

# Impact of Altitude on Population Structure and Distribution of Assamese Macaque (*Macaca assamensis* Mc'clelland, 1840) in Dampa Tiger Reserve in Mizoram, India

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## ABSTRACT

A study on population status and distribution of Assamese macaque (*Macaca assamensis*) across altitudinal gradients in Dampa Tiger Reserve (DTR), Mizoram, India was conducted. Six species of diurnal primates inhabit in DTR and a study on Assamese macaque is reported here. Line transect method was adopted for population sampling. Total distance covered was 293.5 km. Data on group locations, demography and site covariates including trail length, duration of walk, forest type were recorded. Nine groups of Assamese macaque comprising of 123 individuals were recorded mostly at an altitude between 250 m to 856 m. The smallest group was consisted of 7 individuals, and the largest was of 21 individuals. An average group size calculated was 13.6 ( $\pm 4.32$ ) individuals. The population comprised of 36.59% male, 53.66% female, and 9.76% immature. All the groups were comprised of multi-males and multi-females. The population encounter rate was 0.42 individual/km and the group encounter rate was 0.03 group/km. Total male to female ratio was 1:1.46, adult male to female ratio was 1:1.53. All female to immature ratio was 1:0.18 and an adult female to immature ratio was 1:0.26. Maximum sighting were at the distance between 30-50 m. Area of occupancy of groups was about 26 km<sup>2</sup> and ecological density was 4.7/km<sup>2</sup>. Among primates in DTR, wild population of Assamese macaques were found to occupy altitudinal range between 250 to 856 m. 67% individuals were distributed at the altitude between 400 to 600 m. Presence of other primate species in DTR restricted the occurrence of this species.

**Key words:** Assamese macaque, population status, group size, age-sex ratio, visible distance, altitude occupancy, Dampa Tiger Reserve

## INTRODUCTION

Of the 43 primate species in South Asia, 24 species occurs in India. Several species including the Slender loris (*Nycticebus bengalensis*), Bonnet macaque (*Macaca radiata*) Assamese macaque (*Macaca assamensis*) also have distinct subspecies making India very rich in primate taxa. Two sub-orders (Prosimii and Anthropoidea) of primates form an integral part of the biodiversity of north-east India (Molur et al. 2003, Choudhury 2003, Singh et al. 2020). India has 32 taxa at sub species level of primates in the wild. Of the seventeen primate species, ten occurs in the north-east India (Srivastava 1999) and eight species are found in Mizoram (Sawmliana 2009). Out of eight species found in Mizoram, seven species occurs in Dampa Tiger Reserve (DTR).

The Assamese macaque (*Macaca assamensis*) is distributed in the south and south-east Asia including India (Fooden 1982, Francis 2008, Chalise 2003,

Timmins and Duckworth 2013), and mostly prefers diverse habitat types (Zhang et al. 1997). Its distribution is patchy along rivers in the tropical and subtropical areas (Wada 2005). This macaque is mostly arboreal and requires dense forest with continuous canopy for dispersal in wild. However, in recent times its habitat has been severely degraded due to a number of human activities such as deforestation, degradation of natural habitat, hunting for trade, medicine and food, and so on (Adhikari et al. 2018, Choudhury 1986, 1988, 2013, Molur et al. 2003). Further, it is also considered a pest animal in different ranges of its distribution leading to a decline in its number in the wild due to human-monkey conflicts (Chalise 2001, Regmi and Kandel 2008, Regmi et al. 2013).

Primates are less ecologically flexible than many mammals, and particularly vulnerable to fragmentation effects (Harcourt et al. 2001, Isaac and Cowlshaw 2004). Population densities, distribution, and occurrence are also highly correlated with forest

structure and other habitat and landscape characteristics, human density and cutlural torelance (Hamard 2010, Karanth et al. 2010, Solanki 2016). However, anthropogenic activities are the paramount cause that leads to large-scale disturbances in habitat and population decline (Johns and Skorupa 1987, Marsh et al.1987, Laidlaw 2000, Phoonjampa and Brockelman 2008). Tropical forests are undergoing rapid transformation and fundamental question about the primates is to understand how ecological conditions shape the social organization of animals in general and specially folivorous monkeys (Chapman et al.2014).

