
Chapter-VIII

Conclusion, recommendation and research scope

8.1. Conclusion and research scope

The present study has assessed different ecological aspect of *Macaca munzala* with respect to altitudinal gradient, habitat type and threats. Altitude and climate has significant influence in population distribution of *Macaca munzala*. High altitude environment is found to be an ecological niche of the species as predicted by the distribution modelling in the study. *M. munzala* are recorded from sub-tropical habitat at low altitude zone and high altitude habitat of broadleaved forest and mixed coniferous forest. However, highest population of the species was recorded from high altitude region of the study area during the population survey. The study has found that disturbance in plant community structure did not have significance influence in population occurrence of *M. munzala*. In accordance to this, the highest population of *M. munzala* was recorded from the degraded forest and human modified landscape. Thus, it indicates that population of *M. munzala* is tolerant to anthropogenic disturbance in their habitat. However, hunting is found to be a potential threat to *M. munzala* in protected area of western Arunachal Pradesh.

The study shown that *Macaca munzala* spent maximum percentage of time of its daily active period on feeding activity (33.27 ± 0.55) followed by resting (26.96 ± 0.56), moving (23.30 ± 0.64), grooming ($10.12\% \pm 0.20$) and others (6.46 ± 0.19). Seasonally, feeding ($F=68.50$, $df=2$, $p<0.05$), moving ($F=71.71$, $df=2$, $p<0.05$), resting ($F=153.45$, $df=2$, $p<0.05$) and grooming ($F=5.64$, $df=2$, $p<0.05$) activities were found to be significantly different among the troops.

The behavioural activity and ranging pattern of *M. munzala* is significantly influence by availability of quality food resources, habitat matrix and thermoregulatory cost. *M. munzala* covers mean daily path length (DPL) of 1.23 ± 0.10 km as recorded by the studied troops and home range varied from 106 ha to 149 ha which is actually influenced by the distribution of preferred food plants. Food plant distribution is a driving factor in home range demarcation of *M. munzala*. Seasonal variations in time spent on activities were varied profoundly, but variation on the basis of habitat was not significantly different. The result of the present study has shown that the distribution of preferred food plants is limiting the home range area and daily path length of *Macaca munzala* in the study area.

M. munzala are known as a folivore primate but they preferred to feed on fruit, when abundant. *M. munzala* have wide range of food plant species in diet contributing about 97.83% but highest contributions are found only from limited species. Animal matter contributed 2.17% in diet of *M. munzala*. The study established that *Macaca munzala* consider those food plant as their staple food which have higher nutritive value, protein content, carbohydrates and available feeding material throughout the year to feed on. The study also revealed that *M. munzala* avoids negative consequence of secondary metabolite, if the food material contains higher nutritive value. Thus, present study has shown “nutritive value” as a potential tool for explanation of food plant selection in *M. munzala*.

The “alarm call” of *M. munzala* is used as a signal to convey the disturbance, predatory threat and long distance communication purposes. The “alarm call” is distinct among the other vocalization in terms of loudness and used for alert in presence of potential threat. The spectral analysis determined that “alarm call” of *M. munzala* is low frequency call with “peaky” distribution.

The morphometry and colour variation study of *Macaca munzala* and *Macaca assamensis pelops* has shown evident of sympatric evolution between the species. The study has revealed that both the species independently shares similar morphological characteristics. The morphological characteristics in *M. munzala* vary with ages and it is difficult to enumerate distinct species specific characteristics. However, presence of longer cheek hair in older adult female and absence in older adult male are distinguishable morphological characteristics in *M. munzala*. Nevertheless, the similar morphological variation has been found in *M. a. pelops* but not prominent as that of *M. munzala*. The few variations between the species might be resulted due to change in altitude and climate. The relative tail length and body length variation between the species is supported by Allen’s rule i.e., increase of altitude decreases the appendages and body length. The coat colour and facial skin of *M. munzala* is found to be darker than *M. a. pelops* and this result has shown contradiction with Gloger rule i.e., darker pigmentation is occurred in colder environment rather than warm and humid area. Further, present study has suggested that solar radiation might be an important factor in term of colour appearance of primate. The photogrammetry and modified method of colour assessment has shown potential implementation in primate’s colouration study.

