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Developing Conservation Strategies for Rare, Endangered and Threatened Species of Sahyadri Tiger Reserve, Northern Western Ghats, Maharashtra

Technical Report



Submitted to:
Kolhapur Forest Division

By
IUCN India
In collaboration with A.V.C. College (Autonomous)

February 2018

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Executive Summary

A short-term field study, to identify Rare, Endangered and Threatened species of Mammals (Medium and large sized) and Herpetofauna in the Sahyadri Tiger Reserve, located in the northern Western Ghats, in Maharashtra, was conducted between November 2016 and June 2017. This intensive field study was aimed in providing robust scientific information for the Sahyadri Tiger Reserve, on the mammals and herpetofauna found in this landscape as information on this aspect remains negligible.

The objectives of the study included a comprehensive listing of mammals and herpetofauna species for the Sahyadri Tiger Reserve, providing inputs and reassessing the status of Rare Endangered and Threatened species of mammals and herpetofauna reported from the Sahyadri Tiger Reserve and lastly on providing recommendations for developing conservation plans for priority RET species of Sahyadri Tiger Reserve.

Systematic surveys were conducted beat wise throughout the reserve for both Mammals and Herpetofauna. Mammal diversity was documented using the line transect protocol (Burnham, Anderson, & Laake, 2012; Thomas et al. 2012) for direct sighting and sign surveys were done to document species that are elusive (Wilson et al., 1996; Society, 2016). Camera trap data as well as line transect data was also collected from the forest department in order to substantiate and cross verify our results. Visual Encounter surveys (Heyer et al. 1994), systematic quadrat surveys (5 m²) (Krebs, 1998) as well as opportunistic sighting method (Grismer 2006) were used to sample for herpetofauna. A weighted scoring system based on the IUCN Red List criteria (IUCN, 2017) and on the endemism of each species was used to prioritise species under them as Rare, Endangered and Threatened (RET).

This study, established the presence of 16 mammal species (medium and large sized) within STR. Out of the total 16, 12 qualified as RET and this highlights the biological significance of the landscape. Apart from these 12 identified during this study, the tiger and the brown palm civet was also added to the list from the supplementary data by the department bringing the list to 14 RET mammals in STR. The tiger, Indian pangolin, wild dog, four-horned antelope and south-western langur received a higher priority among the RET classified species for mammals. The herpetofauna survey in the present study has identified 66 species with four species listed in the threat category of IUCN Red List (IUCN, 2017). Out of 66 species of herpetofauna 14 species have qualified as “RET” list and includes 7 species of amphibia and 7 species of reptiles.

There was no significant difference in diversity of RET species of mammals among the different ranges in the STR, and thus management practices for the conservation of RET species cannot focus on only particular areas. Density estimates for Gaur (4.4 ± 1.92), Giant squirrel (7.1 ± 3.44) and Sambar (1.6 ± 0.69) from STR computed from the current study showed that these were comparatively low when compared with other Protected Areas in the Western Ghats. Encounter rates of RET species was higher in the core ranges as compared to the buffer ranges reflecting the level of protection and management efforts.

Four-horned antelope had a significant positive relationship with grassland, while gaur signs had a significantly positive relationship with plateaus, Karvi patches as well as grasslands. Similar to the langur, the giant squirrel also an arboreal species had signs with a significant positive relationship with tall evergreen and medium-tall evergreen forests. Mouse deer signs had a significantly positive relationship with medium evergreen forests and sloth bear signs had a significantly positive relationship with tall evergreen forests. On the other hand, the presence of cattle within the reserve has a negative influence on the gaur and the south western langur.

In case of herpetofauna, the survey identified 66 species of herpetofauna belonging to 44 genera, 21 families with four species listed in the threat category of as IUCN Red List (IUCN, 2017). Of the 66 species, amphibian (22 species), lizard (20 species) and snakes (24 species) consisting each almost one-third of the total numbers. It is important to note that the STR landscape is home for four IUCN Red Listed amphibian species, which includes one critically endangered species (*Pseudophilautus amboli*), two endangered species (*Xanthophryne koynayensis* & *Uperodon marmorata*) and a vulnerable species (*Nyctibatrachus humayuni*). Of the total of 66 species of herpetofauna 27 species recorded as endemic to Western Ghats and seven species endemic to northern Western Ghats. Among the 14 RET species identified by the current study, amphibians accounted the highest number of species (7 species) followed lizard (4 species), snake (2 species) and turtle (1 species). Not surprisingly the study again showed that the presence of diverse micro-habitats played a crucial role in the distribution and species richness of herpetofauna species.

The study has illustrated that the Sahyadri landscape shelters a number of RET species and recommends detailed long-term species specific studies for better conservation and management. It is argued that the presence of ferrel and domestic cattle could be detriment for the long-term conservation of habitats and mammal diversity of STR. Similarly, human dependency on forest resources especially from the peripheral villages needs to be minimized in the Evergreen, Semi-Evergreen, Deciduous and Grassy Lands as the habitat quality in these landscapes play an important role, in the survival and persistence of a diverse herpetofaunal assemblage.

1. INTRODUCTION

The Western Ghats is a unique global biodiversity hotspot, home to a rich diversity of tropical flora and fauna. The region however is facing an ever-increasing threat from habitat degradation and habitat loss, due to local factors such as land use change, spread of invasive plant species, pollution, as well as climate disruption (Brilliant et al. 2012). A central approach to addressing these threats and enabling long-term conservation of biodiversity is establishing Protected Areas (PAs) (nature reserves, National Parks and Wildlife Sanctuaries). These PAs are geographical spaces where resource regulations are put in place to limit human impacts and conserve nature. Increasingly, PAs are expected to serve dual goals: protect biodiversity and secure ecosystem services and nature (Xu et al. 2016). With proper management, these National Parks and Wildlife Sanctuaries could not only protect but also be able to increase the populations of species dependant on its these habitats.

The Sahyadri Tiger Reserve (hereafter referred as STR), was recently declared as a tiger reserve in 2010. Identified as the only tiger reserve in the northern Western Ghats, the reserve is envisaged to provide safe refuge for tigers, their prey and as well as other fauna and flora that make STR their home. STR has been identified as a vital inviolate area and connects tiger habitats in the south like the Ratnagiri WLS. While efforts are being augmented to improve the landscapes overall management by improving the prey base for big cats like tigers, and minimize biotic interference, it has also been widely recognized that biodiversity inventories for all taxa in the region, has been inadequate and needs to be addressed especially given that fact that the site is part of UNESCO's World Heritage Site.

Of a total 384 species of amphibians and 539 reptile species over 50% are endemic to the Western Ghats (Venugopal, 2010; Palot et al. 2011; Dinesh et al. 2010, 2013 & 2015); Gururaja 2012; Subramanian et al.2013; Srinivasalu et al. 2014; Sharma 2007). There has been a significant increase in the description of new species of herpetofauna from the Western Ghats (Giri et al. 2004; Bauer and Giri 2004; Giri and Bauer 2008; Giri et al. 2009; Padhye et al. 2014; Mirza et al. 2014; Padhye et al. 2015; Sayyed et al. 2016; Gower et al. 2016; Gower et al. 2017; Garg et al. 2017; Garg & Biju 2017; Padhye et al. 2017), especially since 2004 and illustrates that our understanding of herpetofaunal distribution and their taxonomic status are still evolving and brings to the front the need for systematic and scientifically robust inventory of species in newly designated PAs. Detailed species inventories also help the PA management in prioritizing species for long-term conservation in particular the "Rare, Endangered and Threatened" species (Talukdar et al. 1994) and support in promoting actions on the conservation aspects for species.

It is argued that in comparison to other PAs in the Western Ghats, the STR landscape has received much less research attention and the few studies that have been undertaken lack a holistic approach to long-term conservation of species. Equally acknowledged is the fact that the remote nature of the Sahyadri hill range and lack of road networks has meant that species inventory is still in its nascent stage and that detailed inventories of all taxa is needed and of utmost importance to the landscape. The Forest Department reorganizing this gap in scientific knowledge has been encouraging species inventory related research in this landscape. This has also been identified in the Tiger Conservation Plan for this landscape as priority research actions that would support the managers in the interest of conservation and management. In this regard, it is noted that there has been an increase in the number of NGOs and Universities who are undertaking studies on certain taxa specific species inventories and their distributional status.

The current study, led by IUCN India, in close collaboration with STR officials have identified Rare, Endangered and Threatened (hereafter referred as RET) species of mammals (medium and large mammals) and herpetofauna species inventories. The study also provided inputs in developing conservation and management strategies for specific species to ensure long-term species conservation for these priority species.

2. BACKGROUND AND LITERATURE REVIEW

2.1 Historical listing of mammalian species with probable distribution in STR

The state of Maharashtra is home to over 129 species/subspecies of mammals (Annon, 2012). This list goes down to 45 species when small mammals, bats and aquatic mammals are excluded (but includes porcupine and giant squirrel) (Blanford, 1888; Gazetteer of India, 1974; Annon, 2012). This is provided in Appendix I. Among these enlisted species, only a few are not reported from the forest landscapes in the Western Ghats region viz. northern plains langur (*Symnopethicus entellus*), Caracal (*Caracal caracal*), blackbuck (*Antelope cervicapra*), Indian gazelle (*Gazella bennettii*), Nilgai (*Boselaphus tragocamelus*), and Water buffalo (*Bubalus bubalis*). Zoological Survey of India has documented 40 species from the Western Ghats region or the Sahyadri's within the state, of which nine species are endemic to the country. Unlike the flora and herpetofauna, the northern Western Ghats that encompass the STR landscape do not support many mammals that are endemic. Limited studies have been carried out on the mammalian diversity in the region, and in reference to the Sahyadri Tiger Reserve, Lawate and Mule (2009) has documented 34 species of mammals, while Abdar (2013) has documented 23 species in Chandoli National Park. Similarly when documenting diversity for the Satara district, Sayyed (2016) reported species such as hyaena, fox and wolf in Koyna and Vasota, which were not reported by the state forest department or any other publications in the recent years.

STR though having an ideal habitat, has no records of elephants since recent past, although the state forest department reported sporadic movement of elephants in the regions south of the reserve viz. Radhanagari, which is contiguous to elephant habitats in the state of Karnataka. Similarly, apart from local knowledge, there has been no record of the existence of spotted deer within the reserve. Among other commonly found species in the state, the blackbuck, honey badger and nilgai too have not been recorded from the reserve, but there may have been historic records. The slender loris also another endemic species to the Western Ghats, which is elusive but can most easily be identified by its call, has been recorded in regions south of the reserve without any record within the STR.

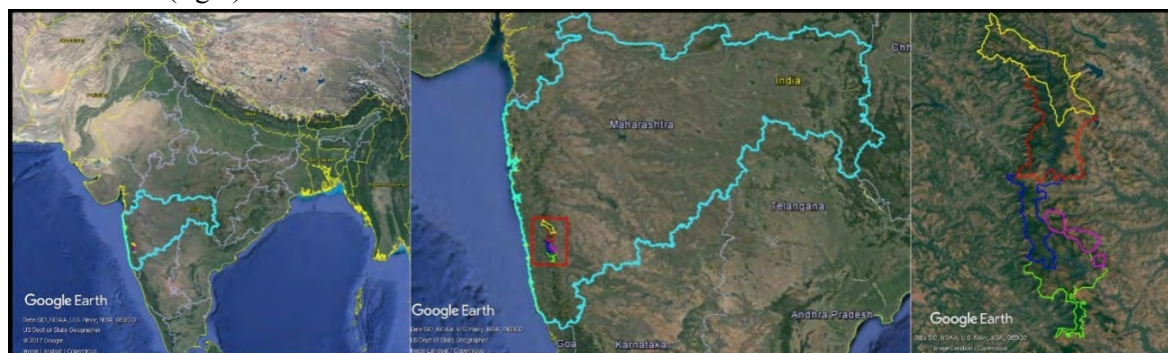
2.2 Historical listing of Herpetofauna with probable distribution in STR

The literature review shows reports of 102 species, including 40 amphibians and 62 reptiles from STR and adjoining areas (Ghate and Pathye 2012; Nande and Deshmukh 2007; Bansode et al. 2016; Nitin et al. 2012; Yadev et al. 2015; Yadev and Yankanchi 2013; Chikane & Bhosale 2012; Abdar 2014; and Sayyed 2016). It is also important to that several new species have been discovered from the landscape and includes *Indotyphlus maharashtraensis* (Giri et al. 2004); *Cyrtodactylus deccanensis* and *C. albofasciatus* (Bauer and Giri 2004); *Hemidactylus sataraensis* (Giri and Bauer 2008); *Cnemaspis kolhapurensis* (Giri et al. 2009); *Indirana chiravasi* (Padhye et al. 2014); *Cnemaspis girii* (Mirza et al. 2014); *Hydrophylax bahuvisthara* (Padhye et al 2015); *Sarada darwini*, *S. superb*, *Sitana spinaecephalus* (Deepak et al., 2016), *Cnemaspis flaviventralis* (Sayyed et al. 2016), *Melanophidium khaierei* (Gower et al., 2016), *Fejervarya cepfi* (Garg & Biju 2017), *Sphaerotheca pashchima* (Padhye et al. 2017) and *Rhabdops aquaticus* (Giri et al., 2017). Appendix II provides the list of herpetofauna reported from the STR landscape.

3. STUDY AREA & OBJECTIVES

STR is located between 16.5°–18°N and 73.5°–74°E, and is the only Tiger Reserve in northern Western Ghats (Figure 1). STR is spread across 4 districts of Maharashtra, viz. Kolhapur, Sangli, Satara and Ratnagiri. The tiger reserve is comprised of the Chandoli National Park (317.67 km²) and the Koyna Wildlife Sanctuary (423.55 km²), which form the core regions of the Reserve. The 63.48 km² forests, viz. Waghane and Rasati beats, of the Patan Territorial Division that connects these two core areas are part of the buffer region along with an additional 196 km² to the east and 107.3 km² to the north. Among the inclusion as buffer areas, a narrow strip of 35.28 km² forests from the Amba Territorial Forest Division to the south was added to the reserve and identified as a corridor for the movement of wildlife along the Sahyadri into Radhanagari and eventually into reserves in Karnataka and Goa. The entire STR stretches over 1165.5 km², comprising of five forest ranges namely Chandoli, Helwak, Dhebewadi, Koyna, and Bamnoli (Figure 2), and these five ranges are further subdivided into 71 beats for administrative purpose.

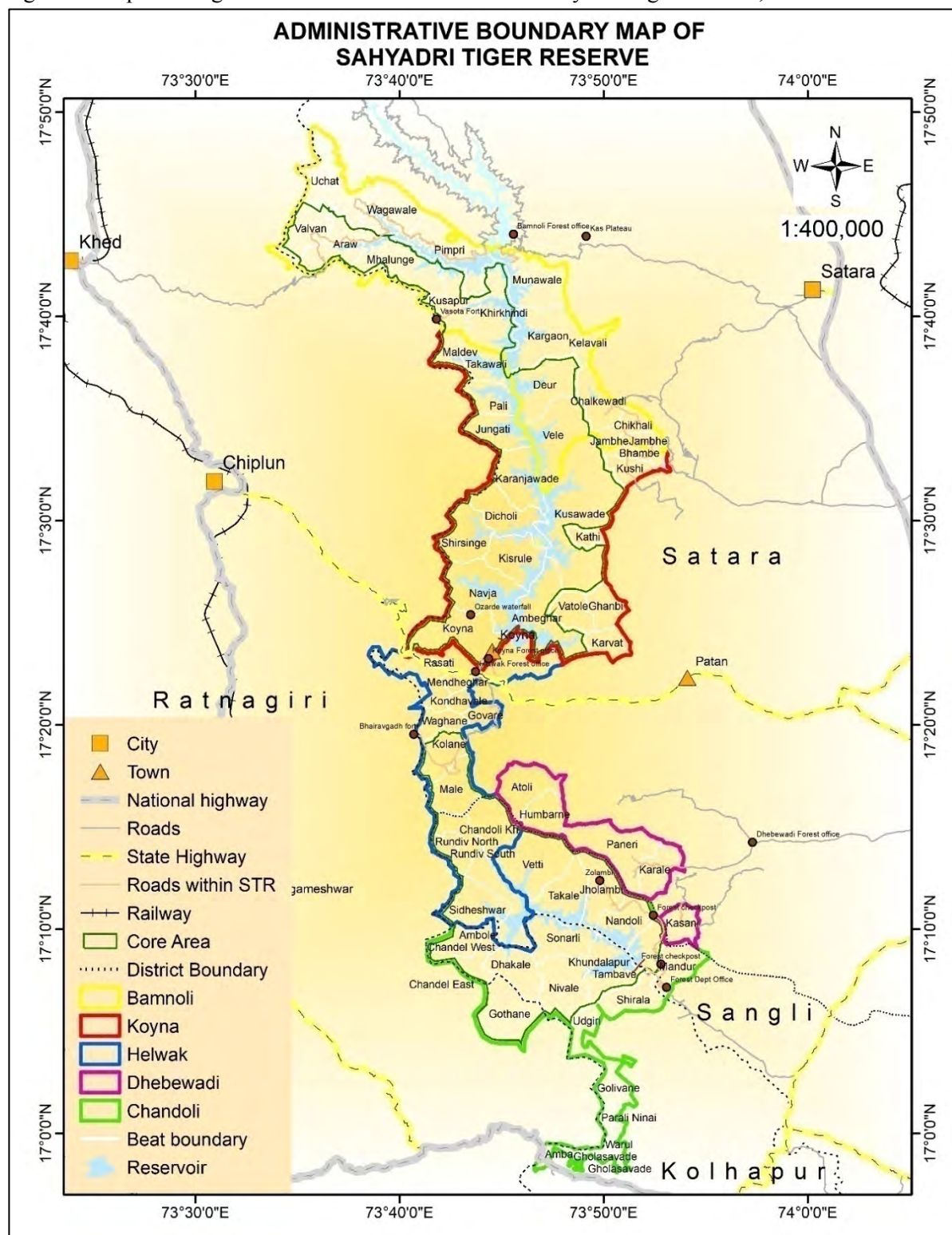
Figure 1: Map showing study area Sahyadri Tiger Reserve in (left) India, (centre) state of Maharashtra and (right) northern Western Ghats



India belongs to the Oriental Zoogeographical region, and comprises of 10 biogeographic zones, which are further sub-classified into 26 Biotic Provinces, for systematic biodiversity conservation planning (Rogers and Panwar, 1988). STR falls within the 5B Western Ghats Province that is formed from the high rising border of the Deccan Plateau (Rogers and Panwar, 1988), and is the most conspicuous physiographic feature of Peninsular India. Thus, the tiger reserve is popular for its rugged terrain and interspersed plateaus, which experiences an elevation range from 544 to 1222 m.

Along the western side, the reserve is cut off from the Konkan region of Maharashtra by the steep crest line, which is characteristic of the Sahyadri landscape and is believed to make the reserve almost inaccessible from this side. The Shivsagar Reservoir, which supplies water to the hydroelectric project, is almost entirely surrounded by the Koyna Wildlife Sanctuary. The Vasantsagar Reservoir (32 tmc), which facilitates irrigation water to 289 villages in Sangli, Satara and Kolhapur districts (*Warna Major Irrigation Project JI00462*), through the Warna dam, is confined within the Chandoli National Park. Thus, the entire tiger reserve act as an important catchment area to these two reservoirs. As an ecosystem benefit, preserving these habitats hold significance not only in preserving its biodiversity and preventing erosion, but also in providing safe drinking water and sustaining the agricultural livelihoods for several lakhs farmers in the four districts of Maharashtra.

Figure 2: Map showing the administrative boundaries of Sahyadri Tiger Reserve, Maharashtra



During the hot season, between early March and late May, there is a considerable difference in temperatures among various habitats owing to their vegetation cover, where the plateau regions experience extreme heat. Although the southern part of Maharashtra is less cool than the northern part of the state in the winter, the Sahyadri is significantly colder than the adjoining regions in the Konkan and Deccan, owing to its high elevation. Unlike the southern Western Ghats, the northern Western Ghats experiences longer dry periods of up to 6-8 months, however, the region receives between 5000 to 6000 mm of rainfall annually (TCP 2013), most of it between early June and late September, which is the highest recorded in the state (Annon 2012).