Dampa Tiger Reserve (DTR) in Mizoram is one of the prime habitats for primates in the region; it is home for seven species. Six diurnal primates species namely Western hoolock gibbon (*Hoolock hoolock*), Phayre's leaf monkey (*Trachypithecus phayre*), Capped langur (*Trachypithecus pileatus*), Pig-tailed macaque (*Macaca leonina*), Assamese macaque (*Macaque assamensis*), Rhesus macaque (*Macaca mullata*), and the Slow loris (*Nycticebus bengalensis*) - a nocturnal species is also occurs in DTR. All the diurnal primate species recorded to occupy different altitudinal ranges (Solanki 2016). Details of population structure and occurrence at altitudinal ranges of Assamese macaques (*Macaca assamensis*) are presented here. Assamese Macaque (*M. assamensis*) has most recently been assessed for The IUCN Red List of Threatened Species in 2015. *M. assamensis* is listed as Near Threatened under criteria A2cd. The Assamese macaque is the less-studied primate in India. Studies mostly carried out on road and river side areas (Mukharjee et al.1995, Mitra 2002,200, Murmu et al.2004) and in reserve forest areas (Choudury, 1988, 1996). In this study, we have tried to evaluate the population status of Assamese macaques and distribution along the altitudinal gradients in natural habitat in the Dampa Tiger Reserve (DTR). Information thus generate will strengthen database for this species for proper evaluation and to develop and implement effective conservation plans in its natural habitat.

## MATERIALS AND METHODS

### Study site

The study was conducted in Dampa Tiger Reserve (DTR), the largest protected area in Mizoram. It lies

between N23°20' to N23°47' and E92°15' to E92°30'. It covers a geographical area of approximately 500 km<sup>2</sup> as core zone and 488 km<sup>2</sup> as buffer zone. The mountainous terrain ranges from 200 to 1200 m above sea level. It consists of forests interpolated with steep precipitous hills, deep valleys, lots of streams, ripping rivulets and natural salt licks. It shares international border with Bangladesh in the western side and northern boundary with the state of Tripura (Fig. 1). Administratively the DTR is divided in two forest ranges namely Phuldungsei and Teirei. Phuldungsei range is highly disturbed because it is close to international border. Present study was conducted in Teirei range of DTR. The area is an integral part of Indo-Myanmar bio-diversity hotspot and thereby supports rich floral and faunal diversity (Rodgers and Panwar 1988, Stattersfield et al.1998, Myers et al.2000). Primate community is also very rich and diverse in DTR (Parida and Solanki 2018).

The climate of the area is moderately seasonal. October to January is cool and dry temperature ranging between 11 to 21°C. February to May is hot and dry, and temperature ranges between 19 to 37°C. Monsoon is prolonged from March to September. The average rainfall is 2,150 mm. Most of the rainfall is due to southwest monsoon that remains active between from June to September (Devi et al. 2011). Natural vegetation is tropical evergreen forest type in the lower reaches, grading into moist deciduous and semi-evergreen type on the upper slopes (Champion and Seth 1968). The principal tree species in this area are *Derris robusta*, *Dipterocarpus turbinatus*, *Lagerstoemia flosreginae*, *Artocarpus chaplasi*, *Heritiera acuminate*, *Canarium bengalensis*, *Magnolia oblongata*, *Terminalia myriocarpa*, *Amoora wallichii*, *Schima wallichii* and *Magnolia pleiocarpa*. There are about 11 species of bamboo - the most common species being *Melocanna baccifera*, *Bamboosa tulda*, *Dendrcalamus dulloa*, *D. longispathus* and *D. compactiflora*. Thirteen villages are located on the periphery of core area of the DTR and exert high pressure on forest resources due to extraction from the reserve.