The present study advocated that HTML colour codes and RGB additive colour model need to be use for colour assessment study.

In overall, present study has shown that *Macaca munzala* is a habitat generalist primate with greater ecological adaptation in terms of disturbance in habitat and feeding behaviour. The natural habitat of the species is severely degraded due to anthropogenic activities such as, extensive firewood collection, timber extraction, agricultural activity and forest burning. The presence of hunting in the study area imposes greater threat for future survivability of the species in their distribution range. *M. munzala* has greater plasticity in feeding behaviour and capable to revision of food material according to degree of disturbance in habitat. The nutritional basis of food plant selection has found significance influence food plant material selection of *M. munzala*. *M. munzala* population composition, activity and feeding pattern, and ranging behaviour has similarity with sympatric Assamese macaque (*Macca assamensis*) than other geographically closer species.

8.2 Recommendations

Based on the present study following recommendation are forwarded:

1. Study on sympatric evolution of *Macaca munzala* on the basis of molecular genetic study

Arunachal macaque (*Macaca munzala*) and geographically closer Assamese macaque (*Macaca assamensis*) has significant similarity in terms of morphological characteristics. The recorded population distribution of *M. munzala* overlaps with *Macaca assamensis* distribution in Arunachal Pradesh. Thus, there is need of extensive study on genetic variation of *Macaca assamensis* by collecting samples from different altitudinal gradient of Arunachal Pradesh.

2. Colour variation based on altitude and solar radiation:

The study has found that altitude has significance influence in coat and facial skin colouration i.e., increase of altitude increases the darker pigmentation in sinica group of species. Thus, this phenomenon need to studied in other group of primate species for the confirmation. Moreover, solar radiation need to be include in the study as predictable factor.

3. Population survey and conservation status:

The predictive distribution modelling has shown that high altitude area of Arunachal Pradesh is suitable habitat of *M. munzala*. Subsequently, population survey of *M. munzala* has been conducted in high threshold area as depicted by distribution model in the present study. Therefore, remaining potential area of the species need to be surveyed to conclude the population and conservation status of this endangered species.

4. Time activity pattern, feeding ecology and ranging behaviour of *Macaca munzala* in subtropical habitat:

The present study has done extensive study on *M. munzala*'s behavioural pattern that inhabit in eastern Himalaya broadleaved forest, human dominated landscape and mixed coniferous forest. However, behavioural pattern of *M. munzala* in sub-tropical habitat is unknown. Thus, further study is required on behavioural aspect of *M. munzala* in sub-tropical habitat to understand the overall ecology of the species.

5. Self-medication in *Macaca munzala*:

The present study has observed that pregnant individual of *M. munzala* feed on particular food plant material, that are not usually consumed. However, present study could not conduct research on this aspect. A long term study is required to conduct self-medication behaviour of *M. munzala* followed by phytochemical screening to assess the medicinal quality of these materials.

6. Vocalization of *Macaca munzala*:

Present study has found that "alarm call" of *M. munzala* can be used for species identification, as it has distinct pattern of sound. Further, study has found that call has significance similarity with "alarm call" of *M. leucogenys* that described previously. Thus, there is need of further comparative assessment of acoustic characteristics of alarm call of *M. munzala*, *M. leucogenys* and *M. assamensis*.

7. Community based conservation:

The presence of higher anthropogenic disturbance in protected habitat is a serious concern for the conservation of the species. Thus, concerned government agency need to be functional on this regard. The study has found that community based conservation can act as an instrumental tool for conservation of wildlife in the study area. Thus, policy maker of the protected area is needed to include community participation and community based conservation as a tool for long term conservation of species in natural habitat.