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Mammalian fauna of Rajaji National Park, India: a review on ecological observations and checklist

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Abstract: Rajaji National Park, in the Gangetic Plains biogeographic zone, has a diverse and biogeographically important mammalian assemblage. In the recent past, several studies on the herbivores, large carnivores and mega-herbivores have been carried out, but limited work has been done on the distribution of mammals in the park. This study illustrates the ecological observations and review of the mammals of the Rajaji National Park, based on field surveys, carried out during 2006–2008, using direct and indirect sampling methods. A total of 44 mammal species, belonging to nine orders and 20 families were recorded, which included one insectivore, six chiropterans, two primates, one pholidotan, 16 carnivores, one proboscidean, six artiodactylians, one lagomorph and 10 rodents. Of these, seven are classified as Endangered/Vulnerable in the IUCN Red List of Threatened Species; however, three species are Near Threatened, a lower risk category.

Key words: Gangetic Plains; Shivalik landscape; northwest India; Rajaji National Park; mammals; checklist

INTRODUCTION

Of all the global faunal diversity (ca. 13 million described species), India has about 92,000 species, which is 7.5% of the world's faunal diversity (Zoological Survey of India 2011; IUCN 2015). In contrast, global mammalian fauna is represented by approximately 5,416 species, belonging to 1,229 genera, 153 families and 29 orders (Zoological Survey of India 2012). Nearly, 420 species of mammals, belonging to 191 genera and 48 families and 14 orders were reported from India, which is about 8% of the world's mammalian fauna (Zoological Survey of India 2012). As per the Red Data Book of the International Union for Conservation of Nature and Natural Resources (IUCN), 96 species are threatened in India (Hilton-Taylor et al. 2009). The Indian Wildlife (Protection) Act, 1972 includes 80 mammalian species in Schedule I, which are considered nationally threatened (Anonymous 2003).

The state of Uttarakhand is located in northern India and has 34,651 km^2 of forests, which constitute 64.79% of the state's geographical area. Protected forests constitute 28.52% of the total forested area (Forest Survey of India 2011). Most of the state is in Himalayan biogeographic zone and the West Himalayan province is a stronghold for nearly 23% (93 species) of Indian mammals. However, information on the mammals of Uttarakhand is very scarce and scattered in published and unpublished sources, including the working plans of the State Forest Departments, environmental impact assessment reports and scientific tour reports (Sati and Tak 2010).

Rajaji National Park (RNP), which lies in the upper Gangetic Plains province, has a rich mammalian assemblage. This can be attributed to a wide altitudinal range and presence of the Ganges River that flows through the park. The Shivalik landscape is categorized as part of the Indo-Gangetic Plains biogeographic zone and has special significance in India's biogeography due to intermingling of taxa from the Indo-Malayan and Palaearctic regions (Sivakumar et al. 2010). A considerable number of mammals, both strictly Oriental and partly Holarctic, inhabiting Peninsular India and the Gangetic Plains are found in the Terai, the foothills and the forest slopes of the Himalayas (Pocock 1939).

The status of mammals in RNP is poorly known and thorough surveys are needed to better understand species' distributions and population trends. Large mammal populations in the RNP is threatened mainly by habitat fragmentation, anthropogenic activities and disconnectivity of migration corridors. In a study by the Zoological Survey of India (ZSI) during 1981–1987, 49 species of mammals were recorded from RNP (Sinha 1995). This study was the first consolidated account on the distribution of mammals in RNP. However, geographic distribution of mammals within the park

and the individual site records were not recorded. There is a need for scientifically sound evidence-based surveys. Since 1995, no systematic review has been done in the area, and after a gap of nearly two decades, this present study updates the checklist of mammals in the RNP.

RNP constitutes an important repository of the mammalian fauna of Uttarakhand state and perhaps is the last refuge for a number of threatened mammal species in the lesser Himalayan zone and upper Gangetic tract. Therefore, the future survival of the mammals in this area largely depends on effective management and conservation approaches in the park.

MATERIALS AND METHODS

Study area

RNP (Figure 1) is located in northwest India at 29°51′ N to 30°15′ N, 077°52′ E to 078°22′ E, and is at elevations from 250–1,100 m and is 820.21 km^2. It falls within the Gangetic Plains biogeographic zone and upper Gangetic Plains province (Rodgers et al. 2002) and major portion of the area is dominated by tropical moist deciduous forest. RNP was established in 1983 with the aim of maintaining a viable population of the Asian Elephants and is designated as a reserved area for 'Project Elephant' by the Ministry of Environment, Forest and Climate Change, Government of India. The dominant vegetation is *Shorea robusta* Gaertner f. (Sal), *Mallotus phillipinensis* (Lam.) Mull. Arg. (Kamala), *Acacia catechu* (L.f.) Willd. (Cutch), *Haldina cordifolia* (Roxb.) Ridsdale (Kadam), *Terminalia bellirica* (Gaertn.) Roxb. (Bahera), *Ficus benghalensis* L. (Indian Banayan) and *Dalbergia sissoo* Roxb. ex DC (Indian Rosewood).