The underlying rock in this landscape is the igneous trap – basalt and the superficial rock is laterite in general. The plateaus locally referred to as ‘Sadas’ are classified as high-level ferricretes (sedimentary rock), which are laterite plateaus located between 800 to 1400 m elevation (Watve, 2013). The soil is gravelly, red clay or reddish – brown. Bauxite is the main ore found in the region, and in 2012, a bauxite mine operating in Udgiri was shut down due to its proximity to the reserve. Besides this, many small-scale bauxite mines can be found on plateaus in Chandoli, which were used prior to the declaration of the protected area.

Vegetation communities as described in Joglekar et al. (2015), comprise of medium elevation wet evergreen and southern tropical semi-evergreen, in undisturbed areas, along with mixed evergreen, moist deciduous and scrub-type while highly disturbed patches have thorny vegetation in Chandoli National Park (Figure 3). Kanade et al. (2008) have documented evergreen, semi-evergreen, moist deciduous and scrub in Koyna Wildlife Sanctuary. Champion and Seth (1968), suggest the overall vegetation type in the reserve as southern tropical evergreen, southern moist mixed deciduous, grasslands and scrub. Anjani (*Memecylon umbellatum*), Jamun (*Syzygium cumini*), Katak (*Bridelia retusa*), Kinjal (*Terminalia paniculata*), Phanasi (*Carallia chiata*), Ain (*Terminalia alata*), Amla (*Phyllanthus acidus*), Umbar (*Ficus hispida*), Harra (*Terminalia chebula*) are some of the dominant tree species found in this area. Common grasses include Bangala (*Andropogon* sp.), Dongari (*Crysopogon fulvus*), Kalikusli (*Heetropogon contortus*), Karad (*Themeda quadrivalvis*), Saphet-kusli (*Aristida afuniculata*) as well as the bamboo species Kalak (*Bambusa bambos*). Besides these, the plateau regions experience extreme climatic changes annually and these account for unique micro habitats which have recorded an ephemeral floral diversity of up to 47 species, some being of monotypic genera (Kanade et al. 2008; Watve, 2013).

Presence of hunting on a large scale has been prominent in the history of the state, targeting all large carnivores, large herbivores (Gazetteer of India, 1974). The lack of adequate corridor connectivity to the landscape and fragmentation have been identified to adversely affect the natural habitats (Imam et al. 2009). Koyna is the only major town located within the Reserve, Satara and Karad are the closest cities, while Kolhapur and Pune lie within 100 km from the reserve on the eastern side. The Karad–Chiplun state highway, bisects the reserve between Chandoli and Koyna, and falls within the buffer region. The Mumbai-Bangalore National highway runs parallel to the reserve on the eastern side and multiple roads connect the reserve to the highway. The reserve can be accessed from the western side by only three roads, namely the Ghat-mata (which is the Chiplun–Karad highway), the Raghuveer Ghats (the road between Valvan in Bamnoli and Khed) and Ambaghat (which is at the southern most extreme of the newly attached corridor of the Amba

territorial). There are multiple roads within the buffer, which connect each village in the buffer and 3 motorable roads that continue toward the villages. There is a fair intensity of vehicular movement along the roads in the buffer, but the roads that run through the core areas are strictly monitored.

3.1 Objectives

The following were the stated objectives of the study;

1. A comprehensive species inventory of mammals and herpetofauna of STR,
2. Identify and reassess the status of RET species of mammals and herpetofauna proposed STR,
3. Provide suggestions for developing conservation plans for prioritised RET species in STR.

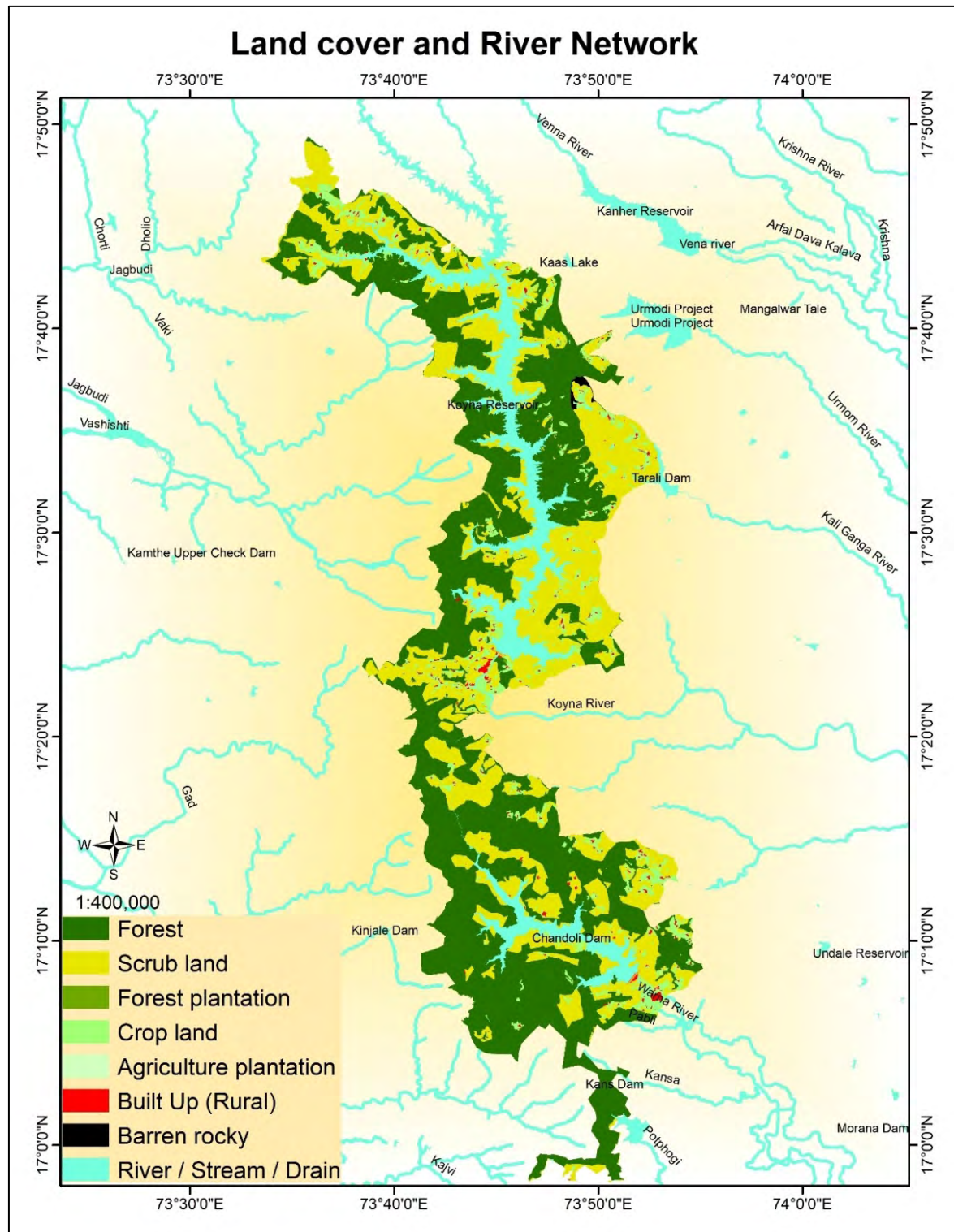
3.2 Study Period

The study was carried out for a period of eight months between November 2016 and July 2017, consists of two phases viz. (I) Reconnaissance survey (carried out between November and December 2016) and (ii) Intensive survey (between January and July 2017).

3.3 Reconnaissance Survey

In order for the project field team to familiarize with the landscape, vegetation/habitats types, as well as field conditions and logistics, the first 40 days of the project (November and December of 2016) was used for the reconnaissance survey. This period also helped in field testing of the appropriateness of various sampling methods. Based on the learnings from this period, and in consultation with senior STR officials, it was decided to treat the Forest Ranges and Beats (administrative units for the reserve), as our sampling blocks. Such a sampling strategy helped the study in developing species distributional maps for each range, which would directly enable implications of management and conservation planning for the RET species.

Figure 3: Map showing the land cover and land use pattern of Sahyadri Tiger Reserve and its adjoining area



4 METHODOLOGY

4.1 Mammals

4.1.1 Documentation of mammalian species in study area

A comprehensive inventory of mammalian fauna (herbivores, large carnivores, arboreal and small mammals) requires the use of a range of standard sampling protocols like line transects direct sighting method (Marques et al., 2001; Plumptre, 2000; Varman & Sukumar, 1995), conducting indirect sign surveys (Johnsingh & Negi, 2003; Wilson et al. 1996) and capture-recapture by camera trapping (Chanchani et al., 2014; Karanth et al. 2004). Both the line transect and sign surveys require greater efforts and are time consuming however they are inexpensive as compared to camera trapping, which requires the use of expensive automated trigger cameras. Given the required outcomes, as well as limitations on funding and logistics, the line transect direct sighting and sign survey methods were the optimal methods used by this study. The study benefitted from the camera trap data shared by the FD.

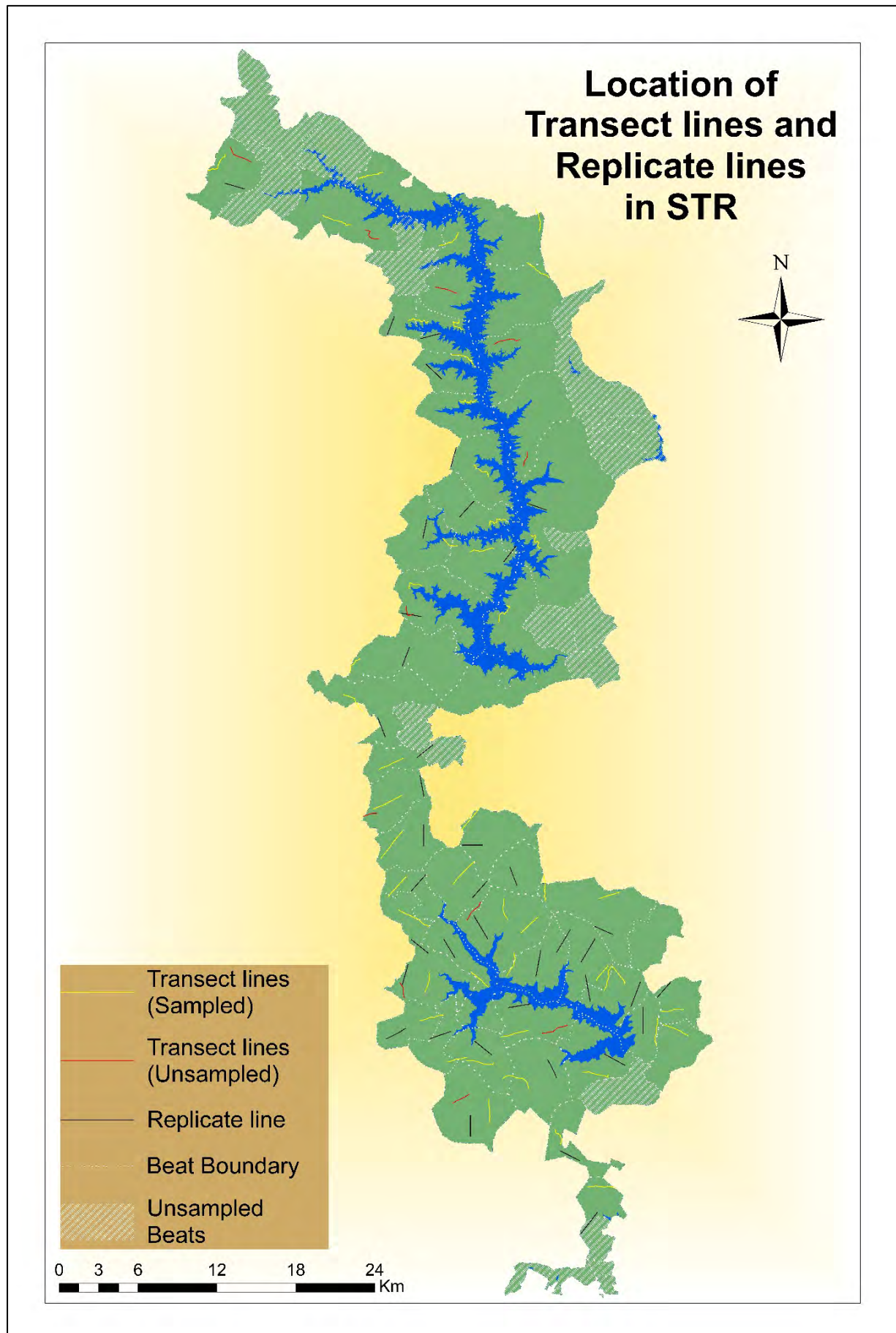
4.1.1.1 Line transect (Direct sighting)

Line transects are used to assess the density of species by direct sightings, where an observer travels along a series of straight lines, called transects, while recording the number of target objects (species) and the perpendicular distance of each target from the transect line (Burnham, Anderson, & Laake, 2012; Thomas et al., 2012). Line transects are considered the most reliable method to understand population status of mammal species, which are more common and easy to encounter when they are active.

As the study aimed to support the long-term management of the PA, we used transect lines already laid down by the forest department. These transects were established treating the beat, which is an administrative unit, ranging from 8-12 km² in size, as the base. Each beat, depending on its size, has one or two line transects, in which the project team walked a minimum of one transect. Transects in Chandoli and Helwak range were walked for 2 mornings, while the transects at Koyna, Bamnoli and Dhebewadi were sampled only for one morning. Since the study was covered from the onset of winter in January and continued through peak summer in May and monsoon in June, no fixed time slot was selected instead sampling started at the break of dawn during all seasons and on an average lasted between one and a half to two hours. The minimum length of the transect lines was 1600 m with a majority of the lines being 2000 m long. A total of 49 lines transects (Figure 4) totalling to 147.3 km was sampled.

For each animal sightings, the following variables were recorded; number of individuals, the radial distance (using a range finder) and sighting angle (using magnetic field compass). When animals were observed in a group, the measurements of distance and angle were obtained to the centre of the group. Also, on occasions where the animals were flushed out due to observer movement, observations were recorded for location where the animals were sighted initially. Additional information such as time of observation, GPS location of observer during encounter, and habitat type in which animal was sighted were also recorded.

Figure 4: Location of sampled and un-sampled transect lines and replicate lines within the Tiger Reserve.

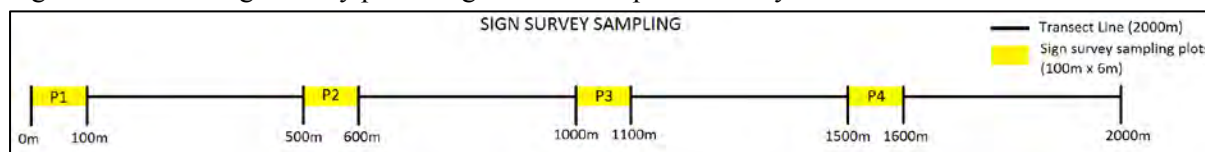


4.1.1.2 Sign survey (Indirect signs)

Surveying for indirect evidences are commonly used in cases where presence of the animal cannot be confirmed by visual detections (Wilson et al. 1996). This is mainly done for instances where the species are highly sensitive to disturbances and are cryptic (Society, 2016). Signs can be used to determine species occupancy rate as well as in some cases relative abundance, however, it must be noted that the problem with using sign is the susceptibility to identification (Wilson et al. 1996). The project team also used sign surveys, as our study mainly aimed at understanding the distribution and abundance of Rare, Endangered and Threatened species, which typically live in low density and elusive in nature and thus hard to sight them directly. Even species such as tigers, leopards and sloth bears are rarely observed directly as they are crepuscular and or nocturnal, similarly species like the pangolin which are more nocturnal in nature are encountered rarely.

Similar to line transect sampling, the sampling for indirect evidence of mammals were restricted only to the beats that contained transect lines. Sign surveys were carried out laying four rectangular plots measuring 100 x 6 m placed at 500 m intervals along each transect line (Figure 5). For every transect line, a parallel line was walked at a minimum distance of 1 km away from the transect line (Figure 4) as a replicate sampling for each beat. Similar to the permanent transect line, four plots of 100 by 6 m were surveyed at every 500 m intervals along the parallel lines. Since these parallel lines were placed arbitrarily on the map, the actual ground conditions were unknown and due to this some plots partially ended up in inaccessible area due to terrain conditions.

Figure 5: Indirect sign survey plot design used in the present study.



All 49 transects surveyed for line transect data were surveyed for indirect signs, while 41 parallel lines were sampled. In total, the field team surveyed 144 kms together from permanent established by the forest department and parallel transects established during the study and a total of 357 plots were surveyed for indirect signs.

The data on sign survey were collected on two levels (i) presence/absence within each plot, and (ii) number of signs for each species within each plot. For every observation, data relating to species, type of sign and their numbers observed in each plot were recorded. In addition, the types of habitats in which each plot was established were recorded. On occasions where signs were unidentifiable, photographs were taken initially to capture information of substrate and habitat type and in case of pellets or scats, the samples were collected along with geo-coordinates and later identified using standard references (Talwar and Usmani, 2005; Menon, 2014). Indirect signs recorded include, faecal signs viz. pellets, dung, dropping and scat; activity signs such as tracks, wallowing, debarking, digging, scrape and scratch; halts and home signs viz. nests, dens, burrows, and apart from these, animal calls and direct sightings encountered during the sampling were also recorded (Appendix IV). Sign of domestic or feral cattle or goats which were commonly seen in the reserve were also recorded in order to test their influence on wild species.

4.1.1.3 Supplementary data

Besides the primary data, the project also collected the (i) Camera traps data, which were deployed by forest department staff within a km from the surveyed transect lines to substantiate our species data for the different locations. The images of camera traps deployed during 2016 and early 2017 were used to capture latest available data and (ii) the line transect data collected by the state forest department, during annual census (October 2016 & June 2017) was acquired for similar substantiation and cross verification of our results.

4.1.2 Identifying RET species of mammals and comparing the list provided by the FD

The International Union for Conservation of Nature (IUCN) classifies species that fall within the Vulnerable, Endangered and Critically endangered criteria as Threatened. As per IUCN's Red List of Species (2017), each category has a set of criteria (2001 Categories and Criteria, Version 3.1), mainly relating to the population trend and threats faced by the species, which are used to determine whether a species belongs to that category. An endemic species is a species which is confined to a particular region due to selective environmental conditions and is found nowhere else in the world. Thus, protecting these regions are significant in protecting these sensitive species, as their population may become threatened with alterations in the local environment and in some cases the species would be driven to extinction and we stand to lose the species completely.

To determine RET criteria, a weighted scoring system was adopted using their threatened (IUCN, 2017) and endemic status. Species that are endemic to the country are given a score of 1 as compared to species that are not endemic to the country who are given a score of 0. Additionally, species that are vulnerable are given a score of 1 point, Endangered are given a score of 2 points, and critically endangered are given a score of 3 points. Thus, any species with a score of 1 or more were prioritised as RET species.

4.1.3 Developing recommendations for conservation plans for mammals

Using the data acquired from direct sightings and indirect signs, analysis for all data sets were done at 2 levels (i) RET species combined, and (ii) individual RET species

4.1.3.1 Preliminary analysis

For each range total abundance was arrived along with the encounter rate, which is a function of abundance, and is calculated as $\frac{Abundance}{Distance\ sampled}$ (Buckland et al. 2001) for direct sighting data as well as indirect sign data in order to present an overall comparison between the ranges.

4.1.3.2 Occurrence

Both direct sighting and indirect sign datasets were combined in order to map the occurrence and species richness beat wise as well as range wise.

