6±5.2 | 14–31 | 1:2.84 | 1:1.64 |
| Total/overall | 5313 | 176 | 30.2±10.9 | 10–78 | 1:2.86 | 1:1.70 |

Note: * Immature=sub-adult male, sub-adult female, juvenile and infant.

increased human-monkey conflict. Since 2009, local people have reported a considerable increase in the incidents of monkeys biting and scratching people (Hasan 2010).

The smallest group sizes in urban areas were found in Rampur in the Narshindi district. Rampur is located in a rural area with abundant natural vegetation. Rhesus in these areas are not habituated to people and they mostly depend on natural food sources. Rhesus from Rampur are frequently trapped for pet and for performance monkeys, which may contribute to the animal's avoidance of humans.

The Sadhana herbal medicine factory is situated in the heart of old Dhaka city, which is densely populated. There

are very few natural food sources near Sadhana, and monkeys are mostly dependent on food supplied by visitors. The herbal medicine factory authority regularly provides food to the monkeys. Although a decade ago rhesus macaques were distributed in 11 areas in Dhaka city (Feeroz *et al.* 1995) currently they are confined to four. The increasing human population is one of the reasons for their population decline. In Dhaka city, monkeys are now limited to Hindu communities, where they range along the walls and roofs of buildings and use utility lines to cross over busy roads. Monkeys climbing onto utility lines are occasionally electrocuted, resulting in burns that are sometimes fatal.

If we use 40 km as the geographic distance at which gene flow is restricted, rhesus macaques found in the natural habitat in Bangladesh can be divided into four distinct regional populations: 1) northeastern population, 2) southeastern population, 3) central Madhupur population in the central part, and 4) Sundarbans population in the southwest of the country.

The forests of Bangladesh in the northeast region are surrounded by tea plantations. Three sub-populations of rhesus have been identified in this area. Of these, the largest comprised 39 rhesus groups spread over 100 km², extending from the Satchari Forest Reserve to the border area of Karimganj, and including the Rema Kalenga Wildlife Sanctuary, West Bhanugach Forest Reserve, Adampur, Gazipur tea estate, Jhemai tea estate, Borlekha-Juri forests, Madhabkunda forest patches and surrounding tea gardens. Human settlements have fragmented these forest patches, and tea gardens may provide corridors between them. The rhesus groups are separated by less than 10 km, and surrounding tea gardens make male migration possible among them, making them a single sub-population.

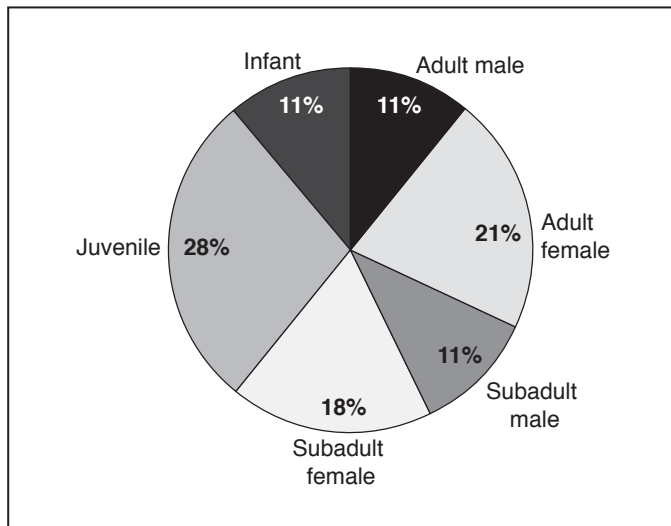


Figure 2. Composition of rhesus populations in different urban areas of Bangladesh.