Data collection

The mammalian fauna of RNP was surveyed in Haridwar, Motichur, Chilla and Gohri forests for 432 days (12 field visits per month, three each in every site), from January 2006 to December 2008. The line transect method (direct observations) was used to record the presence of species. These transects were traversed either on foot, or where roads permitted access, by vehicle (keeping an average speed of 20 km/h). For each transect surveyed on foot, a distance of ca. 2 km was covered. For each transect made by vehicle, the distance covered varied from 2–5 km, depending on the length of the roads. Transects were selected based on topographical features of various habitats (mixed forests, *Shorea robusta* forests, *Mallotus phillipinensis* forests and *Ficus* species dominant forests. Some transects crossed potential riparian corridors of Ganges and perennial/annual rivers (<500 m), or higher ridges (>500 m), and in some parts, adjoined agriculture fields and human habitations.

Surveys were made during January 2006 to December 2008 with the assistance of experienced staff, villagers and local guides, who knew the terrain and wildlife

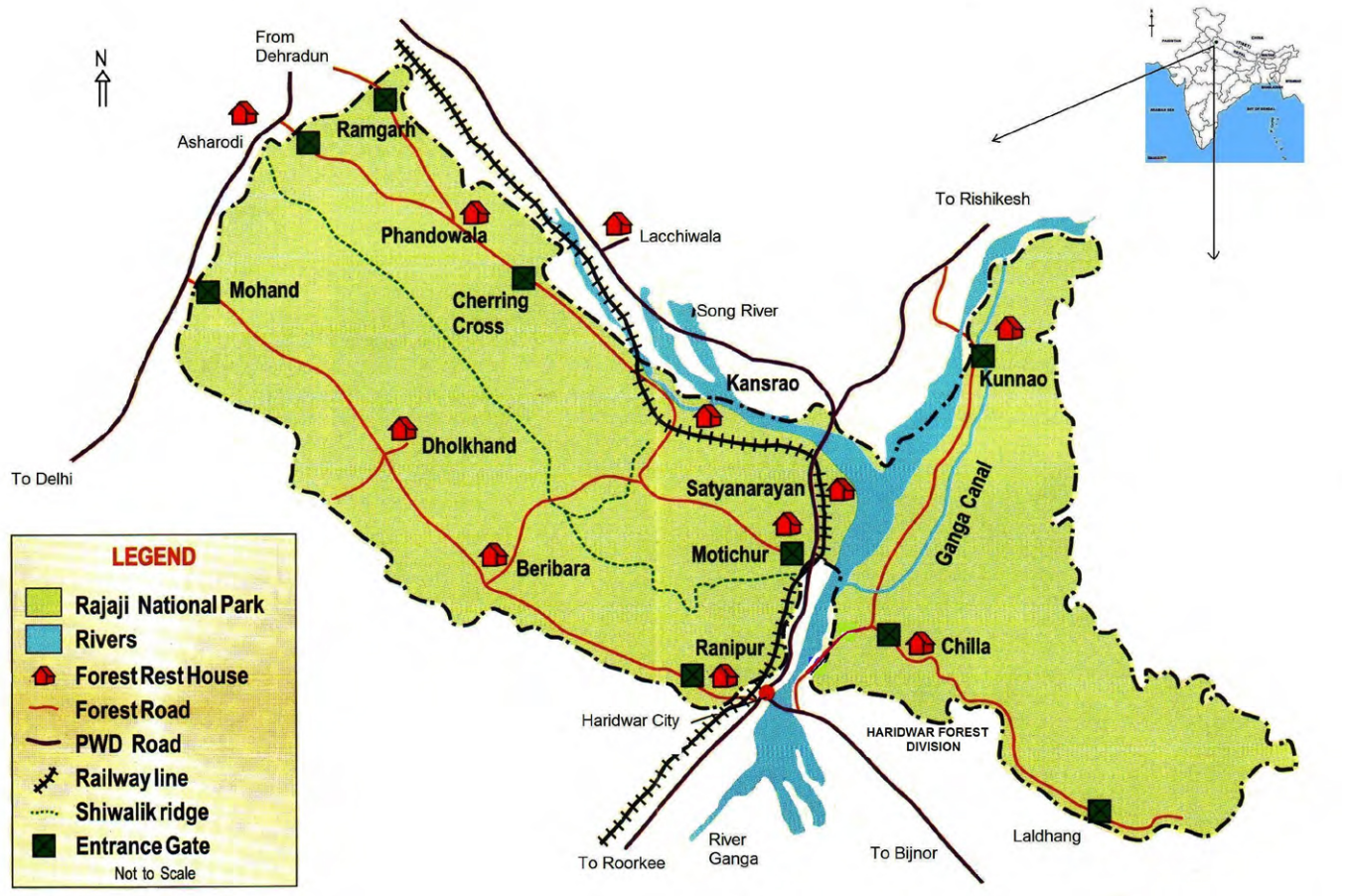

Figure 1. Location map of the Rajaji National Park in India.

well. Indirect evidence (i.e. tracks, feeding signs, scat, and remains of body parts such as carcasses, hair and quills) were also recorded. Because most carnivores are nocturnal, their tracks were recorded during the early morning. As mammals are most active during early morning and evening (near dawn and dusk), all field surveys were undertaken between 05:30–09:30 h and 15:00–19:30 h in summer and 06:00–11:00 h and 14:00–18:00 h in winter.

Prior information on the mammals of the park was gathered from the records and literature available in different forest range offices of the RNP, various scientific institutions, like Wildlife Institute of India, Forest Research Institute, etc. and scientific journals. Information was also obtained from the park managers, field staff, local communities, including Gujjars (a nomadic pastoral community).