4.1.3.3 Density estimates of RET species

Transect data was analysed in software DISTANCE 7.1 (Thomas et al. 2010), to arrive at density estimates following distance-sampling techniques. Group and individual density and encounter rate were estimated along with standard error (SE), evaluating each model of detection probability, viz. uniform, half-normal and hazard-rate with three different

series adjustment terms such as cosine, simple polynomial and hermite polynomials (i.e. detection probability uniform with cosine series adjustment, uniform with simple polynomial and uniform with hermite polynomial and similar combination for half-normal and hazard-rate). Given the minimum observations required for distance analysis, density could only be estimated for gaur, sambar, giant squirrel and langur. Nine different models were run each for each species. In the case of the langur, due to the presence of 1 outlier, 9 models were run first while including the outlier data and then once again 9 models were run using truncation and excluding the outlier.

All warnings were adhered to for each model and these included, use of mean cluster size for cluster size estimation as well as weakly monotonically non-increasing / No constraints for constraints on fitted function, whenever appropriate warnings were generated, and the respective model was run again. To estimate density and encounter rate, the best model was selected for each species, using the minimum Akaike Information Criteria (AIC) as the standard model selection procedure.

4.1.3.4 Influence of habitat and cattle grazing pressure on the abundance of RET species

To determine how different habitat influence the distribution and abundance of RET species of mammals, data on indirect evidence obtained using systematic plots were used, as we had both habitat details and cattle grazing pressure for every plot. At every plot, the habitat type was classified into ten types (Table 1).

Similarly, grazing pressure was ascertained based on the presence of cow and goat direct sightings and their indirect evidences such as dung/pellet. In cases where a plot had more than one habitat type, the plot was bifurcated and signs were recorded in relation to habitats. The influence of independent factors on the dependent factor was tested for each RET species separately using multiple regressions, with indirect evidences of each RET species obtained from individual plot as dependent factor and the habitat type and cattle grazing pressure obtained from the respective plot as independent factors.

Table 1: Vegetation types classified for mammal study

S. No.	Forest type	Description
01	Deciduous Forests	Forests with species that characteristically shed their leaves annually during the dry season (Champion and Seth, 1968)
02	Grasslands	Habitat where grass species alone dominate the stand
03	Karvi patches	These patches contain purely, <i>Strobilanthes</i> sp. especially along low hills.
04	Scrub Forests	Habitat with discontinuous patches of short bushes interspersed with grass.
05	Plateau	Characterized by stunted grass cover with a black rock substrate; barren without vegetation during the dry months.
06	Evergreen	Unlike deciduous forests, species here do not shed their leaves in the dry period. This was the most prevalent habitat throughout the reserve and was further classified on the height class into the following five types
6a	Short Evergreen	Short and stunted evergreen bushes. Unlike the scrub, these patches did not contain grass and were continuous with evergreen bushes of up to six feet high.
6b	Medium Evergreen	Contains tree species of evergreen forests and grow between 10 to 15 feet tall.
6c	Tall evergreen	Contains tree species of evergreen forests and grow between >15 feet tall.
6d	Short and medium evergreen mixed	Patch that contains a mixture of short evergreen bushes and medium evergreen height class trees.
6e	Medium and tall Evergreen mixed:	Forest patch that contains a mixture of medium evergreen and tall evergreen height class trees

4.2 Herpetofauna

4.2.1 Documentation of Herpetofauna

Herpetofaunal communities are highly diverse, occupy a range of habitats and micro habitats and typically characterised by their low densities, limited mobility and ability to camouflage with their substrate. Therefore, sampling protocols for herpetofaunal communities are adapted based on the primary habitat (aquatic/terrestrial/arboreal). Based on the reconnaissance survey, it was decided to use three globally accepted sampling protocols namely; (i) Visual Encounter Survey (Heyer et al.1994) – targeting arboreal species, (ii) Quadrats (Krebs 1999) – for aquatic and forest floor dwelling and (iii) Non-Systematic Opportunistic Sightings Method (Grismer 2006). Detailed desk review of past work on herpetofauna was also used for a comprehensive species listing for STR.

4.2.1.1 Visual Encounter Survey (VES)

Following Heyer et al. (1994), this is an intensive sampling for herpetofauna, normally carried out during morning (between 08:30 and 10:30 h) and during late evening to night (from 18:00 to 23:00 h). These are time periods when the target species are active, mostly in and around the bodies of water and marshy lands, where herpetofauna tend to aggregate (Naniwadekar and Vasudevan 2007, Bhattarai et al. 2017). While looking for arboreal species, we carefully observed branches and bushes and used flashlights for nocturnal species (Boruah et al. 2016). For a majority of the sightings, individual were photographed, identified based on taxonomic keys following standard literatures (Smith 1931, 1935 & 1943, Boulanger 1885 & 1890, Gunther 1864, Tikader 1992, Murthy 2011, Das 2002, Whitaker & Captain 2004, Daniel 2002, Ganesh 2011, Gururaja 2011, Wallach 2014, Dinesh 2016, Uetz et al. 2017). Additionally, we noted down the microhabitat details such as physical characteristics of the sampling unit, (leaf litter, shrubs, artificial substrate, rocks,

ledges, temporary/perennial stream banks on the ground) and associated vegetation (Ward 2012). When sighting/recording the unfamiliar herpetofauna species, standard morphometric measurements using digital calliper to the nearest 0.1 mm following Smith (1935) Whitaker and Captain (2004) for reptiles and Chandramouli and Amarasinghe (2016) for amphibians were taken to enable a positive identification later. In case of unidentified species, herpetofauna taxonomic expert from IUCN India county office (N.M. Ishwar) and Snake Park Chennai (S.R. Ganesh) were consulted showing the photographs on various part of the body and morphometric measurements, for identification and confirmation of the species. In total, using the VES sampling protocol, we sampled 42 beats from four ranges covering 192 km distance, spending 142 man-hours, which includes 70 h during day and 71 h during night time sampling (Table 2).

4.2.1.2 Systematic Quadrat Survey (5m²) (SQS)

The field team placed (5×5 m) quadrats systematically at 500 m along the line transect established by STR. The plots was demarcated with a nylon rope and four sticks at the four corners and combed the entire 25 m² area. The area was searched systematically covering all microhabitats within plot including scanning the tree trunk, shrubs, searching under stones, boulders, leaf litter, in and around the water bodies, marshy land, on rocks and in the holes and crevices on rock, stone and trees for herpetofauna species. As mentioned earlier, at each sighting of herpetofauna, the species was photographed and information on microhabitat of the quadrat and individual sightings such as tree & shrub, small holes/crevices in the stone/rock/tree and under small stones, leaf litters and decay woods materials were recorded to document patterns in species richness, distribution and abundance of forest-floor herpetofauna (Krebs 1999, 2014; Loehle et al.2005, Vasudevan and Surendran 2015). In total 298 plots spread over 41 beats of STR were sampled using this method (Table 2). All the plots were surveyed once for a period of 15 minutes (Ryan, 2002) during day light hours.

4.2.1.3 Opportunistic Sighting Method (Grismer 2006)

Opportunistic sampling is an informal sampling protocol, often used as an additional source of information while compiling comprehensive herpetofauna checklists for a site. This opportunistic sightings were carried out in all ranges viz. Bamnoli, Chandoli, Dhebewadi, Helwak and Koyna. Therefore, we pooled all opportunistic sighting and Road kills records (Grismer 2006) and also this data help to develop the comprehensive species checklist of Sahyadri Tiger Reserve.

Table 2: Sampling intensity; Visual Encounter Survey and Systematic Quadrat Survey - on herpetofauna survey in STR during January and July 2017.

S. No.	Forest covered Range	No. of Beats sampled	Visual Encounter Survey			Systematic Quadrat Survey (5m ²)		
			Man-hours spent		Distance walked (km)	No. of plots surveyed	Area covered (m ²)	Man-hour spent
			Day	Night				
1	Bamnoli	08	08	06	21.4	35	850	08
2	Chandoli	12	22	24	61.0	96	2400	24
3	Helwak	10	20	18	55.4	80	2000	20
4	Koyna	12	20	23	54.1	88	2000	19
	Overall landscape	42	70	71	192.0	298	7250	71

4.2.1.4 Data entry and compilation

All data pertain to three methods (VES, SQS, OSM) were keyed into separate excel sheet. In the excel sheet labelling the column with variables pertains to survey and sightings such as date, time, range, beat, distance, and habitat (surveyed) and species, its number, microhabitat, altitude, temperature, morphometric measurement and photo ID of individual (sighted), every sighting was entered in a separate row. Later from these three databases, extracting common variables such as range and species sighted, merging these with data from literature survey, a comprehensive check list of herpetofauna species documented by this study along literature survey was arrived. To illustrate sampling efficiency species accumulation curve using EstimateS 8.2.0 was used (Colwell, 2006) and Past 3.16 (Hammer, 2017).

4.2.2 Determining the RET species for STR

Similar to mammals, the IUCN Red List of species was used to identify the species to the Red list categories (Critically Endangered, Endangered, Vulnerable and Near Threatened). The endemic status of species was assigned two categories, endemic to Western Ghats, and endemic to Northern Western Ghats Endemic based on known and published distributional records (www.iucnredlist.org), Reptile database 2017 (<http://reptile-database.reptarium.cz/>) and Amphibian Web 2017 (<http://www.amphibiaweb.org/>).

A weighted score was assigned to each species based on their threat status and endemic status. Species with a score of one and above is considered RET species. The scoring was as follows; species endemic to Northern Western Ghats - score of 2 (higher score as their survival is depended on the long-term conservation of the Northern Western Ghats); species endemic to Western Ghats - score of 1; non-endemic species - score 0. Further, species under Critically Endangered category assigned with score of 4, species under Endangered category with score 3, Vulnerable with score 2 and Near Threaten was with score 1.

4.2.3 Developing recommendations for conservation planning of herpetofauna

For Species richness analysis we combined data from all the four methods (VES, SQS, OSM and Lit. Survey) and for species abundance, we relied on data only from VES because data on SQS yielded very few species unlike VES, but the trend in abundance between the two methods (VES and SQS) remained the same indicating the results obtained from VES is realistic and not because of difference in visibility among habitats. From the sighting based VES raw data of RET species was extracted range-wise. The data on RET species richness and abundance so obtained, depicted on study area map using ARC GIS (Version: 10.0) (ESRI 2011).

5 RESULTS AND DISCUSSION

5.1 Mammals - results

5.1.1 Comprehensive species listing for STR

In total, 16 species were recorded during the study period based on line transects and systematic plots sampling protocols (Table 3). Detailed literature review of mammal studies/surveys carried out in the area (Lawate and Mule, 2009; Abdar, 2013; Sayyed, 2016), and taking into account the camera trap surveys and line transect data collected and maintained by the forest department, we can confirm the presence of 33 species in STR. The camera trap data collected by the department due to its inherent nature of scanning the sampling location continuously both during day and night was able to capture a greater number of mammalian species.

Among the 33 species documented using various sources, identification of endemic species following IUCN distribution details revealed that, seven species viz. four horned antelope, south western langur, Indian giant squirrel, mouse deer, brown palm civet, stripe-necked mongoose and bonnet macaque were endemic to India.

5.1.2 Identifying RET species and comparing the list provided by the Department

Based on the scoring system, this study identifies a total of 14 mammals as RET species for the reserve (Table 4). The tiger, wild dog and pangolin received an overall score of 2 owing to their endangered status. The four-horned antelope and south-western langur are both vulnerable and endemic and thus they too received an overall score of 2.

5.1.3 Towards the development of conservation plans:

5.1.3.1 Spatial variation in species richness

In case of overall mammalian species, Chandoli Range recorded the highest number of species (16) followed by Helwak (15 species), while Bamnoli (12 species) recorded the least number of species (Figure 6). A similar trend was observed for RET species as well across the ranges with Chandoli recording 11 species and Bamnoli recording 8 species. Although the assessment suggests that Chandoli and Helwak ranges would be given a higher priority in terms of RET richness, a considerable number of RET species were also recorded in the other three ranges viz. Koyna and Dhebewadi and Bamnoli, suggesting these three ranges are also important for RET species in terms of supporting viable population size.

Table 3: A comprehensive list of mammals recorded in Sahyadri Tiger Reserve

S. No.	Common name (<i>Scientific name</i>)	IUCN (2017)	Endemic to India	Present study	State Forest Department		Publications (Abdar, 2013; Lawate & Mule, 2009; Sayyed, 2016)
					Camera trap/line transect	Tiger Cons. Planning	
1	Tiger (<i>Panthera tigris</i>)	EN	-	-	-	☐	☐
2	Pangolin (<i>Manis crassicaudata</i>)	EN	-	☐	CT	☐	☐
3	Wild dog (<i>Cuon alpinus</i>)	EN	-	+	CT	☐	☐
4	Four-horned antelope (<i>Tetracerus quadricornis</i>)	V	☐	☐	CT	☐	☐
5	South wester langur (<i>Semnopithecus hypoleucos</i>)	V	☐	☐	CT/ LT	☐	☐
6	Sambar (<i>Rusa unicolor</i>)	V	-	☐	LT	☐	☐
7	Indian Gaur (<i>Bos gaurus</i>)	V	-	☐	CT/ LT	☐	☐
8	Sloth bear (<i>Melursus ursinus</i>)	V	-	☐	CT/ LT	☐	☐
9	Leopard (<i>Panthera pardus</i>)	V	-	☐	CT/ LT	☐	☐
10	Giant squirrel (<i>Ratufa indica</i>)	LC	☐	☐	CT/ LT	☐	☐
11	Mouse deer (<i>Moschiola indica</i>)	LC	☐	☐	CT	☐	☐
12	Bonnet macaque (<i>Macaca radiata</i>)	LC	☐	☐	CT		☐
13	Stripe-necked mongoose (<i>Herpestes vitticollis</i>)	LC	☐	-	CT	☐	☐
14	Brown palm civet (<i>Paradoxurus jerdoni</i>)	LC	☐	-	CT	-	-
15	Striped hyaena (<i>Hyaena hyaena</i>)	NT	-	-	-	-	☐
16	Golden jackal (<i>Canis aureus</i>)	LC	-	-	CT	☐	☐
17	Barking deer (<i>Muntiacus muntjac</i>)	LC	-	☐	CT/ LT	☐	☐
18	Wild pig (<i>Sus scrofa</i>)	LC	-	☐	CT/ LT	☐	☐
19	Jungle cat (<i>Felis chaus</i>)	LC	-	☐	CT	☐	☐
20	Leopard cat (<i>Prionailurus bengalensis</i>)	LC	-	-	CT	-	☐
21	Rusty spotted cat (<i>Prionailurus rubiginosus</i>)	NT	-	-	CT	-	☐
22	Common palm civet (<i>Paradoxurus hermaphrodites</i>)	LC	-	-	CT	-	☐
23	Small Indian civet (<i>Viverricula indica</i>)	LC	-	-	CT	-	☐
24	Grey mongoose (<i>Herpestes edwardsii</i>)	LC	-	-	CT	-	☐
25	Ruddy mongoose (<i>Herpestes smithii</i>)	LC	-	-	CT	-	☐
26	Indian hare (<i>Lepus nigricollis</i>)	LC	-	☐	CT/ LT	☐	☐
27	Indian crested porcupine (<i>Hystrix indica</i>)	LC	-	☐	CT	☐	☐
28	Smooth coated otter (<i>Lutrogale perspicillata</i>)	V	-	-	CT	-	-
32	Indian fox (<i>Vulpes bengalensis</i>)	LC	-	-	-	-	☐
33	Indian wolf (<i>Canis lupus</i>)	NT	-	-	-	-	☐

Table 4: List of RET species Identified from the exhaustive list of mammals recorded in the Reserve.

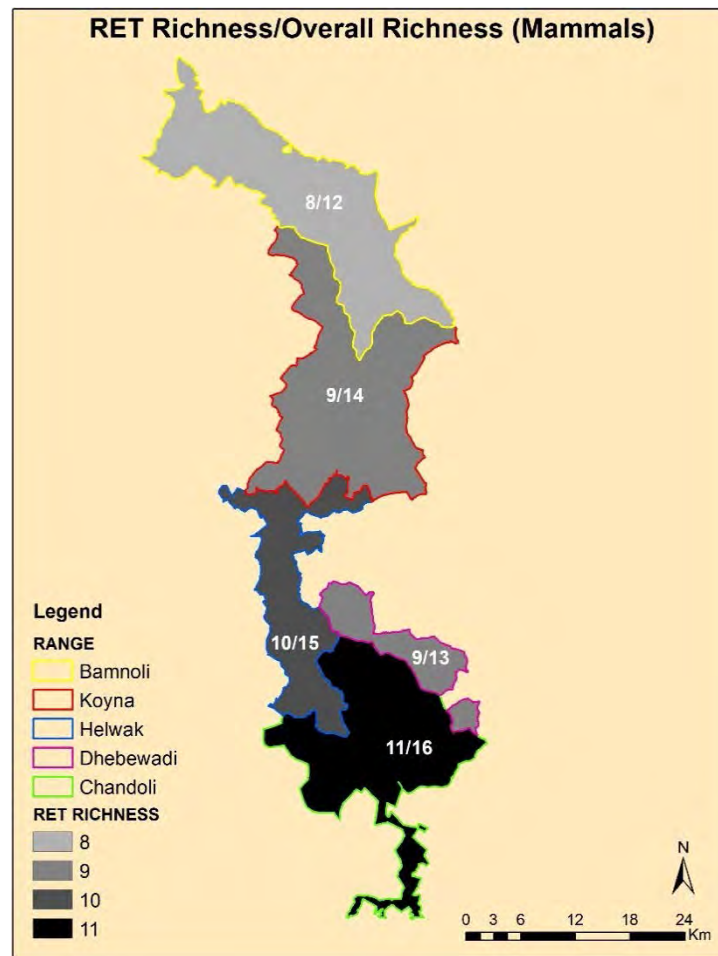
S. No.	Common Name	Scientific Name	Endemic species	IUCN status	Overall score
1	Tiger	<i>Panthera tigris</i>		EN	2
2	Indian pangolin*	<i>Manis crassicaudata</i>		EN	2
3	Wild dog	<i>Cuon alpinus</i>		EN	2
4	Four-horned antelope	<i>Tetracerus quadricornis</i>	✓	V	2
5	South-western langur	<i>Semnopithecus hypoleucos</i>	✓	V	2
6	Sambar	<i>Rusa unicolor</i>		V	1
7	Gaur	<i>Bos gaurus</i>		V	1
8	Sloth bear	<i>Melursus ursinus</i>		V	1
9	Common leopard*	<i>Panthera pardus</i>		V	1
10	Indian giant squirrel**	<i>Ratufa indica</i>	✓	LC	1
11	Mouse deer	<i>Moschiola indica</i>	✓	LC	1
12	Bonnet macaque	<i>Macaca radiata</i>	✓	LC	1
14	Brown palm civet**	<i>Paradoxurus jerdoni</i>	✓	LC	1
* Species Red List status shows an increasing trend as compared to previously published Red List (IUCN, 2008), where species were not classified under Threatened. ** Species Red List status shows a decreasing trend as compared to previously published Red List (IUCN, 2008), where species were not classified under Threatened.					

5.1.3.2 Abundance and encounter rate

From line transect, a total of 289 individuals were recorded. Owing to 116 langur sightings from Helwak, this range recorded the highest sightings (n = 189) or encounter rate (5.5/km) of overall mammalian species and 94.7% (n = 179) of them were of RET species. On the other hand, Koyna had the lowest number of mammalian fauna encounter rate. No mammals were detected during line transect sampling in Dhebewadi range, which is entirely located in the buffer region of the reserve (Figure 7A).

In total, 987 different signs were recorded for mammals in Koyna and 61% (599) of these were from the species classified as RET in the study (Figure 7B). Although there were no direct sightings in Dhebewadi range, we recorded 253 signs with 39% (98) from RET species and the least number of signs (111) were recorded from Bamnoli 49% (54) of these being of RET species.