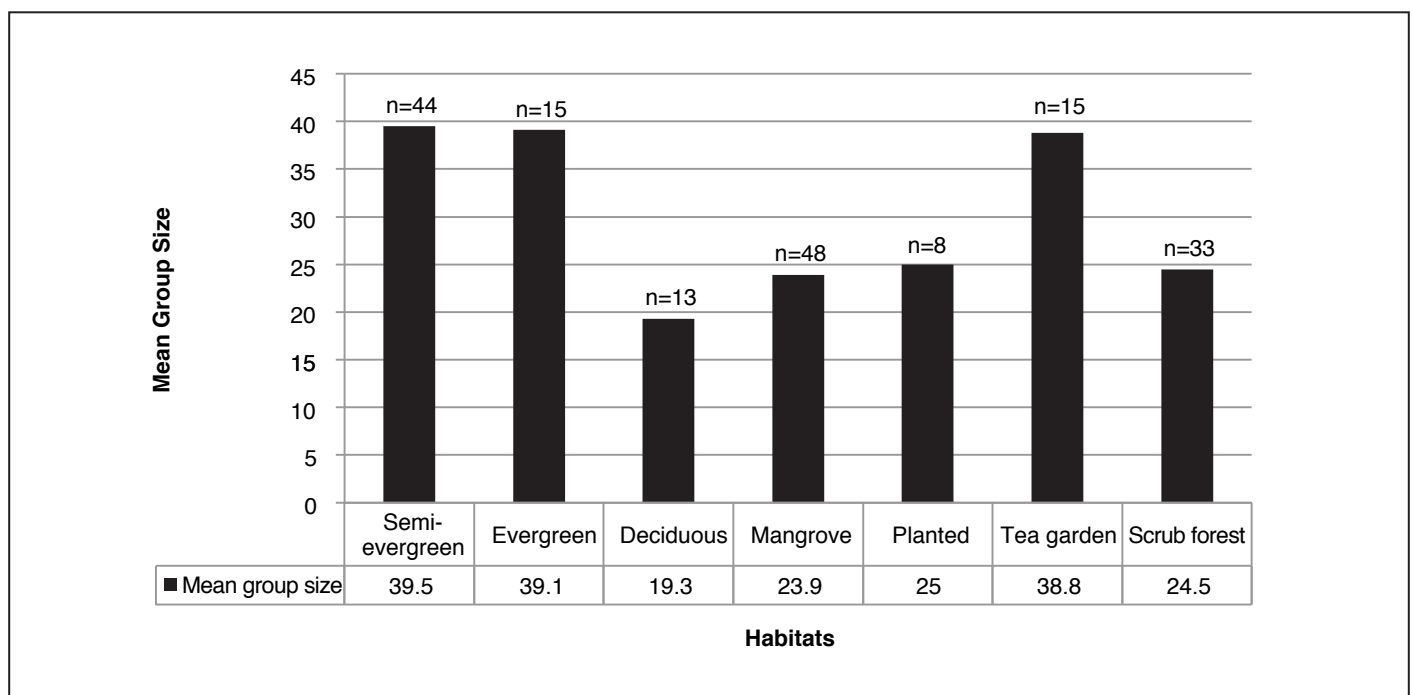


Figure 3. Mean group size of rhesus macaques in different natural habitats.

Two other sub-populations of rhesus were distributed more than 40 km apart from each other, and separated also by large water bodies (locally known as *haor*). The second sub-population (Fenchuganj) comprised six groups of rhesus, ranging in the Fenchuganj-Maijgaon tea estates. The third northeastern sub-population comprised only four rhesus groups ranging in the Malnichara tea estate, the Pathantula villages of Sylhet (Feeroz *et al.* 1995), and the forested areas of Khadimnagar.

The southeastern hill areas of the country support Bangladesh's largest rhesus macaque population: comprising at least 68 groups identified over an area of about 10,000 km² of forests and hills. Evergreen and semi-evergreen forests are more productive than any other forest habitat of Bangladesh, and they provide food for the primates throughout the year (Feeroz 1991, 1999), explaining as such the large group sizes in this area.

Eighteen groups were identified in the Madhupur deciduous forest in the central part of the country. This forest covers about 250 km², with comparatively low habitat fragmentation. Because groups were located less than 10 km apart from

each other they were considered to form a single population. Diversity and density of tree species are lower in this forest than in any other forest in the country (Stanford 1991), creating a limited food supply for the macaques during the year. Trees shed their leaves during the winter months, increasing food scarcity during this period. The smaller group sizes observed in Madhupur may be an adaptation to, or result of, low food availability.

The mangrove forests of the Bangladesh Sundarbans cover an area of about 6,000 km², and are criss-crossed by numerous rivers and canals. The Rhesus macaque is the only primate species native to the Sundarbans. Forty-one groups were identified there and were considered to make up the southwestern rhesus population of the country. Impermeability of the marshes in the mangroves was a barrier to carrying out more extensive surveys in this region. We considered these groups to be a single rhesus population though some were found in distinct locations more than 40 km from the nearest group.

Female macaques are philopatric, that is, they generally remain in the same group throughout their life. In contrast, males may leave their natal group when they mature. The sex ratio (adult male:adult female) was significantly higher in the forest populations than in the urban populations. This might be due to the restrictions on male migration among urban populations. On the other hand the ratio between adults and non-adults (immature) in urban areas was higher than in the forested populations. Due to provisioning in urban areas by the government, local inhabitants and visitors, the population growth rate is higher than in forested habitats (Hasan 2010).

Rhesus macaques (*Macaca mulatta*) are the most commensal of the non-human primates in many Asian countries such as Afghanistan, Pakistan, India, Myanmar, Nepal, China and Vietnam (Southwick *et al.* 2005). Problems arise when this commensal species becomes a practical competitor with the human population, and Bangladesh is no exception. Rhesus macaques in urban areas generally reside in and around Hindu communities but most of the residents were hostile toward monkeys. Although the Hindu culture venerates monkeys, even Hindus are often hostile toward the monkeys, reflecting the "NIMBY" (not in my back yard) attitude mentioned by Southwick *et al.* (2005).

Increasing conflict between humans and rhesus macaques is a growing problem for both species. In urban areas such as Bormi, Dhamrai, Charmuguria, Chandpur and Chashnipeer-ermazar (shrine), many people have been badly scratched and bitten by the monkeys. Monkeys destroy their home gardens, fruit trees and crops. On the other hand, monkeys are also beaten, injured and killed by the local people. These types of interactions may increase the risk of bidirectional disease transmission (Jones-Engel *et al.* 2008).

Translocation of rhesus subgroups and groups from urban to rural and forested areas may temporarily appease local human populations but is short-lived and creates problems in the areas of relocation. For the management of the



Figure 4. Provisioning in an urban area (Charmuguria) by: (a) visitors and tourists, and (b) the government authority. Photos by M. K. Hasan

commensal populations, a variety of management techniques such as vasectomies of dominant males, hormonal contraception of adult females, olfactory and taste aversion, noise devices and aggressive dogs have been successful (Southwick *et al.* 2005). We cannot be sure which techniques will be effective in Bangladesh, but the problem needs to be addressed, for the well-being of both of the species.

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