For identification and classification of species, books on Indian mammals were consulted (Pocock 1939; Prater 1971; Menon 2003; Alfred et al. 2006). Field binoculars (Nikon Action Series, 10 × 50 CF) were used to observe the animals and a Nikon Coolpix 8700 camera was used to produce photographic evidence. Geographical coordinates were recorded using a handheld GPS receiver (Garmin GPS 72).

RESULTS

A total of 44 mammal species, belonging to nine orders and 20 families were recorded. Seven of these are categorized in the IUCN Red List as Endangered or Vulnerable (IUCN 2013). Three species are categorized as Near Threatened. Most observations were made from the Gohri and Chilla forests (37 and 33 species, respectively), followed by Haridwar and Motichur forests, (27 and 23 species) (Table 1; Figures 2 and 3). Of all species recorded, 21 (48%) were observed from all the four sites, but 23 (52%) were recorded from some specific sites. The mammalian order with most species recorded was Carnivora with 16 species, belonging to six families, followed by Rodentia with 10 species, belonging to three families. The results also indicate that large-scale habitat fragmentation, corridor discontinuity and anthropogenic activities are threats to long-term persistence of mammals by impeding natural activities.

DISCUSSION

A single-species approach to conservation, management, and monitoring is insufficient to combat the threat to the overall biological diversity of an area; multi-species-based monitoring approaches are believed to be more reliable, timely, and informative in

Table 1. Mammals recorded from the Haridwar, Motichur, Chilla and Gohri forests of the RNP, their status in IUCN Red List and Indian Wildlife Protection (Prevention) Act, 1972 Schedule, evidence of record and species' occurrence in different forests, during January 2006 to December 2008.

Taxa	IUCN Red List Status[1]	Wildlife Protection Act, 1972 Schedule[2]/ status	Evidence	Species' occurrence			
				Haridwar	Motichur	Chilla	Gohri
INSECTIVORA							
Soricidae							
Suncus murinus (Linnaeus, 1766), Grey Musk Shrew/ Asian House Shrew	LC	Schedule V	Sighting	+	-	-	+
CHIROPTERA							
Pteropodidae							
Pteropus giganteus (Brunnich, 1782), Indian Flying Fox	LC	Schedule V	Sighting	+	+	+	+
Rousettus leschenaultii (Desmarest, 1820), Fulvous Fruit-Bat	LC	Schedule V	Sighting	-	-	+	+
Cynopterus sphinx (Vahl, 1797), Short-nosed Fruit Bat	LC	Schedule V	Sighting	+	-	-	-
Rhinolophidae							
Hipposideros cineraceus Blyth, 1853, Least Leaf-nosed Bat	LC	-	Sighting	-	-	-	+
Vespertilionidae							
Myotis formosus (Hodgson, 1835), Hodgson's Bat	LC	-	Sighting	+	-	-	+
Pipistrellus coromandra (Gray, 1838), Indian Pipistrelle	LC	-	Sighting	+	+	+	+
PRIMATES							
Cercopithecidae							
Macaca mulatta (Zimmermann, 1780), Rhesus Macaque	LC	Schedule II	Sighting	+	+	+	+
Semnopithecus entellus (Dufresne, 1797), Common Langur/Northern Plains Gray Langur	LC	Schedule II	Sighting	+	+	+	+
PHOLIDOTA							
Manidae							
Manis crassicaudata E. Geoffroy Saint-Hilaire, 1803, Indian Pangolin	EN	Schedule I	Sighting	-	+	-	-
CARNIVORA							
Canidae							
Canis aureus Linnaeus, 1758, Asiatic Jackal	LC	Schedule II	Sighting	+	+	+	+
Vulpes bengalensis (Shaw, 1800), Indian Fox	LC	Schedule II	Sighting	-	-	-	+