Figure 6: Details of RET species richness vs overall species richness of mammals recorded in forest ranges of STR



Among the five ranges, Helwak had the highest encounter rate for both overall mammalian species as well as RET species followed by Bamnoli, Chandoli and Koyna ranges. As there was no detection of mammals during line transect surveys in Dhebewadi, the encounter rate for the range was 0 (Figure 7A). On the other hand, in sign survey (indirect evidence) method, though Chandoli had numerically a higher value than Helwak, closely followed by Koyna, they were statistically same, as their error bars overlap extensively. Similarly, the RET sign encounter rate was though numerically higher in Koyna than Helwak and Chandoli (Figure 7B), they were statistically the same. This trend suggests that these three ranges (Chandoli, Koyna and Helwak) consistently share both overall mammalian and RET abundance.

Figure 7: Encounter rate of mammalian species recorded in different ranges [A. direct sighting and B. indirect signs]

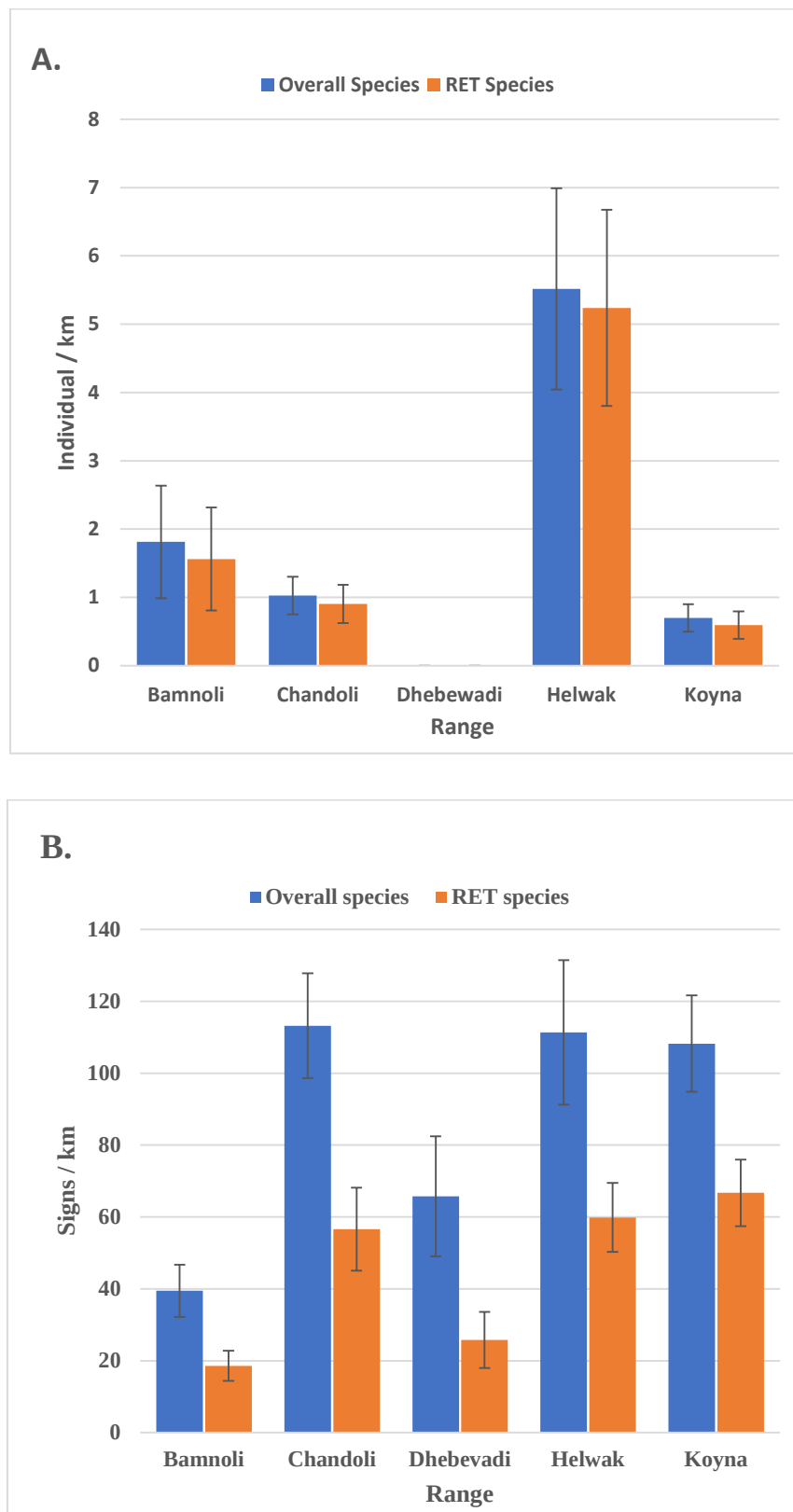
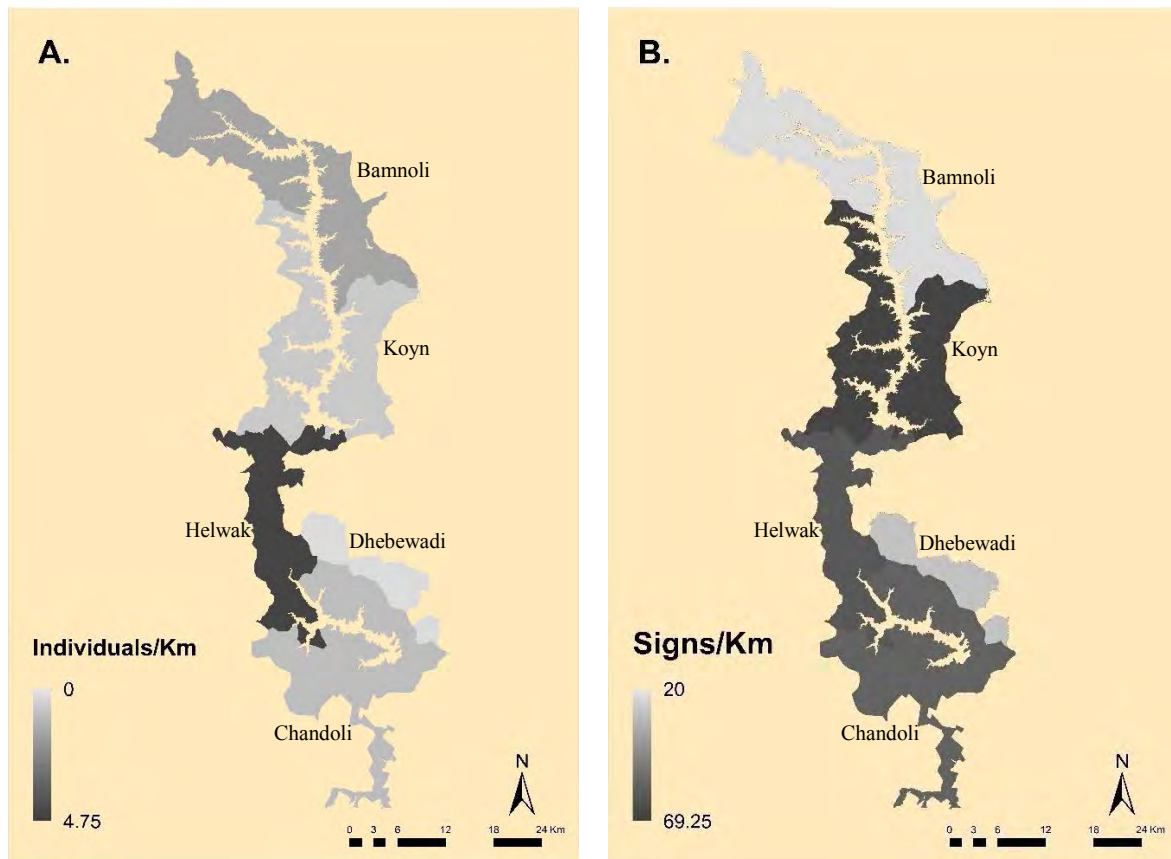


Figure 8: Intensity of RET species encounter rate within each range [A. direct sighting and B indirect evidences].



5.1.3.3 Density estimates

In total, 130 detections accounting for 289 individuals from 11 species of mammals were recorded from 49 transects (a total of 147 km). Out of 130 detections, 107 observations were of RET species, with Indian giant squirrel having the highest detections (38 detections; 43 individuals) followed by south western langur (35 detections; 159 individuals), gaur (12 detections; 29 individuals) and sambar (11 detections; 15 individuals). The other RET species recorded include, four-horned antelope, mouse deer, sloth bear, and bonnet macaque.

The estimated group density and individual density for gaur, south western langur, giant squirrel and sambar for the entire reserve is provided in Table 5. The % CV is a standardized measure of variation in the estimate. With respect to encounter rate, the high % CV values, may therefore be interpreted to mean that the species was encountered in dissimilar numbers across the transects. Smaller species like south-western langur and Indian giant squirrel had a higher but a similar encounter rate, while larger species like gaur and sambar had a much lower encounter rate. Although the group density for giant squirrel was higher ($6.7 \pm 3.23/\text{km}^2$) than south western langur ($4.1 \pm 1.21/\text{km}^2$), it was the inverse for individual density, which is likely be due to the higher group size of south western langur (4.6 ± 0.88 individuals/group) compared to the giant squirrel (1.1 ± 0.04 individuals/group). Although the density estimates have a narrow error, the larger confidence interval or upper confidence interval is 4-6 folds higher than the lower confidence interval (Gaur: 2 to 10 individuals/ km^2 ; Langur: 10 to 37 individuals/ km^2 ; Giant Squirrel: 3 to 18; Sambar: 1 to 4) is

an indicative of lower sample size. Detection probabilities were similar for gaur, giant squirrel and south-western langur, while sambar had a comparatively higher detection probability species.

Table 5: Density estimates for RET species following line-transect DISTANCE sampling method recorded during Nov. 2016 – July 2017 in Sahyadri Tiger Reserve, Maharashtra.

Attributes	Species surveyed			
	Gaur	Langur	Giant Squirrel	Sambar
No. of transects	49	49	49	49
Effort (l, km)	147.3	147.3	147.3	147.3
Number of group detection (n)	12	34	38	11
Key function model	Half-normal	Hazard Rate	Uniform	Half-normal
Key adjustment	Cosine/Simple polynomial	Cosine	Cosine	Simple polynomial
Detection probability	0.5 ± 0.08	0.4 ± 0.04	0.5 ± 0.03	0.8 ± 0.2
Effective strip width (m)	21.4 ± 3.42	28.5 ± 3.02	19.2 ± 1.04	31.6 ± 7.6
Encounter rate of group/km (n/l)	0.08	0.23	0.26	0.07
Encounter rate % CV	33.4	27.9	47.8	34.1
Mean group size	2.3 ± 0.53	4.6 ± 0.88	1.1 ± 0.04	1.4 ± 0.15
Group density/km ²	1.9 ± 0.7	4.1 ± 1.21	6.7 ± 3.23	1.2 ± 0.49
Group density % CV	37.02	29.84	48.14	41.69
Group density 95% CI	0.92 – 3.9	2.26 – 7.27	2.68 – 16.8	0.53 - 2.64
Individual density/km ²	4.4 ± 1.92	18.8 ± 6.67	7.1 ± 3.44	1.6 ± 0.69
Individual density % CV	43.37	35.38	48.32	43.16
Individual density 95% CI	1.9 – 10.2	9.5 – 37.3	2.8 – 17.9	0.70 - 3.7

Due to inadequate sample size on individual species, we pooled the data all the prey base of large carnivores, which includes gaur, sambar, four-horned antelope, barking deer and wild pig to arrive at density. The results show that an average 22 ± 4.6 ungulates /km² (Table 6) with 95% CI varied from 14-33 individuals/km². The individual density % CV nearer to acceptable level (21.4) indicating the estimated density of ungulates is a realistic one.

Table 6: Density estimate following line-transect DISTANCE sampling method using pooled data on gaur, sambar, four-horned antelope, barking deer and wild pig as prey base available for large carnivores recorded during Nov. 2016 – July 2017 in Sahyadri Tiger Reserve

Attributes	Large carnivore prey base
No. of transects	49
Effort (l, km)	147.3
Number of group detection (n)	46
Key function model	Hazard Rate
Key adjustment	Simple polynomial / Hermit polynomial
Detection probability	0.1 ± 0.02
Effective strip width (m)	17.1 ± 2.86
Encounter rate of group/km (n/l)	0.52
Encounter rate % CV	11.12
Mean group size	1.4 ± 0.11
Group density/km ²	15.2 ± 3.06
Group density % CV	20.1
Group density 95% CI	10.3 ± 22.66
Individual density/km ²	21.8 ± 4.65
Individual density % CV	21.36
Individual density 95% CI	14.3 - 33.1

5.1.3.4 Influence of habitat and anthropogenic pressure on RET species

Although all RET species, except for four-horned antelope, were found in multiple habitats, their number/signs varied significantly among habitats especially for the gaur, giant squirrel, langur, mouse deer and sloth bear (Table 7). Among the RET species signs recorded, gaur and sambar were the most predominant with gaur having the highest mean encounter rate in deciduous forest, followed by grasslands, karvi patches, medium evergreen forest, plateaus and scrublands. Similarly, sambar had higher mean encounter rate in short evergreen forest, followed by short and medium evergreen mixed forest, and medium and tall evergreen mixed forest. Mean encounter rate of giant squirrel indirect signs was highest in tall evergreen forest and was closely followed by sambar and sloth bear in the habitat. The mean encounter rate for langur was highest in tall evergreen forest as well. Mean encounter rate for leopard, mouse deer, pangolin and wild dog signs were the lowest in all habitats. The results indicate that some habitat/s are better in terms of resources for supporting higher abundance RET species of mammals. To identify which of these habitats influence positively or negatively on RET species, we further tested the influence of habitat on RET species using multiple regression framework. Besides the habitat factor, we also included cattle grazing pressure into the equation to test the influence of cattle grazing on RET species abundance.

Table 7: Encounter rate of RET mammalian species indirect evidences as prey base available for large carnivores recorded in different habitats during Nov. 2016 – July 2017 in Sahyadri Tiger Reserve, Maharashtra.

Species	Deciduous	Grassland	Karvi	Medium & Tall Evergreen	Medium Evergreen	Plateau	Scrub	Short & Medium Evergreen	Short Evergreen	Tall Evergreen	F(p)
Four horned antelope	0	0.24 ± 0.167	0	0	0	0	0	0	0	0	4.673 (0.031)
Indian Gaur	22.9 ± 7.06	21.4 ± 2.50	25.8 ± 4.31	7.8 ± 2.63	20.3 ± 4.88	36.2 ± 7.91	20.4 ± 4.56	12.7 ± 3.21	16.2 ± 2.45	7.7 ± 1.69	3.153 (0.001)
Indian giant squirrel	2.4 ± 1.36	1.77 ± 0.54	2.73 ± 0.76	13.3 ± 4.04	3.3 ± 1.30	0.48 ± 0.48	1.8 ± 0.66	4.6 ± 1.80	2.9 ± 0.79	18.4 ± 3.43	14.074(0)
Langur	4.7 ± 2.44	2.5 ± 0.66	4.2 ± 1.03	5.6 ± 2.02	5.3 ± 1.96	3.3 ± 1.99	1.6 ± 0.95	7.3 ± 2.14	3.6 ± 0.81	13.9 ± 2.29	6.797(0)
Leopard	2.9 ± 1.87	1.7 ± 0.45	1.3 ± 0.64	1.7 ± 1.21	1 ± 0.56	1.9 ± 1.12	1.1 ± 0.47	2.7 ± 1.17	0.4 ± 0.31	2.1 ± 0.92	1.086 (0.371)
Mouse deer	0 ± 0	0.24 ± 0.238	0 ± 0	0 ± 0	1.11 ± 0.762	0 ± 0	0 ± 0	0.5 ± 0.46	0 ± 0	0 ± 0	5.952 (0.003)
Pangolin	0.6 ± 0.59	1.2 ± 0.34	1.5 ± 0.60	0.6 ± 0.56	0	0.5 ± 0.48	1.1 ± 0.57	0.9 ± 0.51	1.2 ± 0.38	0.2 ± 0.23	0.822 (0.596)
Sambar deer	17.1 ± 6.46	14.5 ± 2.87	20.2 ± 6.21	14.4 ± 8.29	10.3 ± 3.4	6.7 ± 2.61	12.7 ± 3.35	13.9 ± 4.67	19.9 ± 4.65	17.7 ± 4.68	0.583 (0.811)
Slothbear	12.9 ± 3.06	9.5 ± 1.28	7.5 ± 1.50	12.8 ± 4.26	9.7 ± 2.01	7.6 ± 2.48	7.3 ± 1.752	11.5 ± 2.82	8.13 ± 1.53	17.0 ± 4.12	9.587 (0.002)
Wilddog	0	0.2 ± 0.11	0	0	0	0.5 ± 0.48	0.2 ± 0.22	0.9 ± 0.91	0	0.7 ± 0.70	0.922 (0.506)
Ret	63.5 ± 10.39	53.2 ± 4.56	63.1 ± 8.12	56.1 ± 11.58	50.7 ± 6.06	57.1 ± 10.85	46.7 ± 6.24	54.9 ± 7.51	52.8 ± 6.18	77.7 ± 7.67	1.286 (0.242)

Table 8: Regression equation showing the influence of habitats and cattle grazing on the abundance of RET species in Sahyadri Tiger Reserve, Maharashtra.

Species	Habitat	Unstandardized Coefficients		Standardized Coefficients		ANNOVA <i>F</i>	<i>R</i> ²
		B	Std. Error	Beta	T (p)		
Four horned antelope	Grassland	0.238	0.11	0.129	2.162 (0.031)	4.673 (0.031)	0.017
Gaur	Plateau	19.831	5.913	0.151	3.354 (0.001)	8.986 (0.003)	0.018
	Karvi	9.273	3.864	0.11	2.4 (0.017)	6.995 (0.001)	0.028
	Grassland	7.751	2.816	0.128	2.75 (0.006)	6.179 (0.000)	0.037
	Cattle grazing	-0.114	0.03	-0.171	-3.785 (0.000)	8.346 (0.000)	0.065
Giant squirrel	Tall Evergreen	15.939	1.555	0.423	10.249 (0.000)	95.292 (0.000)	0.169
	Medium and tall evergreen	10.9	2.336	0.192	4.665 (0.000)	60.633 (0.000)	0.205
Langur	Tall evergreen	9.768	1.484	0.289	6.583 (0.000)	47.209 (0.000)	0.091
	Short and medium evergreen	3.352	1.662	0.088	2.017 (0.044)	26.409 (0.000)	0.101
	Cattle grazing	-0.035	0.01	-0.147	-3.341 (0.001)	21.707 (0.000)	0.122
Mouse deer	Medium Evergreen	0.993	0.405	0.145	2.454 (0.015)	5.952 (0.003)	0.042
Sloth bear	Tall evergreen	7.676	2.479	0.141	3.096 (0.002)	9.587 (0.003)	0.02

The four-horned antelope was most influenced by grass lands as compared to other habitats and 1.7% variance in the antelope sign encounter rate is explained by the presence of grasslands (Table 8). The encounter rate of gaur sign was significantly highest in plateau followed by karvi patches and grasslands, and showed a negative relationship with indirect signs of anthropogenic pressure. About 7% of the variance in the encounter rate of gaur signs was explained by these four factors. Indirect signs of the two arboreal species i.e. langur and giant squirrel and the sloth bear were significantly highest in tall evergreen. The giant squirrel had a significantly high encounter rate in medium and tall evergreen mixed forests as well and 21% of the variance in their signs was explained by both tall evergreen forests and medium and tall evergreen mix forests. The langur had a significantly highest encounter rate in tall and short and medium evergreen forests. The encounter rate of langur signs had a negative relationship with cattle grazing pressure and these three factors (tall evergreen, short and medium evergreen and grazing pressure) explained 12% of the variance in langur signs. The encounter rate of mouse deer signs was positively influenced by medium evergreen and the same explained 4% of the variance in the encounter rate of mouse deer. The R^2 values of the present analyses are too small to be viewed and if the other factors that (are not captured by the study due to time constraints) actually influence the RET species are incorporated into the multiple regression equation, the habitat factor/s, which has very small effect (as inferred by R^2 value), may get excluded from the equation. However, as habitats are primary needs of any species, we have included the habitat-based analyses to prioritize for conservation. By and large among the habitat components, grasslands are very important to support high density of Indian guar and four-horned antelope, while the evergreen forests are vital both for the arboreal species like langur and Indian giant squirrel as well as terrestrial large mammals like sambar, mouse deer and sloth bears. The cattle grazing pressure influencing negatively on both gaur as well as langur, in which the langur effect by cattle could be through indirect effect in the disturbance by cattle grazers.