### Population Estimation

Surveys were carried out for population estimation in core area of DTR for a period of two years (2012 to 2014) (Fig. 1). Line transect sampling method

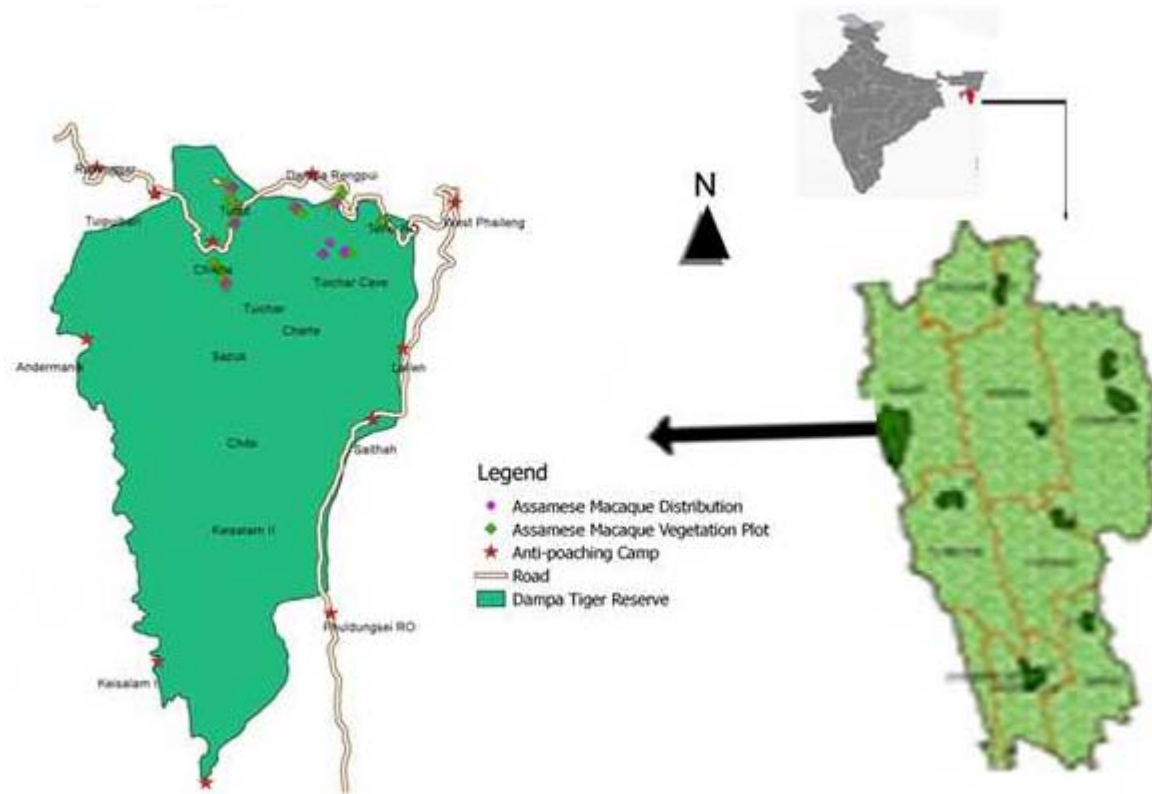


Figure 1. Map of Dampa Tiger Reserve (DTR) India showing distribution of Assamese macaque