Continued

Table 1. *Continued.*

Taxa	IUCN Red List Status[1]	Wildlife Protection Act, 1972 Schedule[2]/ status	Evidence	Species' occurrence			
				Haridwar	Motichur	Chilla	Gohri
Ursidae							
Melursus ursinus (Shaw, 1791), Sloth Bear	VU	Schedule I	Sighting tracks	-	-	+	+
Ursus thibetanus Cuvier, 1823, Himalayan Black Bear	VU	Schedule II	Informed by locals (tracks/feeding signs recorded)	-	-	+	+
Mustelidae							
Martes flavigula (Boddaert, 1785), Himalayan Yellow-throated Marten	LC	Schedule II	Sighting	+	+	+	+
Lutrogale perspicillata (I. Geoffroy Saint-Hilaire, 1826), Smooth-coated Otter	VU	Schedule II	Sighting	-	-	+	-
Viverridae							
Viverricula indica (E. Geoffroy Saint-Hilaire, 1803), Small Indian Civet	LC	Schedule II	Sighting	+	+	+	+
Paradoxurus hermaphroditus (Pallas, 1777), Common Palm Civet	LC	Schedule II	Carcass sighted	-	-	+	+
Paguma larvata (C.E.H. Smith, 1827), Himalayan Palm Civet	LC	Schedule II	Carcass sighted	-	-	-	+
Herpestes javanicus auropunctatus (Hodgson, 1836), Small Indian Mongoose	LC	Schedule II	Sighting	+	+	+	+
Herpestes edwardsii (E. Geoffroy Saint-Hilaire, 1818), Common Mongoose/Indian Grey Mongoose	LC	Schedule II	Sighting	-	-	+	+
Hyaenidae							
Hyaena hyaena (Linnaeus, 1758), Striped Hyaena	NT	Schedule III	Sighting	-	-	+	-
Felidae							
Felis chaus Schreber, 1777, Jungle Cat	LC	Schedule II	Sighting	-	-	+	+
Prionailurus bengalensis (Kerr, 1792), Leopard Cat	LC	Schedule I	Carcass sighted	-	-	+	-
Panthera pardus (Linnaeus, 1758), Leopard	NT	Schedule I	Sighting	+	+	+	+
Panthera tigris (Linnaeus, 1758), Tiger	EN	Schedule I	Sighting/tracks recorded	-	+	+	+
PROBOSCIDEA							
Elephantidae							
Elephas maximus Linnaeus, 1758, Asian Elephant	EN	Schedule I	Sighting	+	+	+	+
ARTIODACTYLA							
Suidae							
Sus scrofa Linnaeus, 1758, Wild Boar	LC	Schedule III	Sighting	+	+	+	+
Cervidae							
Axis axis (Erxleben, 1777), Indian Spotted Deer/Chital	LC	Schedule III	Sighting	+	+	+	+
Rusa unicolor (Kerr, 1792), Sambar Deer	VU	Schedule III	Sighting	+	+	+	+
Muntiacus muntjak (Zimmermann, 1780), Barking Deer	LC	Schedule III	Sighting	+	+	+	+
Bovidae							
Naemorhedus goral (Hardwicke, 1825), Himalayan Goral	NT	Schedule III	Sighting/informed by locals	-	-	+	-
Boselaphus tragocamelus (Pallas, 1766), Nilgai	LC	Schedule III	Sighting	+	+	+	+
LAGOMORPHA							
Leporidae							
Lepus nigricollis Cuvier, 1823, Indian Hare	LC	Schedule IV	Sighting	+	+	+	+
RODENTIA							
Sciuridae							
Funambulus pennantii Wroughton, 1905, Northern Palm Squirrel	LC	Schedule IV	Sighting	+	+	+	+
Petaurista petaurista (Pallas, 1766), Common Giant Flying Squirrel	LC	Schedule II	Carcass sighted	-	-	-	+
Hystricidae							
Hystrix indica Kerr, 1792, Indian Crested Porcupine	LC	Schedule IV	Sighting/spines recorded	+	+	+	+
Muridae							
Bandicota bengalensis (Gray, 1835), Indian Mole Rat	LC	Schedule V	Sighted	+	+	+	+
Tetera indica (Hardwicke, 1807), Indian Gerbil/Antelope Rat	LC	Schedule V	Sighted	+	-	+	-
Nesokia indica (Gray, 1830), Short-tailed Bandicoot Rat	LC	Schedule V	Sighted	+	-	-	-
Golunda ellioti Gray, 1837, Indian Bush Rat	LC	Schedule V	Sighted	-	-	-	+
Mus booduga (Gray, 1837), Common Indian Field Mouse	LC	Schedule V	Sighted	-	-	-	+
Mus musculus Linnaeus, 1758, House Mouse	LC	Schedule V	Sighted	+	+	+	+
Rattus rattus (Linnaeus, 1758), *House Rat*	LC	Schedule V	Sighted	+	+	+	+

[1]Based on IUCN (2013): EN: Endangered, NT: near threatened, VU: Vulnerable, LC: Least Concern, DD: Data Deficient.
[2]Based on the Indian Wildlife (Protection) Act, 1972; Amended 1991 and 2002 (Source: Ministry of Environment, Forest and Climate Change, Government of India, http://www.moef.nic.in/legis/wildlife).