5.2 Mammals - discussion

5.2.1 Documenting mammalian species in the study area

This study was able to establish the presence of 14 (Table 4) RET species distributed uniformly throughout the reserve. However, considering the fact that these species are rare, long-term studies may shed a better light on the spatial distribution of these RET species in the reserve. The Sahyadri Tiger Reserve has been identified as an important forest landscape in the northern Western Ghats for Tigers and its movements (Abdar, 2013; Lawate & Mule, 2009; Sayyed, 2016). Our current study was unable to establish the presence of tigers in the landscape despite nearly 300 km of intensive sampling. However, the presence of the species cannot be ruled out completely.

Of the three recent studies with focus on mammals (Abdar, 2013; Lawate & Mule, 2009; Sayyed, 2016) in the Sahyadri Tiger Reserve, Sayyed (2016) provides a more comprehensive listing of species recorded in the Vasota region and Koyna and reports the presence of striped hyaena, Indian fox and Indian wolf in the region, species that the current study found no evidence. The presence of other small carnivores, especially the striped-necked mongoose, brown palm civet, leopard cat, rusty spotted cat, common palm civet, small Indian civet, grey mongoose, ruddy mongoose and smooth coated otter, were also not

recorded directly by our study, but their presence was established through the camera trap data collected by the forest department. In addition, the golden jackal was also recorded by the camera-traps and not by our study.

5.2.2 Suggested addition to the RET species for STR

Rare species in general have reduced and restricted populations (Drury, 1974; Gaston, 1997), and characterises for endemism. In this study, to classify a species as RET (Rare, Endangered & Threatened), we used a weighted numeric score taking into account both endemic status and rarity. Using this criteria, we propose that the revised final list for RET species in STR landscape should be 14 species (Table 4). The rationale for this are, its rarity, relevance for large carnivore conservation and endemism. Additional details are provided below;

The Indian pangolin has seen a significant jump from near threatened (2008), to endangered (IUCN, 2017) in the Red List. The species has been profusely hunted throughout its range and though there is still little information available on the population status of the species. It is argued that the scale at which the species is hunted, alone, is responsible for the change in its Red List status (Baillie et al. 2014).

The wild dog is a social predator hunting in packs is a species widely been affected by habitat fragmentation, persecution and diseases spread through domestic species (Kamler et al. 2015).

The four-horned antelope along with the south-western langur are both endemic and threatened species (IUCN SSC Antelope, 2017; Singh & Molur, 2008). Classified as Vulnerable (IUCN, 2017) due to their declining populations, it is a major prey species for threatened carnivores like tigers and leopards (Karanth et al., 2004; Karanth & Sunquist, 1995).

The south-western langur is an endemic species that is threatened primarily due to hunting and fragmentation of its habitat, while the sloth bear is threatened due to habitat loss (Desai et al. 1997; Singh & Molur, 2008).

The giant squirrel is an arboreal species and is endemic to India. Although the population of this species may appear to be doing well, habitat fragmentation has been observed through most of its distribution (Molur, 2016).

The mouse deer and brown palm civet are both endemic species with healthy populations, however they still continue to be threatened due to local hunting.

The bonnet macaque, another endemic species is a species whose population is least concerned according to the Red List, however recent studies have revealed threats arising from conflict and hunting to cause decline in the species numbers from most of its distribution (Singh & Rao, 2004).

5.2.3 Recommendations for conservation planning for the RET species

In terms of RET species diversity, similar to the overall diversity, range wise, Chandoli range harboured the highest diversity (11 RET species), while the Bamnoli range recorded the lowest diversity RET species (8 species). Although, this implies that Chandoli range should be given greater priority in habitat management it is important to note that other ranges also support a minimum of 8 RET species. Among direct sightings, south-western langur constituted the bulk and majority of these observations were from Helwak. This higher

abundance of langur suggests that the range is favourable for langur and not RET species altogether. The possible reason for the higher abundance of south-western langur in Helwak could be related to extent of semi evergreen or evergreen vegetation and tree species composition that are predominant in Male, Siddeshwar, Ambole and Rundiv (Kanade et al. 2008), that could act as food source for the langur.

Chandoli, Helwak and Koyna, the core ranges in STR did not vary significantly in the encounter rates of RET species from sign surveys. Similarly, the other two ranges, Bamnoli and Dhebewadi; buffer ranges, as well did not have a significant difference in their encounter rate of RET species from sign survey. However, the RET species encounter rates recorded in the two buffer ranges was significantly lower from the three core ranges. Although, we were unable to assess the factors influencing this difference, greater understanding of species ecology and their responses to threats as well as identifying these threats throughout the reserve could help address this issue effectively. Placed below are some suggestions for moving towards an integrated conservation planning for the 14 RET species.

Tiger

Systematic sampling and assessment: as this is a wide-ranging elusive species typically avoiding human habitations (Schaller, 1984), year round camera trapping must be continued in the STR and adjoin landscapes. This would provide enable the FD to document the usage of this landscape for dispersing tigers into our known tiger occupied landscapes.

Reviving tiger population using reintroduction: The TCP (2013) reports that this reserve has five to seven tigers since 2008. Similarly, the NTCA, has also estimated eight individuals for the reserve (Jhala et al., 2015) and given the total viable habitat area of the reserve (approximately 1165.5 km²), it would put the tiger density between 0.43 and 0.69 individuals per 100 km², which is comparable with the estimate for the adjoining Sharavati Valley-Dandeli-Khanapur population (Jhala et al., 2015). However, the optimal habitats of Nilgiri Biosphere Reserve, further south in the Western Ghats such as Nagarhole-Mudumalai-Wayanad have an estimated population of 5.26 individuals per 100 km² (Jhala et al., 2015), and compared to these, the estimated tiger population in STR is relatively low. Availability of sufficient prey base of large ungulates is one among the major requirements (Schaller, 1984; Karanth et al., 2004). Among major prey species, gaur, sambar, barking deer, four-horned antelope and wild pig have been recorded within the study area. The ungulate prey density estimated from the STR (21.8 ± 4.65 individuals/km²) is much lower as compared to other parts of the Western Ghats (viz Anamalai 72.1 individuals/km²; Mudumalai 95.6 individuals/km² including arboreal mammals and Nagarhole 91 individuals/km², (Andheria et al. 2007; Karanth & Sunquist, 2000; Kumaraguru et al. 2010; Ramesh, 2010). The density of gaur and sambar, which are the major prey species for the tiger was estimated between 3 and 6 individuals per km² for gaur and 1 and 2 individuals per km² for sambar. Therefore, the low density of tiger is also likely due to low prey base in STR. Thus, enhancing prey base through better habitat management (reducing biotic pressure including cattle grazing and poaching incidences) would on its own revive the prey base and eventually the tiger population. However, given the consideration of viable populations (effective breeding individual) so as to avoid inbreeding effect and ensuring genetic viability, translocation of individuals should also be considered as an additional option within STR, as relocation has been effective in reviving populations in tiger reserves (Sankar et al., 2010).

Corridor management: The STR landscape is contiguous to adjoining Sharavati valley-Dandeli-Khanapur Tiger population and thus has potential to accommodate dispersing individuals from this population. It is thus essential to preserve the corridors and additional management of the unprotected landscape that surrounds the reserve (Ekwal et al., 2009; Ranganathan et al. 2008), which would not only increase the tiger population, but will also ensure genetic flow from other populations into the reserve.

Flagship species: The tiger is identified as a flagship species and thus it is important to implement adequate conservation measures and protection to the species, which in turn can will ensure the successful survival other species that share the same ecosystem.

Pangolin

During present study, presence of the pangolin was recorded solely from their signs (burrows). Their nocturnal and secretive behaviour (Mohapatra & Panda, 2013) are reason why direct sightings of these species are not recorded.

Lack of an effective assessment method: While limited information is available on their behaviour in captivity (Kumar et al. 2014; Mohapatra et al. 2014 & 2015; Mohapatra & Panda, 2013, 2014), there are no studies on them in the wild. The Sunda pangolin (*M. javanica*) have been observed to defecate in water and some individuals dig small holes and defecate (Thai, Clark, & Phuong, 2010). This could be a behaviour that is shared with the Indian pangolin, which is why no signs of defecation were recorded of the species in the study. Pangolins had a fair distribution within the reserve with signs being recorded from 18 out of the total 47 beats.

Hunting identified as an international threat: The Indian pangolin is an endangered species (IUCN, 2017), under the A3d and A4d criteria as per the IUCN Red List criteria (ver 3.1), which classify the species specifically on the level of exploitation. IUCN states that there is a lack of population information or assessment studies on the species. Nonetheless, with data deficiency, the species status has changed from vulnerable (2008) to endangered (2017), due to degree of hunting (Baillie et al., 2014). The species is known to adapt to modified habitats and although there is no effective method to assess pangolin populations, efforts can be invested in devising methods to assess the species current population levels, ecology and natural history in STR. Priority must be given in protecting the species from hunting within and around the reserve. On one occasion, we found a burrow that had signs of hunting (Appendix VI). This emphasizes the level of threat faced by the species which requires urgent attention.

Public awareness as a tool for conservation: One of the key factors to curb instances of hunting, is to initiate and spread public awareness among the locals and villages in and around the reserve.

Wild dog

Low number of observations: Wild dog signs were recorded from only 6 beats in total. Substantial numbers were recorded from the camera trap images indicating a healthy population within the reserve. Alongside, species such as the pangolin, the wild dog is also an understudied species in India (Kamler et al., 2015). The presence of wild dog signs in all parts of the reserve indicates good habitat conditions within the reserve.

Species specific studies: Unlike most carnivores, the wild dogs have a unique social structure. They are cooperative breeders (Johnsingh, 1982; Venkataraman, 1998) and packs can sometimes be of up to 25 adults (Kamler et al., 2015). This in turn can determine the prey species, home range as well as heterogeneity of the population, and it is thus important to focus on species specific studies in order to understand their current population, ecology as well as natural history within the reserve.

Competition from large predators: The IUCN has identified, depletion of prey base as one of the major threats for the dhole (Kamler et al. 2015). studies from other regions in the Western Ghats have shown that availability of different size-class of ungulates is critical for sympatric predators to coexist in the same landscape (Karanth & Sunquist, 2000). As mentioned earlier, the overall ungulate prey density (21.8 ± 4.65 individuals/km²) is much lower when compared to other parts of the Western Ghats viz. Anamalai (72.1 individuals/km²), Mudumalai (95.6 individuals/km², including arboreal mammals) and Nagarhole (91 individuals/km²), (Karanth & Sunquist, 1995; Kumaraguru et al. 2010; Ramesh, 2010). Thus, possible threats could include competition from co-predators within the reserve. The absence of chital, a preferred prey, could force the dhole to move on to less preferable species such as sambar and gaur. In cases of unavailability of preferred prey, the dhole might kill livestock and this could lead them to fall victim to persecution and retaliatory killing, which are identified as major threats to the species within its distribution(Kamler et al. 2015).

Threats from persecution and disease: The species is classified as endangered (IUCN, 2017) by the IUCN Red List, under the C2a(i) criteria (version 3.1). Its population estimates continue to decline and subpopulations of the species are present in scarce numbers. Globally, threats observed are from persecution or retaliatory killing, and spread of diseases from domestic and feral species (Kamler et al. 2015). The absence of chital, a preferred prey, could force the dhole to move on to less preferable species such as sambar and gaur. In cases of unavailability of preferred prey, the dhole might kill livestock and this could lead them to fall victim to persecution and retaliatory killing. Although, from our study, it is hard to say that the species faces threats from disease, within the STR, measures such as monitoring feral populations around the reserve need to be implemented in order to ensure a viable population continues to exist in STR.

Four horned antelope: An endemic species to India, the four-horned antelope is among the least studied ungulates. It is classified as a vulnerable species under the C2a(i) criteria (version 3.1) of the IUCN Red List as the species is observed to be present in low densities within its subpopulations (IUCN, 2017). We were able to establish the presence of the species from just 4, of the total 47 beats sampled, substantiated by one record by direct sighting and 4 middens. Among all the other habitat types present, the species had a significant association with grasslands. This observation is in line with other studies done regions of the Western Ghats, where the species shows preference to open canopy habitats with short grass and, sparse and stunted tree growth (Baskaran et al. 2011; Krishna et al. 2008).

Preservation of grasslands and exotic weed control: Grasslands are treated as waste lands and are converted into plantation forests, however the dependence of the four horned antelope on this habitat reflects the importance of conserving grasslands as they are. Imam, Kushwaha and Singh (2009) identified the regeneration of large patches of grasslands from abandoned agriculture fields after relocation of villages from the Chandoli National Park. Grassland and

open canopy habitat species are negatively affected by habitat changes, especially by the presence of weed such as *Lantana camara* (Baskaran and Desai, 1999; Krishna et al. 2008, Baskaran et al. 2011). During the present study, presence of this weed species was not observed inside the reserve but some patches of the weed were seen around the Warna and Shivsagar dams and along the road tract in the western part of Bamnoli range. Understanding the impacts that these invasive weeds have on the STR ecosystem, as well as identifying critical regions for restoration of grasslands and open canopy habitats within the reserve need to be done in order to conserve the four-horned antelope.

South western langur

Taxonomy dispute: Until recently, the *Semnopithecus hypoleucos* was considered as a subspecies of *Semnopithecus entellus*, which is present in central and north-western regions of India (Brandon-jones, 2004). Due to the dispute in taxonomic classification, the exact distribution of the species is still unknown. As per the IUCN, the species is distributed in the Western Ghats from north of Palghat, through Karnataka and to the northern most distribution stops at southern Goa. Menon(2014), had identified two sub species with *S. hypoleucos aches* having distribution in most of south western Maharashtra, through regions along STR and into Karnataka. It is endemic to India and is a vulnerable species under the A2d criteria (version 3.1) of the IUCN red list with observed population declines in most of its range (IUCN, 2017).

Species refuge: It was the most abundant species recorded by direct sighting during the study and was present in a majority of the beats (35 out of 47 beats) with a similar density (18.8 ± 6.67 individuals/km²) found in other parts of the Western Ghats (Nagarhole 25 langur /km²), where they also among the preferred prey species for leopards (K Ullas Karanth & Sunquist, 1995), which is also a RET species. The study showed that cattle grazing negatively influenced the langur abundance in STR. Although, the exact reason for the same is still uncertain, it is likely that mere cattle grazers could disturbance factor for the langur. The STR plays a vital role in ensuring a viable population of this vulnerable and endemic species and efforts must be undertaken in order to understand possible threats to the species within the reserve.

Habitat protection: *Semnopithecus hypoleucos* showed significant positive relationship with evergreen forests, particularly the tall as well as mixture of short and medium evergreen height class. The presence of species rich and undisturbed patches of forests, in Chandoli (Kanade et al. 2008) and Koyna (Joglekar et al., 2015), has ensured the presence of a healthy population of the *Semnopithecus hypoleucos* within STR. Illegal wood cutting was observed during the study at the boundary regions of the protected area (Appendix VI), and with the species facing threat from fragmentation and habitat loss (Singh & Molur, 2008), these activities could threaten their population within STR and thus measures to control fire wood collections are needed to maintain the habitat optimal for the species.

Sambar

Major prey species: We recorded the presence of sambar in a majority of the sampled beats (38 out of 47). However, the species is found in low densities (1.6 ± 0.69 individuals/km²) than recorded in other parts of the Western Ghats viz. Nagarhole (3.4 ± 0.49 individuals/km²; Karanth & Sunquist, 1995), Anamalai (6.54 individuals/km²; Kumaraguru et

al., 2010) and in Mudumalai, (4.5 ± 0.98 individuals/km², Ramesh, 2010). Although, its density is lower than gaur (9.4 ± 2.5 individuals/km²), is still the most preferred prey, with 54% and 46% of the biomass consumed by tigers, in the dry and wet season respectively (Karanth & Sunquist, 1995) and is also a preferred prey for other RET species like leopard and dhole, among all other ungulate species in Nagarhole and Anamalai as well. It is thus crucial to establish and sustain a healthy sambar population so as to enhance large carnivore populations in STR.

Habitat and cattle pressure: Among ungulates, the sambar has a wide distribution, adapting itself to a variety of forest types and environmental conditions (Schaller, 1984). This was substantiated by the fact that the species was present throughout the reserve, showing no relationship to the habitat types categorized within this study. We found no significant relationship with cattle presence as well, which are in line with studies conducted in other regions of its distribution (Madhusudan, 2004). The species being nocturnal and predominantly a browser, unlike the diurnal and predominantly grazing nature of domestic cattle especially cows, temporal and resources partitioning could make the species to use areas disturbed by cattle.

Hunting: The sambar is classified as vulnerable by the IUCN (2017) under the A2cd, 3cd and 4cd, criteria (version 3.1) with hunting being the major threat throughout its distribution (Timmins et al., 2015). Although, no signs from hunting on sambar were observed during the study period, hunting another ungulate (wild pig) was brought to light on one instant and there were signs of hunting of other species such as the pangolin (Appendix VI). Apart from these, a considerable level of anthropogenic pressures was observed in regions along the periphery and close to villages inside the reserve during the study, for collection of firewood and NTFP products such as honey (Appendix VI). As sambar prefers to feed on fallen fruits, berries etc, collection of these items as NTFP might negatively influence the population density of sambar.

Gaur

Major prey species: The gaur was the most widespread RET species in the STR, and its presence was recorded in almost all the sampled beats (45 out of 47 beats). Distance estimates established a higher density of gaur (4.4 ± 1.92 individuals/km²) than sambar within the reserve. However, its density in STR is comparatively lower than other regions in the Western Ghats, viz. Nagarhole (5.6 individuals/km²), Anamalai (12.34 individuals/km²) and Mudumalai (9.4 ± 2.5 individuals/km²). In Bandipur, while the gaur is a principal diet of tiger (42% of total biomass consumed), it is among the least preferred prey species by leopards, and dhole (Andheria et al. 2007). A similar result was observed in Nagarhole (Karanth & Sunquist, 1995), Anamalai (Kumaraguru et al. 2010) and Mudumalai (Ramesh, 2010) as well, and this along with the low abundance of tigers in the STR could be responsible for observed higher density of gaur than sambar in STR.

Habitat loss: Although the species is adaptable, this large mammal cannot survive in human dominated landscapes, causing conflict, more recently due to habitat loss and fragmentation (Duckworth, Sankar, Williams, Samba Kumar, & Timmins, 2016). The species is primarily a grazer, and grasslands as well as Karvi patches along with plateau areas had a significant positive influence on the presence of the species in the reserve. Imam and Kushwaha (2013) were able to determine about 95% of the Chandoli National Park to have some level of

suitable habitat (based on topography, forest types, forest density and human influence). Thus, these findings underline the significance of the landscape to providing a safe refuge for the species.

Threat from feral species and livestock: The species is classified as vulnerable under the A2cd, 3cd and 4cd criteria (version 3.1) (IUCN, 2014), with hunting having a major impact throughout its distribution. The overall decline rate observed in India is considerably low as the species is culturally protected in most regions of the country (Duckworth et al., 2016). However, hunting has suppressed its densities in parts of the Western Ghats (Jathanna, Karanth, & Johnsingh, 2003). In the STR, we established a significantly negative influence of cattle on the presence of gaur. Apart from competition for food resources (Madhusudan, 2004), gaur face a potential threat from diseases like foot-and-mouth, and rinderpest, which had a devastating impact on gaur populations in southern India in 1968, transmitted by domestic cattle (Duckworth et al., 2016). During the course of field work we were also able to document some potentially diseased cattle in the reserve (Appendix VI).

Livestock on the fringes as well as inside the reserve must be monitored regularly and immunized, if necessary, as a preventive measure. The presence of feral cattle inside the reserve can have a serious impact to the wild ungulate population and efforts must be taken to eradicate the problem.