was employed for population estimation (Buckland et al. 2001, 2004, 2010). A straight line transect was not feasible in the rugged terrain in DTR therefore forest road, existing patrolling trail, animal trail, stream bed, beaten foot path were taken as transect line (Sharma et al. 2013). Observer walked approximately 6.2 ( $\pm 1.27$ ) km length of transect on foot each day at an average speed of 0.7 km/hr. We laid 34 transects covering a distance of 293.5 km. Pedometers were used to record the distance walked. At the beginning of scanning each transect, habitat type, date, weather condition (sunshine, cloudiness), and altitude and geographical coordinates were recorded, when a troop is observed, with the help of GPS (Garmin74 map S model). Starting time and completion time of scanning transects were also recorded. Transects were scanned as per the procedure recommended by NRC (1981) at every 200 m during walks on either side of transect lines and from the canopy to the ground for monkeys from 05:30 am to 12:00 pm and from 14:00 pm to 18:00 pm or until sunset. When a group was seen, group size, age and sex of individuals were recorded except juveniles and infants. Group was numbered and each individual was classified as adult male, adult female,

and sub-adult male and sub-adult female, and immature including juveniles and infants, based on morphological characteristics, as done by Roonwal and Mohnot (1977), Ramachandran and Joseph (2001), and Singh et al. (2002).

Abundance of Assamese macaque was calculated based on the group encounter rate (number of groups/km). The total number of individuals encountered in a group consisted the group size (Fashing and Cords 2000, Srivastava and Mohnot 2001, Pruetz and Leator 2002, Srivastava 2006, Medhi et al. 2007). Population encounter rate was calculated based on the number of individuals encountered per km of trail during single walk. Group encounter rate was calculated based on number of groups sighted during single walk per transect/ trail length (Roonwal and Mohnot 1977). The total count method (Kiszka et al. 2007) was adopted to estimate population of patchily distributed species (White and Edwards 2000, Whitesides et al. 1988, Peres 1999, Davies 2002). Observer's distance from the troop and its GPS location, time of sighting, activity of animals at first detection (for each group) was recorded. Population was analyzed for age-sex ratio (Chalise 2003). We calculated population density (ecological

density)  $D$  from the number of individuals in all groups divided by area surveyed for population estimation. Difference in age-sex composition between the troops was tested by paired t-test.

## RESULTS

In total 293.5 km length of transects, nine troops of Assamese macaque consisting of 123 individuals were sighted. Total area of their occurrence calculated using GIS (Archview) was 26.3 km<sup>2</sup>. All the groups observed were in multi-male-multi-female class. Composition of all nine groups in the core area of Dampa Tiger Reserve is given in Table 1. The smallest group consisted of seven individuals and the largest was of 21 individuals, with an average group size of 13.66 ( $\pm 4.32$ ). Ecological density of Assamese macaque was 4.7/km<sup>2</sup> in area of occurrence. Individual encounter rate was 0.42 individual/km and population encounter rate was 0.03group/km. The number of adult males per group varied from 1 to 5, (mean 3.33  $\pm 1.15$ ). Fifty five

percent of the groups had four or more adult males and total adult males were 30. The number of adult females per group varied from 3 to 8 (mean 5.11 $\pm 1.73$ ), and the total number of adult females was 46. Overall composition of the population consists of 36.59% males, 53.66% females, and infants and juveniles were 9.76% (Table 1). The population encounter rate was 0.42 individual / km and the group encounter rate was 0.03group/ km. Total male to female ratio was 1:1.46, adult male to female ratio was 1:1.53. All female to immature ratio was 1:0.18 and an adult female to immature ratio was 1:0.26.

The group sighting distance from line transects varied between 20-60 m. Maximum sighting occurred between 30 m to 50 m from mid-line of transect (Fig 2). Range of sighting distance and number of groups sighted was compared using 't' test and it was found significant ( $t = 6.04$ ,  $N=4$ ,  $p < 0.01$ ) that the distance at which the macaques species mostly visible was between 30-50 m. The macaques move away when they see a person in close proximity