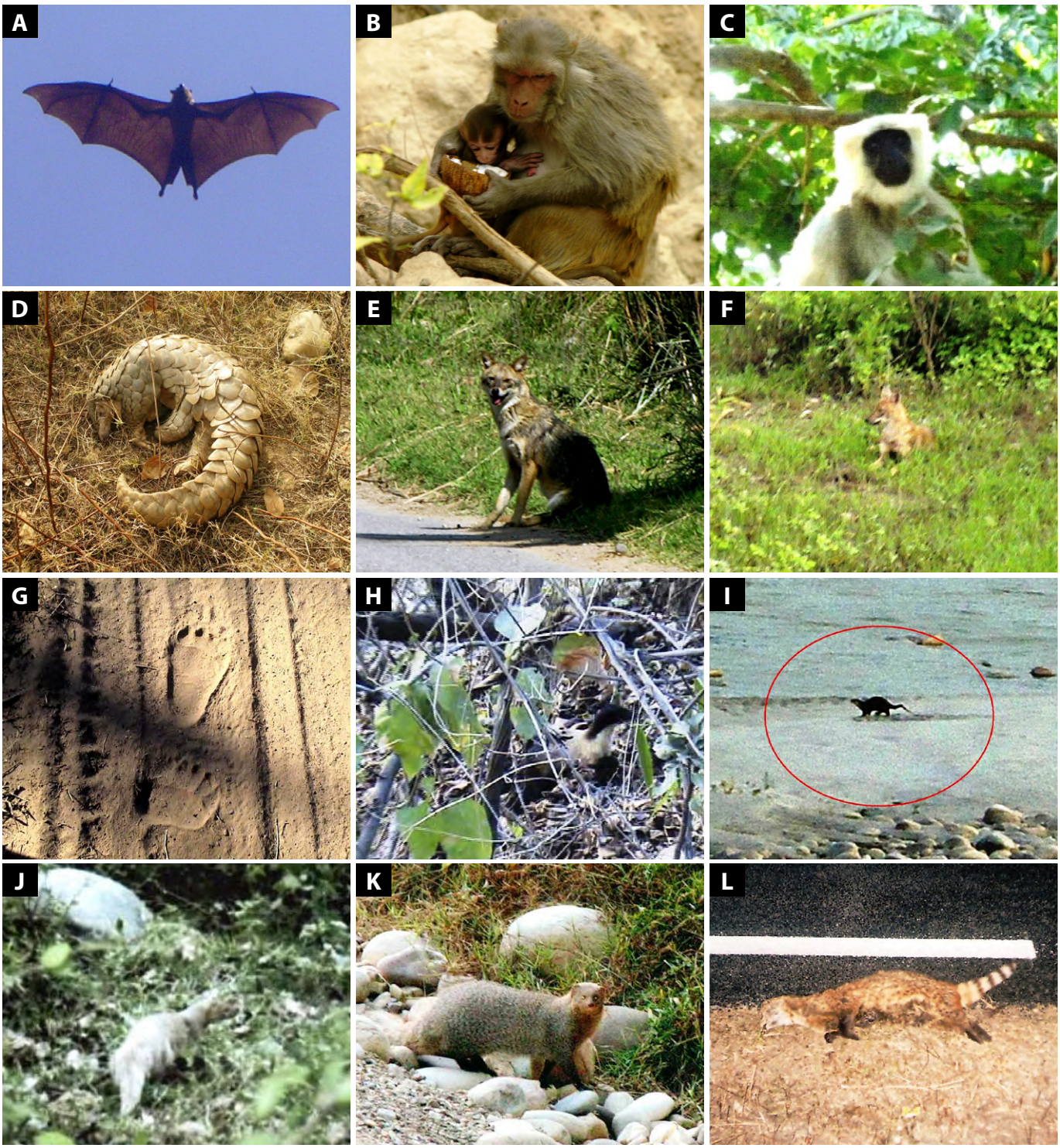

Figure 2. Photographic records of some mammals observed directly and indirectly in Haridwar, Motichur, Chilla and Gohri forest ranges of the RNP during January 2006 to December 2008. **A:** *Pteropus giganteus*; **B:** *Macaca mulatta*; **C:** *Semnopithecus entellus*; **D:** *Manis crassicaudata*; **E:** *Canis aureus*; **F:** *Vulpes bengalensis*; **G:** Footprints of *Melursus ursinus*; **H:** *Martes flavigula*; **I:** *Lutrogale perspicillata*; **J:** *Herpestes javanicus auropunctatus*; **K:** *Herpestes edwardsii*; **L:** *Viverricula indica*. Photos by Ritesh Joshi.

measuring changes in populations, communities and biological diversity (Manley et al. 2005). Despite the fact that RNP is biologically rich, little has been done on the distribution and status of species in the park. In contrast, several studies were conducted on the ecology of Asian elephants and tigers in the area (Johnsingh and Williams 1999; Johnsingh and Negi 2003; Johnsingh 2006a; Joshi and Singh 2007; Harihar et al. 2009; Joshi and Singh 2010; Harihar et al. 2011; Joshi 2015). Because some parts of the RNP are still unexplored, the altitudinal distributions of some species, except some large carnivores and elephants, are not well known.

Among Insectivora, only one species *Suncus murinus* (Linnaeus, 1766) (Grey Musk Shrew) was observed

Figure 3. Photographic records of some mammals observed directly and indirectly in Haridwar, Motichur, Chilla and Gohri forest ranges of the RNP during January 2006 to December 2008. **A:** *Paradoxurus hermaphrodites*; **B:** *Hyaena hyaena*; **C:** *Panthera pardus*; **D:** *Panthera tigris*; **E:** *Elephas maximus*; **F:** *Sus scrofa*; **G:** *Axis axis*; **I:** *Rusa unicolor*; **J:** *Muntiacus muntjak*; **K:** *Boselaphus tragocamelus*; **L:** *Lepus nigricollis*; **M:** *Funambulus pennantii*. Photos by Ritesh Joshi.

from the boundary of the Haridwar forest. Six species of bats (subclass Chiroptera) were observed at all four. Most bats were recorded from riparian corridors and a few abandoned field stations that provided rooting sites in the forest. *Pteropus giganteus* (Brunnich, 1782) (Indian Flying Fox) occurs throughout the park and the largest colony (>400 individuals) was observed from a small patch of *Mangifera indica* trees (Mango) in the Chilla forest. However, a few other larger colonies (>250 individuals) were also recorded from Haridwar, Motichur and Gohri forests. Most sightings of chiropterans occurred in early summer. In a study carried out on the chiroptera fauna in Himachal Pradesh (Saikia et al. 2011), 28 species, belonging to 14 genera and 5 families were recorded. Himachal Pradesh is adjacent to Uttarakhand, and shares similar topographical features in some part.