Sloth bear

Habitat loss: The sloth bear, is classified as vulnerable species under the A3c criteria (version 3.1) of the red list (IUCN, 2017), with major decline in area of occupancy and extent of occurrence being detrimental for their population size reduction (Dharaiya et al., 2016). The species was recorded in a majority of the sampled beats (35 out of 47 beats) in the STR. They were found in almost all parts of the reserve, but their presence was influenced positively by tall evergreen forests as compared to the other habitats classified in the study. Although, the species is an omnivore, predominantly feeds on fruits and in the absence of fruits, it sustains with insects especially ants and termites (Baskaran 1990; Baskaran et al. 1991; Desai and Baskaran, 1996; Baskaran et al. 2015). Among the habitats available in STR, evergreen forests could support a higher number of fruit bearing trees and the observed influence of evergreen forests thus be attributed to higher fruit abundance than the rest of the habitats in STR.

The occurrence of forest fires is not uncommon in the STR, and has been observed multiple times during the study period (Appendix VI). Forest fires can have a significant impact on the food resources available for the species (Baskaran et al. 2015) and fire management requires attention. Due to their secretive nature and lack of research on the species in the region, species specific studies must be undertaken in order to understand their ecology, diet, distribution and natural history.

Public Awareness: Sloth bear are dependent on termites, ants, fruits and honey for food termites (Baskaran 1990; Baskaran et al. 1991; Desai and Baskaran, 1996; Baskaran et al. 2015). Over exploitation and illegal collection of honey especially, which was observed during the study period (Appendix VI), can reduce availability of these resources for the species. Garshelis *et al.*, (1999), has discussed the effect of diminishing food supply on the reproduction of the sloth bear, and increasing the possibility of bears straying into croplands for food, thus resulting into conflict. Although a secretive species, Garshelis *et al.*, (1999)

further discusses the aggressiveness and low tolerance the species has toward humans. Human bear conflict has resulted the sloth bear to be one of the most miss understood species and awareness can help avoid conflict as well as prevent illegal collection of forest products.

Leopard

The leopard is classified under the A2dc criteria (version 3.1) of the red list (IUCN, 2017), with threats due to decline in its area of occupancy, by habitat loss and fragmentation, and persecution from human leopard conflict at the forefront (Stein et al. 2016).

Habitat loss and degradation: The species presence was detected by signs alone in 22 of the 47 beats sampled. The species showed no significant influence from the habitat types classified in the study. Leopard distribution is dependent on availability of prey and not specific to habitat type (Stein et al., 2016). The leopards prey on a range of species including ungulates, primates, rodents, jungle fowl, reptiles and frogs (Stein et al. 2016). Medium-sized ungulate species viz. sambar, chital, wild pig and barking deer are the principal diet, where prey species are abundant (Adheria et al. 2007; Karanth & Sunquist, 1995; Kumaraguru et al. 2010; Ramesh, 2010). In regions, where these prey species are less abundant, especially in areas of close proximate to human settlements, they kill livestock and goats (Athreya, 2013; Athreya, 2007), thus giving rise to human-leopard conflict. Among major prey species, gaur, sambar, barking deer, four-horned antelope and wild pig have been recorded within the study area. The overall ungulate prey density estimated by the study (21.8 ± 4.65 individuals/km²) is much lower as compared to other parts of the Western Ghats viz. Anamalai (72.1 individuals/km²), Mudumalai (95.6 individuals/km², including arboreal mammals) and Nagarhole (91 individuals/km²). The chital is the major prey of leopards in other regions of the Western Ghats, which is absent in the STR.

Conflict and translocation: Current management practices in conflict situations, implies that problem individuals are captured and translocated from problem areas into the forest areas, where conflict there is no conflict or very minimal. In practice of this, during the course of the study, on a couple of occasions, leopards captured elsewhere from conflict areas were released in the reserve (Appendix VI). Athreya et al. (2010) discusses the negative impacts of leopard translocation, both, on the animal and the people living along the areas, where the leopard is released, especially when translocation is done not far from the capture site. These factors are influenced the spatial ecology (territoriality) of the species.

It is thus necessary to study the existing leopard population within the STR, especially their spatial ecology. Camera trap capture recapture method can help understand abundance as well as distribution and home ranges of the existing population. It is essential to make sure that there is adequate prey base available within the reserve in order to accommodate more individuals.

Even with adequate prey base in the translocated areas, individuals that can't sustain with wild prey due to age factors or health issues might end up into conflict in the newly translocated locations too and hence background details about the conflict nature of individual also needs to be taken into account in such management steps.

The Guidelines for human-leopard conflict management (2011) provides all the essential details to follow with regard to conflict and translocation. Ensuring that guidelines have been strictly followed during translocation is of utmost importance, as it ensures the well-being of the animal, during translocation, and its future interactions with humans after

release. It may also be suggested that, the forest department must verify that all measures were taken to avoid conflict, and translocation was the last resort, prior to accepting the release of these individuals into the reserve.

Post release animal movements and behaviour into the reserve should be also closely monitored to understand effects of translocation and assess their conditions in the new area.

Giant squirrel

The giant squirrel is an endemic species to India and is present in isolated patches throughout its range (Molur, 2016). A density of 7.1 ± 3.44 individuals/km² was estimated in STR from the study. The species was present in 28 out of the total 47 beats, and it was positively influenced by evergreen forests of the tall, and the medium and tall mix height class. Density estimates from similar kind of habitats in other regions of the Western Ghats, viz. Anamalai (11 individuals/km²), Alkeri (5.5 individuals/km²), and Nalkeri (8.5 individuals/km²) in Nagarhole, and Bhadra (11.35 individuals/km²) (Jathanna, Kumar, & Karanth, 2008; Madhusudan & Karanth, 2000; Umapathy & Kumar, 2000) but higher than estimated in deciduous habitats of Mudumalai (2.9 ± 0.31 individuals/km², Baskaran et al. 2011).

Habitat loss: It is suggested that the Indian giant squirrel, is an indicator of undisturbed closed canopy forests with high diversity (Borges, Mali, & Ranganathan, 1992; Thorington & Cifelli, 1990), and is dependent on these habitats alone (Jathanna et al., 2008). Mehta *et al.*, (2012) observed minimum biotic pressure on the species in Koyna and Chandoli, as compared to the surrounding regions and identified the status of being a protected area to facilitate this. The study also identified tree cutting and lopping to influence giant squirrel occupancy. During the course of the study, instances of illegal tree cutting were observed occasionally along areas close to human habitation (Appendix VI). These identified threats should be forbidden completely, as it can have a great impact on the giant squirrel population in the STR.

Mouse deer

The mouse deer is an endemic species to India, although occasional sightings have been recorded from Nepal and Bhutan (Duckworth & Timmins, 2015). Its population is understudied and its status in most of its distribution is poorly known (Krishnan, 1972; Kumara, 2004; Raman, 2004). The species is frequently recorded in KMTR, Periyar tiger reserve, Anamalai tiger reserve, silent valley, Mudumalai-Bandipur-Nagarhole, Bhadra and Kudremukh (Duckworth & Timmins, 2015). Within the STR, the presence of the species was positively influenced by medium high evergreen forests, as compared to other habitat types. In other regions of the Western Ghats, the species is found in moist deciduous, semi evergreen, evergreen and even in anthropogenically disturbed areas, such as plantation, rural gardens and degraded forests (Duckworth & Timmins, 2015). Very little is known about the ecology and behaviour of the species and their habitat relationship. Species specific studies within the STR can provide a better understanding of the distribution, ecology, abundance and natural history of the species.

Hunting: Throughout its distribution, hunting is a major threat to the species (Raman, 2004). The species is not only hunted as prey by wild predators but also fall easy prey to feral dogs. From an interview survey, Madhusudan and Karanth (2002), concluded that majority (78%)

of hunters, hunted mouse deer the most, and hunters themselves identified hunting as the most important factor for decline in abundance. Protected areas thus provide a refuge for the species.

No instance of hunting of the mouse deer was found during the study. However, in regions along the periphery of villages in Rasati, we stumbled upon wire snares and nooses. Sighting of feral dogs was also not uncommon within the protected area (Appendix VI). Identifying these areas and eliminating these threats are of utmost importance to protect the mouse deer in the reserve.

Brown palm civet

This endemic species is restricted to the Western Ghats and was previously believed to be rare. Studies have found that the brown palm civet is present exclusively in evergreen forests (Mudappa et al., 2016). The northern-most reach of its distribution documented by IUCN (2017), falls just below Koyna Wildlife Sanctuary, possibly cut off by the Karad-Chiplun state highway. The species was opportunistically sighted only once, during the study period, in Rundiv south, and camera-trap data has recorded it multiple times in parts of Chandoli, while no records were obtained from Koyna. With little research done on its ecology and abundance throughout its range (Ashraf et al., 1993; Mudappa, 2001; Mudappa, 2007, 2010; Rajamani et al., 2002), the distribution of the species within STR is not clearly known. Species specific studies would give us a better understanding on spatial ecology, abundance and threats the brown palm civet face within STR.

Bonnet macaque

Bonnet macaque is endemic to peninsular India, and there have been two subspecies identified throughout its distribution, with *Macaca radiata radiata* to be present in the STR. Although the species is abundant throughout its range, they are rarely reported from interior forests (Molur et al., 2003; Sinha, 2001). During the present study, the species was encountered by direct sighting once in Tambawe and once in Siddeshwar. The record of the species in Siddeshwar holds significance, as this area is devoid of any anthropogenic presence. Although the species is dominant in human landscapes, there has been a significant decline recorded in parts of its distribution (Singh & Rao, 2004). With rapid urbanization and change in land-use activities, as well as the conflict and crop raiding (Sinha, 2001) outside protected areas. Molur et al., (2003) identified protected area to be crucial in conservation management of the species. Studying the bonnet macaque ecology and behaviour in the STR can provide useful insights into measures that can suggest sustaining populations away from human dominant landscapes.

5.3 Herpetofauna results and discussion

5.3.1 Documentation of herpetofauna

In total, the survey identified 66 species of herpetofauna belonging to 44 genera, 21 families (Table 9) with four species listed in the threat category of as IUCN Red List (IUCN Red List 2017). Of the 66 species, amphibian (22 species), lizard (20 species) and snakes (24 species) consisting each almost one third of the total numbers (Tables 10 to 12). It is important to note that the STR landscape is home for four IUCN Red Listed amphibian species, which includes one critically endangered species (*Pseudophilautus amboli* Biju & Bossuyt, 2009), two endangered species (*Xanthophryne koynayensis* Soman, 1963; *Uperodon mormorata* Rao, 1937) and a vulnerable species (*Nyctibatrachus humayuni* Bhaduri & Kripalani, 1955).

Table 9: Number of herpetofauna species recorded in Sahyadri Tiger Reserve, Northern Western Ghats during November 2016 - July 2017

Classification	No. of species	Genus	Family	IUCN Red Listed species
Amphibians	22	16	8	04
Lizards	20	8	5	--
Snakes	24	20	8	--
Over all	66	44	21	04

Table 10: Amphibians recorded from STR, November 2016 - July 2017.

S. No.	Family	Species Name	IUCN Red List Status
1	Indotyphlidae	<i>Indotyphlus maharashtraensis</i>	Data Deficiency
2	Bufonidae	<i>Duttaphrynus melanostictus</i>	Least Concern
3		<i>Xanthophryne koynayensis</i>	Endangered
4			
5	Dicroglossidae	<i>Euphlyctis cf. karaavali</i>	Not Assessed
6		<i>Euphlyctis cf. mudigere</i>	Not Assessed
7		<i>Fejervarya cepfi</i>	Not Assessed
8		<i>Fejervarya cf. caperata</i>	Not Assessed
9		<i>Fejervarya syhadrensis</i>	Least Concern
10		<i>Hoplobatrachus tigerinus</i>	Least Concern
11		<i>Hoplobatrachus crassus</i>	Least Concern
12		<i>Sphaerotheca pashchima</i>	Not Assessed
13			
14			
15	Microhylidae	<i>Microhyla laterite</i>	Not Assessed
16	Microhylidae	<i>Microhyla sp.</i>	Least Concern
17		<i>Uperodon mormorata</i>	Endangered
18			
19	Ranidae	<i>Hydrophylax bahuvistara</i>	Not Assessed
20		<i>Indosylvirana caesari</i>	Not Assessed
21	Ranixalidae	<i>Indirana chiravasi</i>	Not Assessed
22	Rhacophoridae	<i>Raorchestes ghatei</i>	Not Assessed
23		<i>Polypedates maculatus</i>	Least Concern
24		<i>Pseudophilautus amboli</i>	Critically Endangered
25	Nyctibatrachidae	<i>Nyctibatrachus sp.</i>	
26		<i>Nyctibatrachus humayuni</i>	Vulnerable

Table 11: Lizards recorded from STR, November 2016 - July 2017.

S. No.	Family	Species Name	IUCN Red List Status
23	Gekkonidae	<i>Hemidactylus frenatus</i>	Least Concern
24		<i>Hemidactylus flaviviridis</i>	Not Assessed
25		<i>Hemidactylus cf. gleadowi</i>	Not Assessed
26		<i>Hemidactylus murrayi</i>	Not Assessed
27		<i>Hemidactylus maculatus</i>	Least Concern
28		<i>Hemidactylus leschenaultii</i>	Not Assessed
29		<i>Hemidactylus triedrus</i>	Not Assessed
30		<i>Cnemaspis girii</i>	Not Assessed
31		<i>Cnemaspis sp.</i>	
32		<i>Cyrtodactylus deccanensis</i>	Least Concern
33	Agamidae	<i>Calotes cf. versicolor</i>	Not Assessed
34		<i>Calotes rouxi</i>	Not Assessed
35	Scincidae	<i>Eutropis carinata</i>	Least Concern
36		<i>Eutropis allapallensis</i>	Not Assessed
37		<i>Lygosoma guentheri</i>	Least Concern
38		<i>Lygosoma lineata</i>	Least Concern
39		<i>Lygosoma punctata</i>	Not Assessed
40	Lacertidae	<i>Ophisops beddomei</i>	Least Concern
41		<i>Ophisops cf. jerdonii</i>	Least Concern
42	Varanidae	<i>Varanus bengalensis</i>	Not Assessed

Table 12: Snake recorded from STR, November 2016 - July 2017.

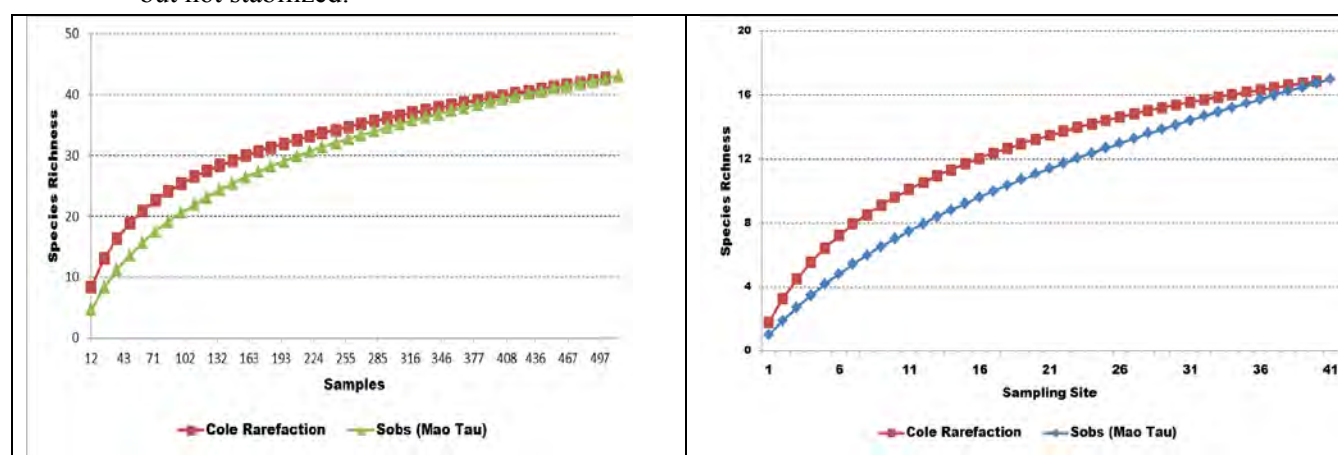
S. No.	Family	Species Name	IUCN Red List Status
43	Typhlopidae	<i>Indotyphlops braminus</i>	Not Assessed
44	Uropeltidae	<i>Uropeltis macrolepis</i>	Least Concern
45	Erycidae	<i>Eryx conicus</i>	Not Assessed
46	Pythonidae	<i>Python molurus</i>	Not Assessed
47	Colubridae	<i>Ahaetulla cf. nasuta</i>	Not Assessed
48		<i>Ptyas mucosa</i>	Not Assessed
49		<i>Oligodon taeniolatus</i>	Not Assessed
50		<i>Boiga trigonata</i>	Least Concern
51		<i>Boiga beddomei</i>	Data Deficiency
52		<i>Coelognathus h. monticollaris</i>	Not Assessed
53		<i>Lycodon aulicus</i>	Not Assessed
54		<i>Xenochrophis piscator</i>	Not Assessed
55		<i>Dendrelaphis tristis</i>	Not Assessed
56		<i>Dendrelaphis girii</i>	Least Concern
57		<i>Dendrelaphis chairecacos</i>	Data Deficient
58	Natricidae	<i>Amphiesma stolatum</i>	Not Assessed
59		<i>Hebius beddomei</i>	Least Concern
60		<i>Macropisthodon plumbicolor</i>	Not Assessed

61	Viperidae	<i>Daboia russelii</i>	Not Assessed
62		<i>Echis carinatus</i>	Not Assessed
63		<i>Trimeresurus malabaricus</i>	Least Concern
64		<i>Trimeresurus gramineus</i>	Least Concern
65	Elapidae	<i>Naja</i>	Not Assessed
66		<i>Bungarus caeruleus</i>	Not Assessed

5.3.1.1 Species accumulation curves

The species accumulation curves for visual encounter survey (Figure 9a) and quadrature method (Figure 9b) shows that the curves have not yet stabilized, implying that a longer period of sampling and specifically during the monsoons would yield more species. The accumulation curves in both methods continue to show increasing trend despite 41 sampling location surveyed in VES and 274 plots in SPS methods. Cole rarefaction curve, which shows probability and sample precision and Sobs (mau tau) curve, which is an index of actual richness from the dataset, though merged but not saturated. Figure 9a showing in the VES method 497 samples yielded 44 species and Figure 9b showing in the plot survey method 41 samples yielded only 17 species. These trends in species accumulation curve clearly indicate that the current effort is inadequate and given more sampling efforts or replicates, the species richness would go up and hence the recorded 66 species should be considered as minimum number of species. Therefore, to present a more comprehensive checklist, we included species recorded from earlier studies (Anonymous, 1974, Padhye & Ghate 2012 & TCP 2014) in around the STR (Appendix II).

Figure 9: Species accumulation curves (a) visual encounter (figure at left) and (b) systematic quadrature survey method (figure at right) though showing merged Cole rarefaction and Sobs curves, but not stabilized.



Of the total of 66 species of herpetofauna recorded from the present study in Sahyadri Tiger Reserve, 27 are endemic species to Western Ghats (Table 13). An additional 13 species have been added to the endemic list based on literature review (Anonymous, 1974, Padhye & Ghate 2012 & TCP 2014). Of the 40 species endemic to STR, 25% (n = 10) species were endemic to Northern Western Ghats. Amphibians accounted the highest number (25 species) of endemic species to Western Ghats; in which six species are endemic to northern Western

Ghats. Lizards seven species endemic to Western Ghats with three species are endemic to Northern Western Ghats and among snakes eight species endemic to Western Ghats; with one species endemic to northern Western Ghats. A species-wise list of endemic species is shown in Table 14, 15, 16.

Table 13: Summary of endemic species recorded from STR.