Table 1. Group Composition of Assamese macaque in DTR

Groups	Male		Female		Immature YF/JUV	Total Individuals
	AM	SAM	AF	SAF		
Group 1	3	2	4	2	0	11
Group 2	4	2	6	3	0	15
Group 3	2	1	3	2	1	9
Group 4	5	1	8	1	6	21
Group 5	3	2	4	2	0	11
Group 6	4	2	7	3	2	18
Group 7	1	1	3	2	0	7
Group 8	4	2	6	2	2	16
Group 9	4	2	5	3	3	15
<b>Total</b>	<b>30</b>	<b>15</b>	<b>46</b>	<b>20</b>	<b>12</b>	<b>123</b>
Composition of age categories (mean $\pm$ sd)	3.33 ( $\pm 1.15$ )	1.66 ( $\pm 0.50$ )	5.11 ( $\pm 1.73$ )	2.22 ( $\pm 0.80$ )	1.55 ( $\pm 1.92$ )	13.66 ( $\pm 4.32$ )
SEM	0.40	0.17	0.59	0.22	0.67	1.50
Composition of sex categories (%)	36.59		53.66		9.76	100
Total Male-Female ratio						1:1.46
Adult Male-Female ratio						1:1.53
Adult female-Immature ratio						1:0.26
Total Female-immature ratio						1:0.18

Abbreviations: AM = adult male, AF = adult female, SAM = sub-adult male, SAF = sub-adult female, Immature= juveniles & infants.

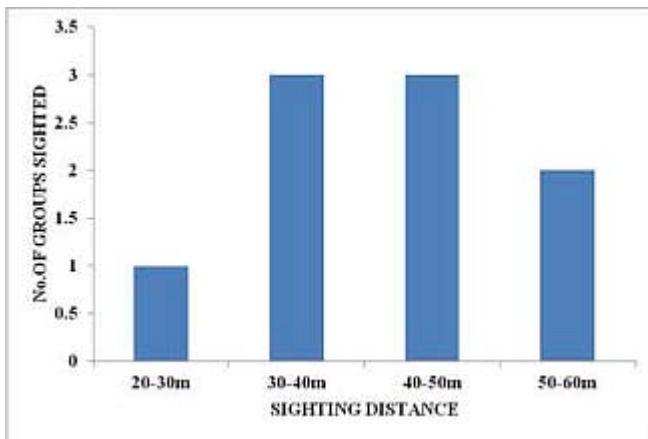


Figure 2. Group encountered distance of Assamese macaque in DTR

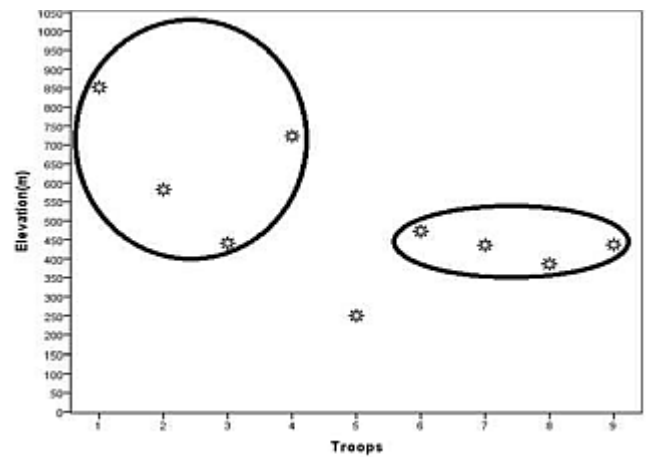


Figure 3. Distribution of group across different altitude levels in DTR

therefore no group was observed at the distance less than 20 m.

Assamese macaques were found to be distributed between 250 m and 856 m altitude in Teirei range of DTR (Fig. 3). They were occupying two altitudinal ranges. One altitudinal range was between > 470 to 863 m and other altitudinal range where population was found to dwell between 250 to <470m. No monkey was recorded below 250 m altitude (Table

2, Fig. 3). We further re-grouped the altitudinal height in 200 m range. Large number of population (66.7%) was distributed between the altitude ranges from 400 - 600 m (Table 3.)