Therefore, there is a scope to study the order in the area and to cross-check it with the study carried out in the State Himachal Pradesh.

The two primate species in the park were present at all four sites, though the population of *Macaca mulatta* (Zimmermann, 1780) (Rhesus Macaque) were observed higher than of *Semnopithecus entellus* (Dufresne, 1797) (Common Langur). Remarkably, a small population of the Rhesus Macaque was observed, residing in the periphery of different shrines, situated inside the protected areas, near the human habitations and near roads. Among the order Pholidota, only one species *Manis crassicaudata* E. Geoffroy, 1803 (Indian Pangolin) was recorded from Motichur forest.

The order Carnivora had the most species, with 15 species observed from all four sites. *Panthera tigris* (Linnaeus, 1758) (Tiger), *Melursus ursinus* (Shaw, 1791) (Sloth Bear), *Paradoxurus hermaphroditus* (Pallas, 1777) (Common Palm Civet) and *Felis chaus* Schreber, 1777 (Jungle Cat) were recorded from Chilla and Gohri forests, respectively, whereas *Panthera pardus* (Linnaeus, 1758) (Leopard), *Canis aureus* Linnaeus, 1758 (Asiatic Jackal), *Viverricula indica* (E. Geoffroy Saint-Hilaire, 1803) (Small Indian Civet), *Martes flavigula* (Boddaert, 1785) (Himalayan Yellow-throated Marten) and *Herpestes javanicus auropunctatus* (Hodgson, 1836) (Small Indian Mongoose) were recorded from all the four sites. Noticeably, *Prionailurus bengalensis* (Kerr, 1792) (Leopard Cat) (carcass sighted), *Hyaena hyaena* (Linnaeus, 1758) (Striped Hyaena), *Herpestes edwardsii* (E. Geoffroy Saint-Hilaire, 1818) (Common Mongoose) and *Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826) (Smooth-coated Otter) were found only in Chilla forest.

Movement of *Melursus ursinus* (Sloth Bear) was observed frequently throughout the year in the core zones of the Chilla and Gohri forests, whereas the movement of *Ursus thibetanus* G. Cuvier, 1823 (Himalayan Black Bear) in the Chilla and Gohri forests was observed mostly in winter. This might be due to migration to lower elevations in cold periods. In summer, Himalayan Black Bears were generally found near timber line (elevations ranging from 3,050–3,660 m), and in winter most of them come down to the lower valleys (ca. 1,525 m) (Prater 1971). Because Himalayan Black Bear is a winter migratory species in RNP and Sloth Bear is resident species, there is a scope to study the ecology of both the species.

Vulpes bengalensis (Shaw, 1800) (Indian Fox), which is endemic to the Indian subcontinent, was sighted only once, in the Binj River that flows through the Gohri forest (2 June 2007, 15:40 h, 30°01′54.8″ N, 078°16′28.2″ E). Discussions held with forest officials and locals indicated that this species was not sighted recently by others. Because of its similarity to the Asiatic Jackal, there are no reliable observations by local people. Ecological studies are needed on the distribution, abundance and population trend of Indian Foxes in this area. The Indian Fox population is declining mainly because of conversion of short grassland-scrub habitats to agricultural fields, as well as industrialization and development projects. There are no available estimates at the rate of its decline (Johnsingh and Jhala 2004). Joshi and Kumar (1970) had also pointed out that the sighting of Indian Fox was rare in the Shivalik Circle.

Among Viverridae, *Viverricula indica* (Small Indian Civet) was documented from all four sites, whereas carcasses of *Paradoxurus hermaphroditus* (Common Palm Civet) and *Paguma larvata* (C.E.H. Smith, 1827) (Himalayan Palm Civet) were observed only from Chilla and Gohri forests, respectively. In 2007, two individuals of *Lutrogale perspicillata* (Smooth-coated Otter) were sighted in the Ganges River that flows across the Chilla forest (Joshi 2014). More studies are needed to better understand its distribution, potential habitats and status within the Gangetic ecosystem.

From the family Hyaenidae, a small population of *Hyaena hyaena* (Striped Hyaena) (ca. 10 individuals) was observed only from the Chilla forest, though its range is expanding in adjoining habitats as well (in parts of Haridwar forest division). A total of seven dens of Striped Hyaena (two abandoned) were recorded in the areas, which were close to riparian corridors. Harihar et al. (2010) recorded six to eight individuals of Striped Hyena in the Chilla forest.

Among Felidae, sightings of *Felis chaus* (Jungle Cat) and *Prionailurus bengalensis* (Leopard Cat) were rare, whereas *Panthera pardus* (Leopard) was common and at all sites. Abundance of *Panthera tigris* (Tiger) was recorded from Motichur, Chilla and Gohri forests. Though there were reports of Tiger present in the entire southwestern part of RNP (in Beribara and Dholkhand forests), this species is disappearing rapidly from the western part, where it apparently occurred until a decade ago (Johnsingh and Negi 2003; Johnsingh 2006a; Harihar et al. 2009; Harihar et al. 2011).