Classification	Endemic to Western Ghats (including earlier reports)	Endemic to Northern Western Ghats
Amphibians	15 (25)	4 (6)
Lizards	6 (7)	2 (3)
Snakes	6 (8)	1 (1)
Overall	27 (40)	7 (10)

Table 14: Endemic amphibian species from STR

S. No.	Species	Endemic to WG	Endemic to NWG	From the present study	From earlier literature
1	<i>Indotyphlus maharashtraensis</i>	+	+	+	Padhye & Ghate 2012; TCP, 2014
2	<i>Ichthyophis bombayensis</i>	+	-	-	Padhye & Ghate 2012 and Yadav et al.2014
3	<i>Xanthophryne koynayensis</i>	+	+	+	Padhye & Ghate 2012
4	<i>Pedostibes tuberculosus</i>	+	-	-	Dahanukar et al., 2004 & Padhye & Ghate 2012
5	<i>Euphlyctis cf. karaavali</i>	+	-	+	Gururaja et al.2016
6	<i>Euphlyctis cf. mudigere</i>	+	-	+	Joshy et al.2009
7	<i>Fejervarya cepfi</i>	+	-	+	Garg & Biju 2017
8	<i>Fejervarya cf.caperata</i>	+	-	+	Subramanian et al.2013
9	<i>Fejervarya brevipalmata</i>	+	-	-	Padhye & Ghate 2012
10	<i>Sphaerothercapa shchima</i>	+	-	+	Pathye et al.2017
11	<i>Microhyla laterite</i>	+	-	+	Seshadri et al.2016
12	<i>Uperodon mormorata</i>	+	-	+	Subramanian et al.2013
13	<i>Uperodon montanus</i>	+	-	-	Anonymous, 1974 and Padhye & Ghate 2012
14	<i>Hydrophylax bahuvistara</i>	+	-	+	Padhye et al.2015
15	<i>Indosylvirana temporalis</i>	+	-	-	Padhye & Ghate 2012
16	<i>Indosylvirana caesari</i>	+	+	+	Biju et al.2014
17	<i>Indirana beddomii</i>	+	-	-	Anonymous, 1974 and Padhye & Ghate 2012
18	<i>Indirana leithii</i>	+	+	-	Anonymous, 1974 and Padhye & Ghate 2012
19	<i>Indirana chiravasi</i>	+	-	+	Pathye et al.2014
20	<i>Raorchestes ghatei</i>	+	-	+	Pathye et al.2013
21	<i>Raorchestes bombayensis</i>	+	-	-	Anonymous, 1974 and

					Padhye & Ghate 2012
22	<i>Raorchestes tuberochumerus</i>	+	-	-	Padhye & Ghate 2012
23	<i>Pseudophilautus amboli</i>	+	+	+	Padhye & Ghate 2012
24	<i>Nyctibatrachus humayuni</i>	+	-	+	Anonymous, 1974 and Padhye & Ghate 2012
25	<i>Nyctibatrachus danieli</i>	+	+	-	Padhye & Ghate 2012

Table 15: Endemic lizard species from STR

S. No.	Species	Endemic to WG	Endemic to NWG	Present study	Literature
26	<i>Hemidactylus prashadi</i>	+	-	-	Anonymous, 1974 & TCP 2014
27	<i>Cyrtodactylus deccanensis</i>	+	+	+	Anonymous, 1974 & TCP 2014
28	<i>Cyrtodactylus albofasciatus</i>	+	-	+	Anonymous, 1974 & TCP 2014
29	<i>Cnemaspis girii</i>	+	+	+	Mirza et al.2014
30	<i>Cnemaspis kolhapurensis</i>	+	+	+	Anonymous, 1974 & TCP 2014
31	<i>Calotes rouxi</i>	+	-	+	Anonymous, 1974 & TCP 2014
32	<i>Ophisops beddomei</i>	+	-	+	Anonymous, 1974 & TCP 2014

Table 16: Endemic snake species from STR

S. No.	Species	Endemic WG	Endemic to NWG	present study	Literature
33	<i>Uropeltis macrolepis</i>	+	+	+	Anonymous, 1974 & TCP 2014
34	<i>Uropeltis phipsonii</i>	+	-	-	Anonymous, 1974 & TCP 2014
35	<i>Eryx whitakeri</i>	+	-	-	Whitaker & Captain 2004
36	<i>Coelognathus h. monticollaris</i>	+	-	+	Anonymous, 1974 & TCP 2014
37	<i>Dendrelaphis girii</i>	+	-	+	Vogel & Van Rooijen, 2011
38	<i>Dendrelaphis chairecacos</i>	+	-	+	Ganesh & Chandramouli 2012
39	<i>Hebius beddomei</i>	+	-	+	Anonymous, 1974 & TCP 2014
40	<i>Trimeresurus malabaricus</i>	+	-	+	Anonymous, 1974 & TCP 2014

5.3.2 RET Species proposed for the Sahyadri Tiger Reserve

The present study proposed the following 14 species as the RET for the Sahyadri Tiger Reserve (Table 17). Species with higher score indicate that they while being endemic are also part of Red List category and thus have higher priority for conservation planning and management of their habitats. Among the 14 species, amphibians accounted the highest number of species (7 species) followed lizard (4 species), snake (2 species) and turtle (1 species).

Table 17: List of RET species proposed for Sahyadri Tiger Reserve (* these species are from earlier literature)

S. No.	Species	E.W.G	E.N.W.G	IUCN	Scoring	Present study
Amphibia						
1	<i>Pseudophilautus amboli</i>	1	2	4	7	yes
2	<i>Xanthophryne koynayensis</i>	1	2	3	6	yes
3	<i>Pedostibes tuberculosus</i>	1	0	3	4	no*
4	<i>Indotyphlus maharashtraensis</i>	1	2	0	3	yes
5	<i>Indosylvirana caesari</i>	1	2	0	3	yes
6	<i>Indirana leithii</i>	1	2	2	5	no*
7	<i>Uperodon marmorata</i>	1	0	3	4	yes
Testudines						
8	<i>Nilssonial eithii</i>	0	0	2	2	no*
Lizards						
9	<i>Crocodylus palustris</i>	0	0	2	2	no*
10	<i>Cnemaspis girii</i>	1	2	0	3	yes
11	<i>Cnemaspis kolhapurensis</i>	1	2	0	3	yes
12	<i>Cyrtodactylus deccanensis</i>	1	2	0	3	yes
Snakes						
13	<i>Uropeltis macrolepis</i>	1	2	0	3	no*
14	<i>Uropeltis phipsonii</i>	1	0	2	3	no*

5.3.3 Recommendations for conservation planning

5.3.3.1 Spatial distribution of herpetofauna richness and diversity in Sahyadri Tiger Reserve

The overall herpetofauna richness and diversity, was similar among the four ranges of STR. However, the Chandoli range harbours higher species richness and diversity, followed by Bamnoli and Helwak. Areas in Konya range had lowest species richness and diversity (Table 18). Although, between the two methods viz. visual encounter method and systematic quadrat method, the actual values of richness and diversity varied remarkably, but trends in species richness and diversity did not vary between two methods indicating that these parameters can be considered in either method. Based on the overall species richness, we found that all the four ranges supporting almost equal number of species, as richness ranged

21-23 species. Similarly, on the basis of herpetofauna diversity there was no significant difference among the four ranges (range 2.35-3.00) with Chandoli had the highest diversity followed by Bamnoli, Helwak and Koyna. While in terms of RET species, Koyna (5 species), followed by Chandoli (4 species), Bamnoli (3 species) and Helwak had no RET species. Although our sampling efforts in all the four ranges were comparable excepting for the Bamnoli (Table 9), Helwak range showing no RET species indicates that the areas in this range not supporting the ecological requirements of the RET species. Thus, considering the herpetofauna overall richness, and diversity and RET species distribution, areas in Chandoli and Koyna ranges appear most suitable for herpetofauna both in terms of RET species and overall herpetofauna diversity.

Table 18: Spatial variation of overall herpetofauna species richness and diversity estimated for Sahyadri Tiger Reserve

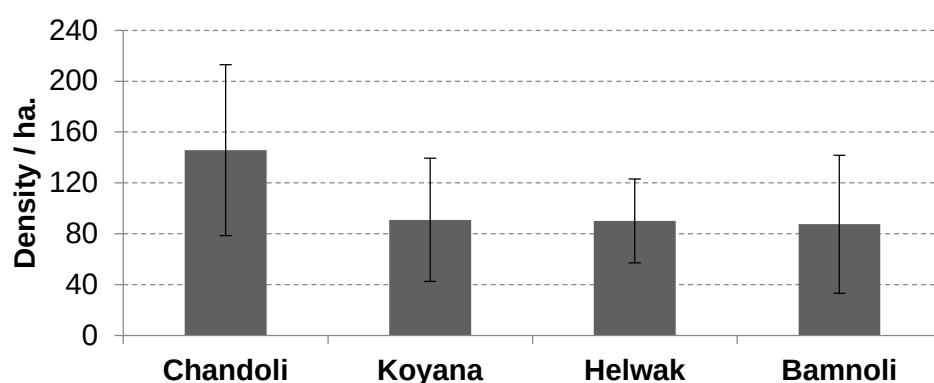
Sample Range	Species Richness*			Shannon H	
	RET	VES	Quadrant	VES	Quadrant
Bamnoli	3	21	6	2.65	1.75
Chandoli	4	23	9	3.00	2.10
Helwak	0	22	8	2.53	1.75
Koyna	5	22	5	2.35	1.45

* To have a holistic approach, the study also considered the total herpetofauna species richness and diversity apart from RET species.

5.3.3.2 Spatial distribution of herpetofauna abundance in Sahyadri Tiger Reserve:

Density of herpetofauna estimated based on systematic plot method showed that Chandoli had the highest followed by Koyna and Helwak and Bamnoli (Figure 10). However, the overlaps in standard errors among the four ranges indicate that the density difference observed among the four ranges is not statistically significant. The result indicates that all the four ranges are equally important for the conservation of all herpetofauna.

Figure 10: Spatial distribution in the density of herpetofauna estimated using systematic plot method for the Sahyadri Tiger Reserve



A total of 290 species of herpetofauna are known within the limits of Western Ghats falling in the political boundaries of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu states, of which 157 anurans and 26 caecilians (Gymnophiona) are endemic to Western Ghats (Subramanian et al. 2013 & Dinesh et al. 2011). In case of reptile 107 species (47%) are endemic to Western Ghats and 50 species (22%) are endemic to peninsular India (Srinivasaulu et al. 2014). The present study and existing records show that the Sahyadri harbours 40 endemic species (Table 14, 15, 16), which constitutes 0.72% of the total Western Ghats endemism. The northern dry forest eco-regions in the study area contributes a substantial proportion of the high herpetofauna diversity and endemism recorded (Garcia, 2016). The 14 RET species, which include amphibians: *Pseudophilautus amboli*, *Xanthophryne koynayensis*, *Pedostibes tuberculosus*, *Indotyphlus maharashtraensis*, *Indosylvirana caesari*, *Indirana leithii*, and *Uperodon mormorata* and reptiles species: *Nilssonia leithii*, *Crocodylus palustris*, *Cnemaspis girii*, *Cnemaspis kolhapurensis*, *Cyrtodactylus deccanensis*, *Uropeltis macrolepis* and *Uropeltis phipsonii* and of these, one critically endangered species (*Pseudophilautus amboli*), two endangered species (*Xanthophryne koynayensis* and *Pedostibes tuberculosus*) and four vulnerable species (*Indirana leithii*, *Nilssonia leithii*, *Crocodylus palustris* and *Uropeltis phipsonii*) were recorded from Sahyadri Tiger Reserve (Table 17). The inclusion of a few species from the earlier literature is due to the reason that the present study has sampled the herpetofauna during off season and considering species identified in recent studies could overcome lacuna of sampling time.

5.3.3.3 Macro and Micro-habitat utilized by Herpetofauna species in STR

The present study has recorded amphibian species in various macro habitats of Sahyadri Tiger Reserve (Figure 11). The habitat dry deciduous support 92 individuals and following grassy habitats support 46 individuals, semi evergreen 15 individuals, river bank 13 individuals, eucalyptus plantation 2 individuals and plateaus 1 individual. Since the data was collected during off season it shows most of the individual has encountered in Deciduous and Grass land probably for body thermoregulation and avoiding dense shadow place. However, the present study also has recorded four red list amphibian species in semi evergreen habitats (*Pseudophilautus amboli*, *Xanthophryne koynayensis*, *Indotyphlus maharashtraensis* and *Indosylvirana caesari*, one species has recorded in deciduous habitat (*Uperodon mormorata*) and one species has recorded from evergreen habitat (*Indotyphlus maharashtraensis*) (Anonymous 1978). The macro-habitat utilized by reptile species (Figure 12).

Figure 11: Macro- Habitats Utilized by amphibian species.

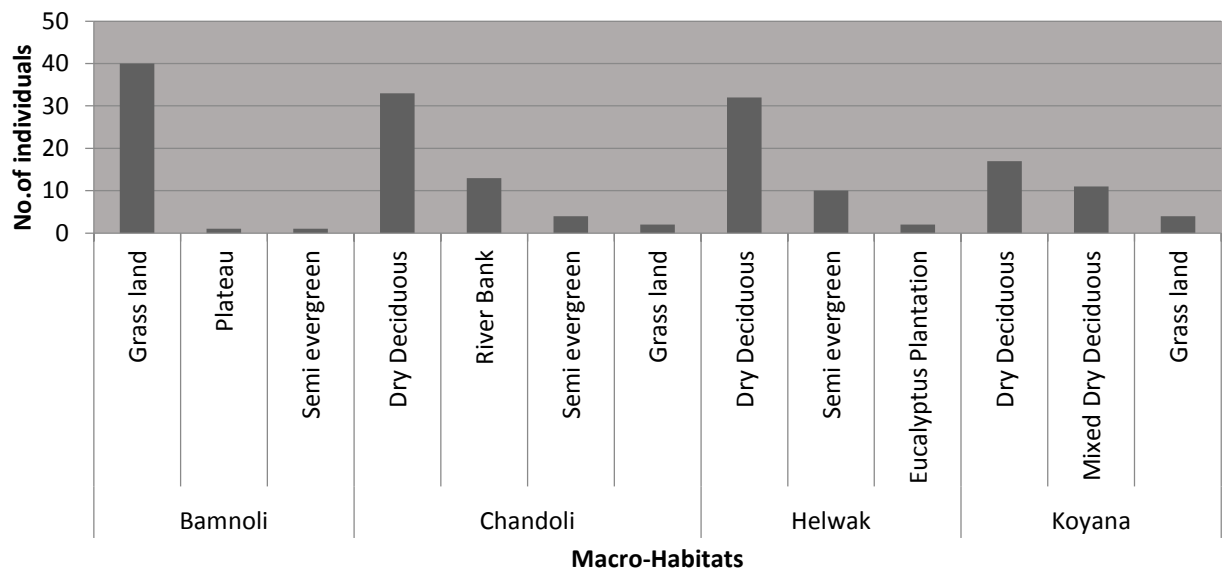


Figure 12: Macro- Habitats utilized by reptile species

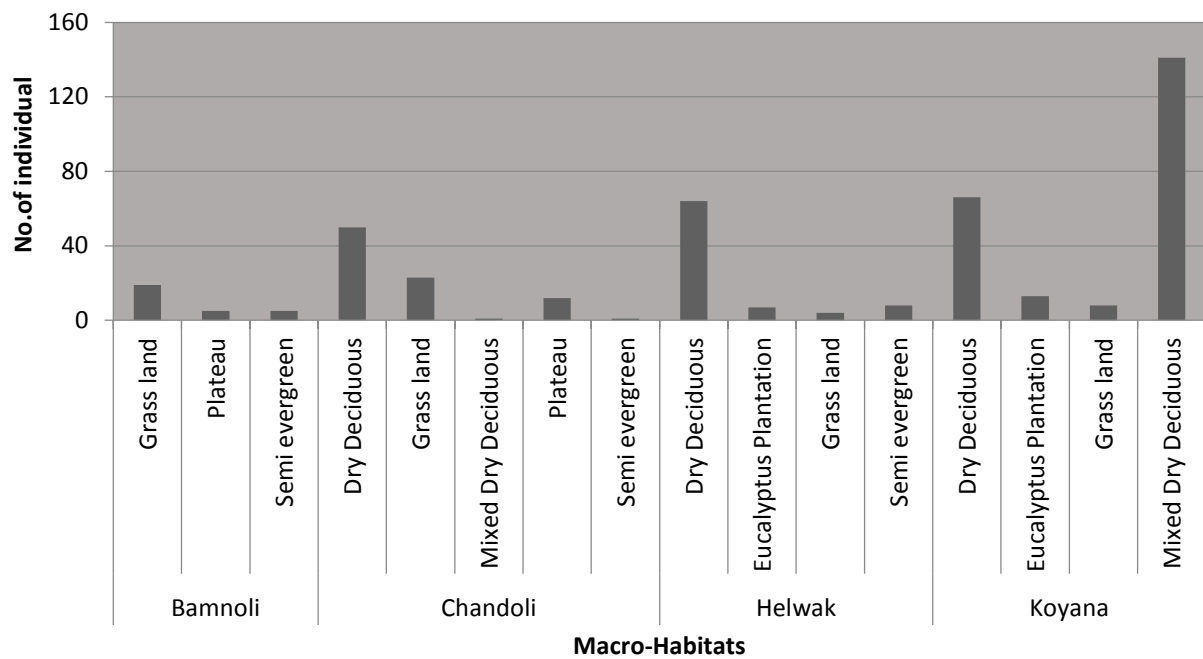


Figure 13: Micro-Habitat utilized by amphibian species.