**DISCUSSION**

Distribution of major population of Assamese macaques in Mizoram is restricted largely to Dampa

Table 2. Distribution of Assamese macaque at different altitudes and forest type in DTR

Group	Location	GPS Coordinates	Vegetation Type	Elevation (m asl)	Terrain Type
Troop 1	Dampa Tlang	N 23 40 42.1 E 92 25 22.4	Mixed woody tree species	856	Highly Undulating
Troop 2	Old Chikha Village road	N 23 39 23.8 E 92 22 04.2	Mixed woody tree species	582	Moderately Undulating
Troop 3	Dampa APC	N 23 41 59.7 E 92 25 33.5	Bamboo mixed forest	441	Low undulating
Troop 4	Pathlawi Tlang	N 23 41 49.6 E 92 24 17.9	Bamboo mixed forest	723	Highly Undulating
Troop 5	Near Teirei FRH	N 23 40 24.3 E 92 25 51.3	Bamboo mixed forest	250	Moderately Undulating
Troop 6	Tuilut APC to Malpui APC road	N 23 42 29.5 E 92 22 15.1	Bamboo mixed forest	473	Moderately Undulating
Troop 7	Tuilut to Bamboo hut road gate	N 23 41 19.2 E 92 22 20.4	Bamboo mixed forest	436	Low undulating
Troop 8	Tuichar Cave	N 23 40 20.2 E 92 25 09.8	Bamboo mixed forest	386	Highly Undulating
Troop 9	Upper hill side of Tuichar Cave	N 23 40 19.2 E 92 25 08.4	Primary Forest	437	Low undulating

Table 3. Distribution of Assamese macaque across altitudinal gradients at 200 m interval

Elevation level	200-400m	400-600m	600-800m
Number observed	27	78	32

Tiger Reserve; and randomly smaller group are also evident in other protected areas (Anonymous 2016). Presence of nine groups of Assamese macaques with a mean group size of 13.6 ( $\pm 4.32$ ) and ecological density 4.7 individuals/km<sup>2</sup> in DTR indicate that the suitability of habitat is still present in the Park. Group size and composition varies with type of habitat (protected /unprotected), environmental constraints, and degree of human interference (Machaires et al. 2003). Assamese macaque *M. assamensis* occurs from central Nepal, north-east India through the Himalaya to southernmost China and north and central South-east Asia (Fooden 1982). It has conventionally been seen as a highland species: Lekagul and McNeely (1977) called it an upland macaque, generally found in forested areas above 500 m to as high as 3,500 m. Fooden's (1982) comprehensive review found most records from 150–1,900 m, with some up to 2,750 m (extended to 3,100 m by Fooden 1986), and a single, disjunct, record from sea-level. A survey in Bhutan found Assamese macaques down to 600 m (Kawamoto et al. 2006, Choudhury 2008). Choudhury (2003) referred occurrences as low as 100 m in Arunachal Pradesh, India, and Timmins and Duckworth (2013) recorded occurrence of this primate species up to 200 m in Lao. Specifically in South-east Asia, records traced by Fooden (1982, 1986) were almost solely in mid- and high-elevation forest, with the lower hill records coming from South Asia. Distribution range of Assamese macaque varies from place to place and region to region (Paudel and Chalise 2018).

Distribution of Assamese macaque in Dampa Tiger Reserve (DTR) was found at the altitude range between 250 m to 856 m in high mountainous terrain of the protected area. Since DTR is also abode for other five folivorous primate (family Cercopithecidae) hence their presences restrict Assamese macaque occupying a wider range, segregate the niche, and partitioning the food resources. Justa et al. (2019) also reported in their

study on resource partitioning between sympatric macaque species in Western Himalaya, India that Assamese macaque has broader niche than rhesus macaque and niches are separated in several dimensions. On re-arranging the altitudinal occurrence of the groups of Assamese macaque, it was found that they were distributed at the altitude between 450-856 m and 386-450 m. This pattern of distribution is probably to avoid intra group competition for critical resources. Some individuals of this group were also recorded occasionally at lower altitude (250m) where they were found raiding agriculture crops at the periphery of the DTR (Solanki et al. 2016).