Elephas maximus Linnaeus, 1758 (Asian Elephant) is the only mega-herbivore. This species was common in all four sites; however, a large population was recorded from the Chilla and Gohri forests. Because Chilla forest is well connected with the Haridwar and Lansdowne Forest Divisions, large groups were observed mainly at the onset of winter and summer, when elephants were migrating in between the parts of RNP and the Corbett Tiger Reserve. Habitat fragmentation, disconnectivity of large migratory corridors and man–elephant conflict has brought this giant animal at risk. Large groups of elephants were observed in the Haridwar forest during 2000–2002, but these groups have gradually become fragmented, as compared to others in the park, mainly

due to rapid development around the edge of the park. Large-scale habitat loss, developmental activities and human encroachment into the deeper forest regime have escalated the instances of man–elephant conflict in northwest India, which also leads to the unnatural deaths of tuskers (Joshi and Singh 2007; Joshi and Singh 2010).

Six species of Artiodactyla were recorded, which includes three deer species and two antelope species. Among the Cervidae, *Axis axis* (Erxleben, 1777) (Spotted Deer), *Rusa unicolor* (Kerr, 1792) (Sambar) and *Muntiacus muntjak* (Zimmermann, 1780) (Barking Deer) were found commonly distributed in all four sites. Among the family Bovidae, *Boselaphus tragocamelus* (Pallas, 1766) (Nilgai) was recorded from all four sites, and *Naemorhedus goral* (Hardwicke, 1825) (Himalayan Goral) was sighted only once in the Chilla forest (Pulani forest, 7 February 2006, 16:00 h, 29°54′01″ N, 078°21′29″ E). Nilgai were only occasionally observed in Chilla, Gohri and Motichur forests but large numbers were encountered in Haridwar forest. *Sus scrofa* Linnaeus, 1758 (Wild Boar) (Suidae) was common at all four sites.

Lepus nigricollis F. Cuvier, 1823 (Indian Hare) was the only lagomorph recorded but was sighted at all four sites, especially in open forests and grasslands. Among Rodentia, 10 species were sighted. Among Sciuridae and Hystricidae, *Hystrix indica* Kerr, 1792 (Indian Crested Porcupine) (Hystricidae) and *Funambulus pennantii* Wroughton, 1905 (Northern Palm Squirrel) (Sciuridae) were found to be commonly distributed in all sites, but, the Indian Crested Porcupine was observed more frequently in Haridwar forest. The sighting of *Petaurista petaurista* (Pallas, 1766) (Common Giant Flying Squirrel) (Sciuridae) was rare. A carcass of *Petaurista petaurista* was recorded from the Gohri forest, which authenticated its presence in higher elevations of the park (29°58′38″ N, 078°19′93″ E; 986 m).

Among Muridae, seven species were observed from all four sites. Most species were observed from forests adjacent to agricultural fields and human settlements. *Tetera indica* (Hardwicke, 1807) (Indian Gerbil) and *Golunda ellioti* Gray, 1837 (Indian Bush Rat) were recorded from Chilla and Haridwar forests, respectively. *Bandicota bengalensis* (Gray, 1835) (Indian Mole Rat), *Mus musculus* Linnaeus, 1758 (House Mouse) and *Rattus rattus* (Linnaeus, 1758) (House Rat) were observed around human habitation, situated across Motichur River in Motichur forest. *Golunda ellioti* (Indian Bush Rat) and *Mus booduga* (Gray, 1837) (Common Indian Field Mouse) were observed in the Gohri forest in the villages along the Ganges River. Sightings of few species of family Muridae were common in Gujjars' shelters, when residing inside the park. However, after the relocation of the Gujjars outside the park, sightings of these rodents became rare, even in abandoned Gujjar shelters. Agricultural fields also provide habitat suitability to these rodents, in peripheral areas where people were found cultivating crops.

Previous records

The value of historical distribution data has been widely recognized for aiding the reconstruction of animal assemblages for a region, over a certain time period, and for understanding the structure, function and processes of ecosystems by ecologists and conservation biologists (Meine 1999; Boshoff and Kerley 2001; Kerley et al. 2003; Morrison 2005; Boshoff and Kerley 2010). Few of the mammal species were earlier recorded in RNP and adjacent areas, which were extinct from the park or were pocketed in a few forests. Osmaston and Sale (1989) recorded the abundance of only a few populations of *Axis porcinus* (Zimmermann, 1780) (Hog Deer) in RNP. Joshi and Kumar (1970) had also recorded the existence of hog deer in Haridwar forest of RNP, before the establishment of the Bharat Heavy Electricals Limited in 1970s. Similarly, the presence of *Tetracerus quadricornis* (de Blainville, 1816) (Four-horned Antelope) in Dholkhand forest of RNP had also recorded (Joshi and Kumar 1970). Besides, the presence of *Cuon alpinus* (Pallas, 1811) (Indian Wild Dog or Dhole) in Dholkhand forest of the RNP and Malowala forest (an adjacent area) in year 1967 had also been recorded (Joshi and Kumar 1970).

The presence of *Naemorhedus goral*, *Vulpes bengalensis*, *Hyaena hyaena*, *Prionailurus bengalensis*, *Felis chaus*, *Canis lupus pallipes* Sykes, 1831 (Indian Wolf), *Cuon alpinus* and *Melursus ursinus* were made in the management plan of Rajaji Sanctuary (now southwestern part of RNP) for the period 1978–1979 to 1982–1983 (Khan 1978). If these species are taken into account, it is evident that the Indian wolf and wild dog were extinct some two to three decades ago from the park, and there were no recent records of sightings of striped hyaena, sloth bear, Indian fox and leopard cat in southwestern part of the park except of goral's sighting (Roy et al. 1995; Johnsingh 2006b). Management plan of the RNP for the period 2000–2001 to 2009–2010 mentioned about the occurrence of 25 mammals, which includes wild dog and hog deer (Pandey 2001), which were extinct nearly four to five decades before.