There are five more species of primate that share habitat in DTR, therefore, all have adopted different feeding strategies. Competition over food resources is likely to favour the evolution of contrasting feeding strategies in different species which share the same environment. Primates are more eclectic in their food choice and most species consume a wide range of food items. Even species occupying the same habitat may differ considerably, not only in the timing of feeding activity but also in the feeding height in the forest to obtain food (Justa et al. 2019). Differences may be in the type of food eaten (insects and other animals, gums, fruits, flowers, or foliage) or in the range of different food items in their diet (Solanki 2016).

Major factors affecting the distribution of the species are anthropogenic disturbances, direct and indirect. The disturbance could be due to hunting, forest degradation, and exploitation of forest resources in form of fuel wood, removal of minor forest produce such as honey, cane, tubers, fruits, flowers, and shoots of edible bamboo (*Dendrocalamus longispathus* and *Melocanna baccifera*). Shoots of these bamboos are often consumed by Assamese macaques. The inherent dependency of the local people on forest resources, particularly those settled in peripheral areas has been explained by Solanki et al. (2016) and Adhikari et al. (2018) in India and Nepal. Community hunting for flesh, traditional medicine and decorative materials by tribal people and habitat alterations in many other areas are the major threats to primate species including, the Assamese macaque (Johns 1986, Merker et al. 2005, Solanki et al. 2016). These

activities can seriously affect arboreal animals through the creation of canopy gaps, reduction of woody climbers, and breakage of canopy routes, which may lead to population fragmentation (Johns and Skorupa 1987, Marsh et al.1987, Rawson et al.2009).

Size and composition of primate group is an intimate expression of its functional ecology. These details differ from group to group (Naher et al. 2016), place to place, season to season (Coelho et al.1977, Eisenberg et al.1972), geographically (Chivers and Raemaeker 1980). Variation in size and composition also depend on habitat structure and food availability (Kumar and Solanki 2008). Troop size varied significantly ( $t=9.11$ ,  $n=8$ ,  $P<0.01$ ) however troops are largely consistent and stable in male-female ratio (Table 1).Adult male to female ratio (1:1.53) was found to be higher as compared to the Nepal population of Assamese macaque in a natural forest (1:0.67) in Shivpuri Nagarjun National Park (Chalise et al. 2013), and also in semi-provisioned population (1:1.75) in Nepal (Adhikari et al.2018). Higher male–female ratio of Assamese macaque in DTR indicate the suitability and sustainability of the habitat. All male to female ration (1:1.46) and adult female to infant ratio (1:0.28) are good indicator for growing population. The population structure denotes the status of the population and different age classes with young individuals in a population indicate a healthy and growing population (Shaw, 1995). However adult male to female ratio (1:2.82) and adult female to infant (1:0.35) in road side populations was recorded higher in Darjeeling, India (Murmu et al. 2004). Road side populations also reported to obtain food from agriculture field and partially provision feeding is done. Provisioned primate group have higher birth rate, shorter lactation period and shorter inter-birth interval as compared to un-provisioned groups (Borries et al. 2001). Number of males in a primate social group varies not only between different species (Yeager and Kool 2000) but also between the group of same species (Koeing and Borries 2012). More than 50% of the groups in this study were with four or more adult males that indicate that all potential female get access to male to mate. Therefore, the Assamese macaque population in DTR is natural and healthy; habitat can be considered suitable.

A comprehensive plan for conservation of this biologically viable population of Assamese macaques are required to support. Important conservation step required at this stage is effective implementation of Wildlife Protection Act (1972) in state of Mizoram. However effective implementation of legislation will also strengthen for protection of habitat and animal, food resources specially growing bamboo shoots which are extracted by local peoples need to be protected. Data base for food plants and dietary diversity also be prepared for better management plan for the species and protection of their natural habitat.

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**Authors' contributions:** Both the authors contributed equally

**Conflict of interest:** Authors declare no conflict of interest

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