In the current management plan of RNP for the period 2012–2013 to 2021–2022, a total of 49 mammalian species were cited (Rasaily 2012). However, references to two locally extinct species (Wild Dog and Hog Deer) were made, confining the total number to 47. Notably, all the species considered in this plan were the same as reported by ZSI (Sinha 1995). Four species namely, *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) (Rusty-spotted Cat), *Ursus thibetanus*, *Paguma larvata* and *Petaurista petaurista* were included in the plan.

However, four species, which were reported by ZSI, namely *Hemiechinus collaris* (Gray, 1830) (Indian Long-eared Hedgehog), *Harpiola grisea* (Peters, 1872) (Peter's Tube-nosed Bat), *Vulpes bengalensis* and *Mus booduga* were not mentioned in the plan.

Conservation threats

Habitat fragmentation and disconnectivity of large migratory corridors were observed as major threat impeding the frequent movement of wild animals within their home range. The crucial four wildlife corridors, namely Motichur-Chilla, Motichur-Gohri, Motichur-Kansrao-Barkot and Rawasan-Sonanadi, which exist across RNP and connect this protected area with Corbett Tiger Reserve have been disrupted severely, mainly because of the expansion of human settlements, industrialization, national highways/motor roads and agriculture lands and increasing traffic in Haridwar-Dehradun railway track. Nandy et al. (2007) carried out the assessment of Chilla-Motichur wildlife corridor, using temporal satellite imagery from years 1972, 1990 and 2005, which exposed that an area of 17.56 km^2 has been lost during 1972–2005 mainly because of various developmental activities. Another study, carried out during 2009–2011, exposed that 352 individuals of 39 animal species were killed on Haridwar-Bijnor and Haridwar-Dehradun national highways and on an ancillary road (Haridwar-Chilla-Rishikesh) existing across RNP (Joshi and Dixit 2012). Noticeably, 23 elephants were also reported killed in collision with trains on Haridwar-Dehradun railway track since 1987.

Anthropogenic activities were recorded affecting the activities of the animals. More than 20 villages are situated along the southwestern boundary of RNP, 20 villages along the eastern fringe and nearly 15 villages are situated along the northern axis of the park. Most of the villagers were found dependent on the forest resources for their livelihood, which primarily includes collection of fuelwood and fodder. Spreading of invasive species like *Lantana camara* L. (lantana) and *Parthenium hysterophorus* L.(ragweed parthenium) and native weeds like *Justicia adhatoda* L. (Syn. *Adhatoda vasica* (L.) Nees (Malabar nut), *Cannabis sativa* L. (Indian hemp) and *Senna tora* (L.) Roxb. (Syn. *Cassia tora* L. (wild Senna) was also recorded affecting the regeneration of various species of grasses. Spreading of these invasive species was found occurring mainly because of cattle's grazing across the boundary of the park. Besides, annual rivers were also noted as cause of spreading of these species. Exotic weeds like *Lantana camara* and *Parthenium hysterophorus* and native weeds like *Adhatoda vasica*, *Cannabis sativa* and *Cassia tora* are problems throughout the Rajaji-Corbett Tiger Conservation Unit, which reduces the suitability of the habitat for ungulates (Johnsingh and Negi 2003).

Poaching, although, uncommon in the park area, was observed occasionally. Non-participation of local communities in conservation initiatives was found another dilemma, which was establishing communication gap among protected area managers and local communities. Electrification of habitats has also been a conservation threat in the area. Nearly three high voltage power transmission lines are crossing through different forests of the RNP.

Conclusion

Mammal survey in protected areas has a very strong bias towards larger and more conspicuous forms. RNP has a diverse and biogeographically important mammalian assemblage, mainly because of myriad types of habitats. Despite ample knowledge on ecological aspects of some large mammals, our knowledge on the occurrence of many species, especially of order Insectivora, Chiroptera and Rodentia is limited. Additional studies on abundance/distribution and status of faunal species and involvement of local communities and all stakeholders in reframing of the conservation guidelines and policies would be of paramount importance in securing long-term persistence of mammalian fauna in the area. Scientific studies on various invasive plant species should be carried out to prepare a plan for their eradication. Villages, which are situated within the crucial corridor area, and the Gujjars, who are still residing in Haridwar Forest Division, should be rehabilitated outside the protected area. Wildlife census should be conducted every year on seasonal basis. In addition to studies on insectivores, chiropterans and rodents, scientific studies are needed to be conducted, especially on species, whose populations are declining, like striped hyaena, Indian fox, Indian pangolin and leopard cat. In the recent past, several studies have been carried out on the herbivores, large carnivores and mega-herbivores, but limited work has been carried out on the distribution of mammals in the park. Moreover, in some parts, the diverseness of forests still remains unexplored and for some groups, like Chiroptera and Rodentia, our existing knowledge and systematic records are limited. Because RNP is a stronghold of mammalian assemblage, scientific based conservation approaches would be of paramount importance. Moreover, local community and stakeholder's participation and habitat's monitoring would be an effective management and conservation strategy.

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