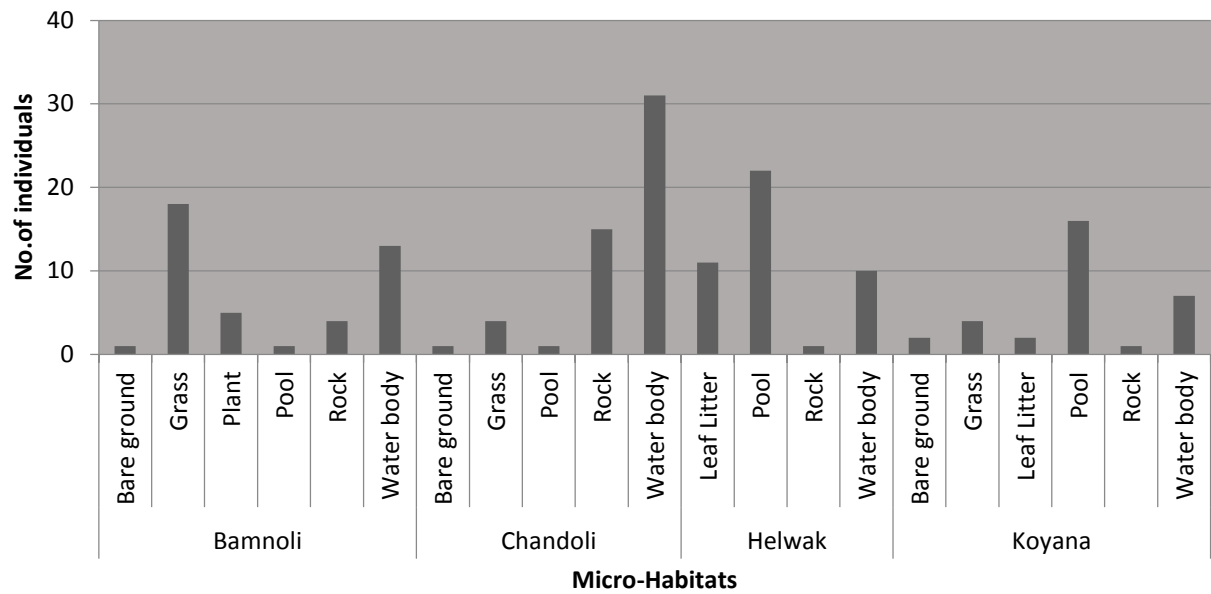
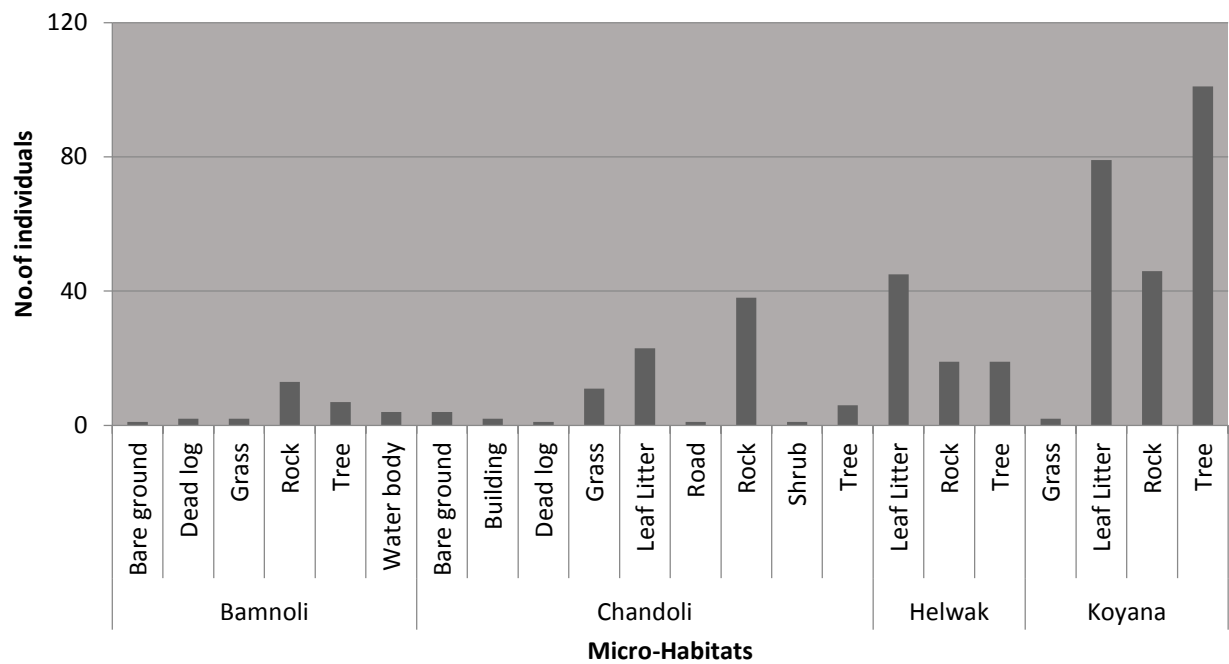
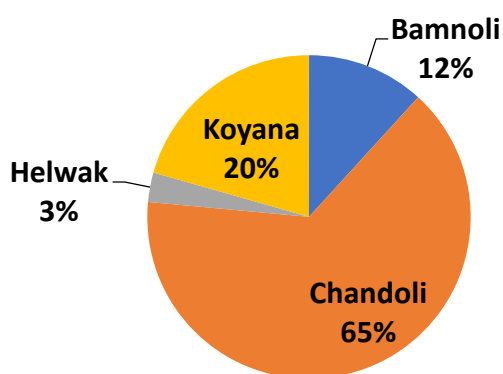
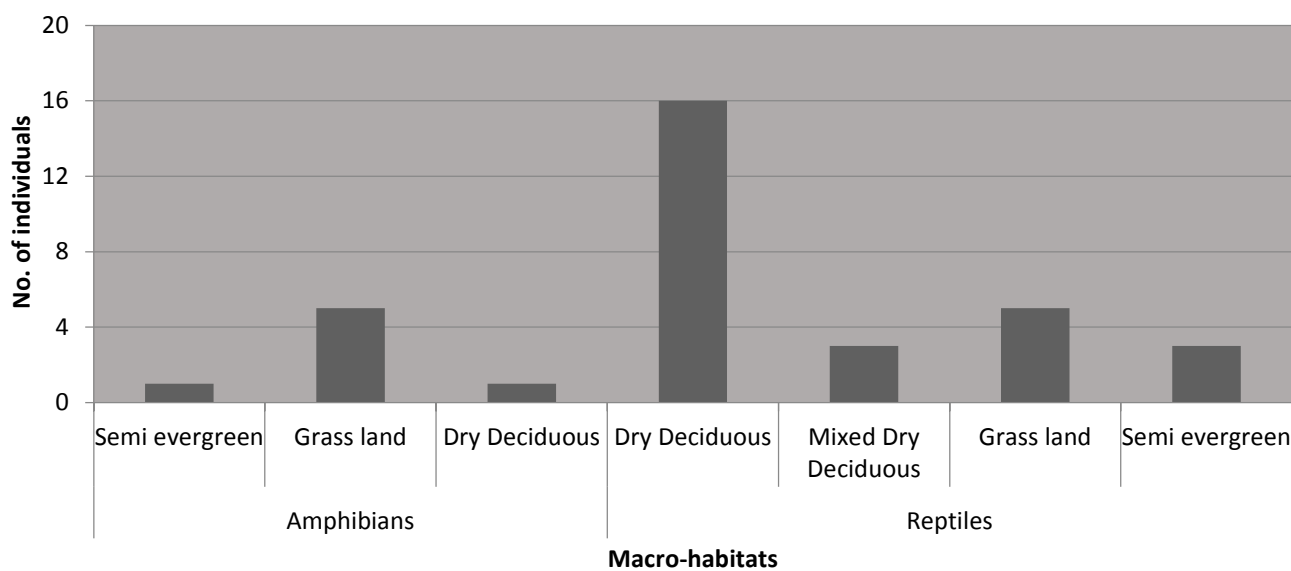


Figure 14: Micro-habitat utilized by reptile species



The graph shown most of the individuals has recorded in deciduous habitat (322) and following grassy (54), Eucalyptus Plantation (20), plateaus (17) and semi evergreen 15 individuals. The deciduous habitat supporting 19 individuals and spanning 2 genera (*Cnemaspis girii* and *Cyrtodactylus deccanensis*) and following grassy land supporting 5 individuals and spanning 2 genera (*Cyrtodactylus deccanensis* and *Uropeltis macrolepis*) and semi evergreen habitat supporting 5 individuals and spanning 2 genera (*Cyrtodactylus deccanensis* and *Uropeltis macrolepis*).

Figure 15: Macro-habitat utilized by RET herpetofauna species in STR



Micro-habitats of amphibians quite unpredictable (amphibians very sensitive in nature) because due to atmosphere temperature and humidity they tend to move following major micro-habitat component viz Bare ground, grass, leaf litter, plant, pool (puddles), water bodies and rock. The present study has come across various micro-habitats utilized by amphibian species (Figure 13) in Sahyadri Tiger Reserve. In terms of amphibians one of the commonest habitat water bodies (perennial or temporary) 61 individuals and spanning 7 genera and following small puddles (pools) 40 individuals and spanning 5 genera, grass 26 individuals and spanning 5 genera, rock 21 individuals and spanning 6 genera, leaf litter 13 individuals and spanning 3 genera, plant 5 individuals and spanning 1 genera. Finally, bare ground 4 individuals and spanning 3 genera.

The reptile niche slightly varies from amphibians due to nature of the body and biological component. The (Figure 14) shown the micro-habitats utilized by reptile species in Sahyadri tiger reserve. The dominant niche was leaf litter has encountered 147 individuals and spanning 11 genera and following tree 133 individuals and spanning 9 genera, rock 116 individuals and spanning 14 genera, grass 15 individuals and spanning 5 genera, bare ground 5 individuals and spanning 4 genera, water bodies 4 individuals and spanning 2 genera, dead logs or fallen logs 3 individuals and spanning 3 genera and (Figure 15) indicating the red list reptile and amphibians recorded in various macro-habitat of STR. The habitat deciduous harvesting 19 individuals and spanning 3 genera and following grassy land 10 individuals and spanning 5 genera. Finally, the habitat semi ever green harvesting 5 individuals and spanning 2 genera. This micro habitat level assessment one of the systemic ways to assess the herpetofauna species assemblage and the species composition would bring the future Nano scale assessment of herpetofauna in Sahyadri Tiger Reserve.

5.3.3.4 Conservation Planning for Herpetofauna of STR

Identifying key areas that harbour significant biodiversity of the landscape helps park managers or policy makers together with other information such as cost, to determine priorities or planning for conservation (Pearlstone et al., 2002; Sarkar and Margules, 2002; Williams et al., 2002; Matsuda et al., 2003; Rey Benayas and de la Montaña, 2003; Rodrigues et al., 2004) and take measures to reduce pressure from anthropogenic factors if any on the biodiversity (Baskaran et al. 2012). Often, researchers identify such areas based on criteria such as species richness, rarity (particularly endemic taxa), taxonomic uniqueness, threatened species, representativeness, and indicator taxa (Kirkpatrick, 1983; Usher, 1986; Williams et al., 1991; Prendergast et al., 1993; Faith and Walker, 1996; Castro et al., 1997; Reid, 1998; Rey Benayas et al., 1999; Williams and Araujo, 2000; Virolainen et al., 2001; Garson et al., 2002; Margules et al., 2002). We in our assessment on developing conservation planning for Rare, Endangered and Threatened species of herpetofauna in Sahyadri Tiger Reserve, using a combination of species richness, diversity of herpetofauna as a whole and considering RET species (arrived based on endemism and IUCN Red List Category), identified the areas of Chandoli and Koyna ranges of the reserve are the most vital for long-term conservation. The possible reason for these two ranges showing numerically higher species richness both in terms of overall and RET species could be related to historical background of Protected Area status that these two ranges enjoyed in the past. Before the declaration of Sahyadri Tiger Reserve, the Chandoli was a National Park and Koyna was a Wildlife Sanctuary, which in general, as a Protected Areas, have a higher protection status for conservation than the Territorial Forest Division, in India. Additionally, the existence large natural habitats that form the major chunk of the present tiger reserve and the presence of large wetlands (Shivsagar Reservoir with 105 TMC of capacity water and Vasantsagar Reservoir with 32 TMC of water capacity) in these two ranges are the added advantages, not only for the aquatic forms of herpetofauna, but also for the other forms of biodiversity that are in need of water source for their survival.

In a large spatial scale, abundance of herpetofauna is naturally influenced by three ecological and evolutionary factors viz. (i) biogeography effect, (ii) the effects of mountain refuges, and (iii) the ecological requirements of the species (Rey Benayas et al. 2006; Meliadou and Troumbis, 1997; James and Shine, 2000). Besides natural effect, manmade

changes to natural habitats in the form of loss, fragmentation and degradation have also been recorded as the major artificial threat to the herpetofauna assemblage (Gibbons et al., 2000; Alfords and Richards, 1999; Gibbons and Stangell, 1999). Human disturbance to natural habitats in the form of alteration in natural habitats and forest management techniques (Block et al. 1998), type of forestry practices (Greenberg et al. 1994), highways inside the parks (Boominathan et al. 2009; Baskaran and Boominathan 2010; Griffin 2015) are well established to affect the herpetofauna directly and indirectly.

6 CONCLUSIONS

Based on field surveys, literature review and in discussions with forest department staff, we have provided the following suggestions for long-term conservation of mammals;

- The Sahyadri Tiger Reserve has a substantial number of mammalian species including RET species that are distributed throughout the reserve. As a result, it is recommended that conservation management plans be implemented for these priority species while employing key strategies for habitat specific interventions rather than administrative regions would have long term benefits to the mammals and their ecosystems, within the STR.
- Studies on abundance, distribution and species ecology should be species specific and systematic globally accepted sampling protocols must be followed while collecting data. Undertaking such studies especially on species such as the pangolin, wild dog, that can provide insights to their ecology within STR as well as identify factors that have a positive or negative influence on their presence.
- Integrating multiple methods such as sign survey and camera trap, reliable and accurate information can be obtained on distribution and abundance of tigers and leopards as well as ranging patterns of individuals of these species.
- Although reintroduction is a promising tool to revive tiger populations, all the required measures must be taken including ascertaining adequate prey density and minimising human disturbance.
- The current density of sambar, which is a principal prey, is low, and measures must be taken to revive and sustain a healthy population.
- Protecting the diverse tall evergreen forest patches as well as maintaining the grasslands are crucial for species that are habitat specific.
- Identifying and maintaining corridor patches for dispersal is important especially for long ranging species tiger.
- Presence of livestock, feral cattle and feral dogs within the reserve is detrimental to the wild population, especially gaur and mouse deer.
- Protection from hunting in and around the reserve must be implemented rigorously.
- Public awareness programmes can help educate people against hunting, resolve misconceptions and avoid conflict situations.
- Keeping a check on illegal movement of people and collection of fire wood and NTFP is important.

The following suggestions are provided for herpetofauna conservation

- The Sahyadri Tiger Reserve lying in northern Western Ghats (also called island habitat), continues to be of interest to taxonomists as new species are being described especially in this northern landscape. It shows the area has yet been studied comprehensively for its species richness and diversity.
- While rigorous habitat loss or fragmentation are not management issues yet, anthropogenic pressure, a moderate level of human settlements along with cattle grazing

pressure and NWFP collection prevailing in the reserve, are all causes for habitat degradation, which may lead to decrease in habitat quality as well species diversity. Thus, human dependency from enclave and peripheral villages on the natural habitats need to be minimized to the maximum level possible.

- Reptiles and amphibians these small taxa has no specific micro habitat unlike comparing with other taxa. They were occupied greater area of Sahyadri Park. For conservation point macro-habitat were talking into account (Fig 3 and 4) showing the macro-habitat utilized by herpetofauna species. Reptiles and amphibian responses would be variable among species (McLeod and Gates, 1998; Grialou et al 2000). For reptile species most of the individual has found in deciduous, grassy land and semi ever green habitats. In terms of amphibians most the individuals has found same kind of habitats deciduous, grassy land, semi ever green and all possible water bodies and also these habitat (Fig 7) supporting following ret list species viz (*Pseudophilautus amboli*, *Xanthophryne koynayensis*, *Indotyphlus maharashtraensis*, *Indosylvirana Caesar*, *Uperodon mormorata* *Cnemaspis girii*, *Cyrtodactylus deccanensis* and *Uropeltis macrolepis*). These three habitats (deciduous, grassy land and semi ever green) crossly supporting herpetofauna species during late summer and pre monsoon. In order to give management recommendation following measures would be increase species heterogeneity and population of herpetofauna species. Land use practices of this size and shape, or confined to areas that were already managed, would protect more cryptic and sedentary species detected in similar microhabitats of the forest manageable area, such as leaf litter, fallen logs, grass land and perennial water source.
- The mature forest patches (evergreen, semi evergreen, deciduous and grassy lands) play a very important role, in the survival and persistence of a large number of amphibian and reptile species. So maintaining such habitat will increase the species diversity as well would be a healthy forest.
- Small-scale, circle-shaped clear-cuts, thinning, or site preparations and grass land management could reduce major land-use effects, edge area, and patchiness, while encouraging spatial heterogeneity (Hunter, 1990).
- For understanding herpetofauna assemblage and niche overlapping the microhabitats (Fig. 5 & 6) playing one of crucial role. The reptiles and amphibians prefer leaf litter, dead or decayed logs, and the tree trunk/bark point to the importance of conserving these to ensure the survival of the species. The dead and fallen trees should not be removed for any purpose.
- For special emphasis of this species should be given priority to conserving such marshy lands (temporary waters), which is the abode of herpetofauna ensuring complete protection from fire and other biotic disturbance.
- There are few herpetofauna species recorded (Sahyadri Park and adjacent areas) an earlier study (Anonymous, 1978 and Ghate & Padhye, 2012), but could not be located in the present survey indicating either its total absence or species rarity. It would be ideal to develop a system intense monitoring these lower taxa's.
- The people residing in the edge of the forest (human settlements and buffer zone villages) frequently kill even non-poisonous snakes due to their ignorance. An awareness programme would be beneficial to the people and also protect snake species.

- The herpetofauna seasonal migration (peak monsoon time) most of them killed by vehicle trafficking especially buffer zone road network to identify those important places and minimize the vehicle traffic or to develop speed breaker system could be more effective to conserve these lower vertebrates.
- Given the legislation, though relocation of enclave villages is legally not possible, but any village showing personal interest for relocation, may be relocated on priority with appropriate relocation package.
- Finally, we recommend the use of observed and estimated species richness, relative abundance, species composition, and distribution of all studies. Future monitoring studies should employ a large diversity of sampling techniques to derive accurate inventory statistics to explore large scale. Seasonal sampling would bring broader level ecological questions to conserve herpetofauna species in Sahyadri Tiger Reserve.

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APPENDIX

Appendix I: A Historic listing of mammalian species found in the State of Maharashtra

S. No	Name	Species	Fauna of Maharashtra ZSI (Annon, 2012)	Gazetteer of Maharashtra fauna (Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
1	Elephant	<u>Elephas maximus</u> Linnaeus, 1756	Sindhudurg dist., Maharashtra goa Karnataka state borders.	Occurred in historic times is now extinct in the state.	Recorded in the Western Ghats as far north as 17° or 18°. Found at considerable elevations above the sea in southern India.	
2	Slender loris	<u>Loris lydekkerianus</u> Cabrera, 1908	Thick forest tracks in Kolhapur dist. in Western Ghats.	Not so far reported, likely to occur in districts bordering Karnatak.	<u>Loris gracilis</u> , recorded from southern India. Probably found on the west coast, near Ratnagiri southern Concan (Konkan), but rare along Malabar coast.	
3	Rhesus macaque	<u>Macacamulatta</u> Zimmermann, 1780	Not recorded around study area closest is SGNP, Mumbai.	Found in North-eastern Vidharba districts, and introduced in Powai lake area.	Found Closest to the west coast near Bombay but not much further south.	(Menon, 2014)
4	Bonnet macaque	<u>Macacaradiata</u> E. Geoffroy Saint-Hilaire, 1812	Not recorded around study area closest is Bhimashankar WLS.	Not uncommon in state from Bombay southwards. Occur in forests and countryside.	<u>Macacussinicus</u> , recorded along the west coast to the neighbourhood of Bombay.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
5	Northern plains langur	<u>Semnopithecus entellus</u> Dufresne, 1797	3 subspecies, <u>Semnopithecus ntallusentallus</u> found in Vidharba, <u>Semnopithecus entellus acheson</u> in Western Maharashtra, Konkan, Pune, and <u>Semnopithecus entellus Anchises</u> . closest record to STR is Bhimashankar WLS.	Not uncommon in forests and nearby towns and villages.	The southern limit needs verification, but certainly inhabiting the Bombay Deccan.	(Lavate and Mule, 2009), (Abdar, 2013), (Menon, 2014)

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
6	South western langur	<u>Semnopithecus hypoleucous</u> Blyth, 1841	<u>Semnopithecus entellus hypoleucous</u> , in south-western Maharashtra, Pune, Helwak, Mahabaleshwar, Ratnagiri, Sawantwadi.	Not identified	Recorded along the Malabar coast, from cape Comorin to 14° or 15° north lat.	(Sayyed, 2016), (Menon, 2014)
7	Indian hare	<u>Lepus nigricollis</u> F. Cuvire, 1823	Closest record in Bhimashankar WLS.	3 subspecies, <u>Lepus nigricollis nigricollis</u> occur south of the Godavari, <u>Lepus nigricollis ruficaudatus</u> north of the river, <u>Lepus nigricollis simcoxi</u> in Berar, jungle and scrub alternating with cultivation.	2 subspecies, <u>Lepus nigricollis nigricollis</u> peninsula south of Godavari, <u>Lepus nigricollis ruficaudatus</u> from Himalaya to Godavari and somewhat further south around Poona (Pune) in the Deccan	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
8	Pangolin	<u>Manis crassicaudata</u> Gray, 1827	Pune	Found in the state	India proper, Himalaya to Cape Comorin	(Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
9	Indian giant squirrel	<u>Ratufa indica</u> Erxleben, 1777	Found in Pune Bhimashankar, Khandala, Dahanu, Helwak, and most places in the Western Ghats.	Purely forest species found in the Western Ghats from extreme south to Dangs in Gujarat.	Identified as <u>Sciurus indicus</u> , and is found throughout the peninsula.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
10	Indian crested porcupine	<u>Hystrix indica</u> Kerr, 1792	Recorded throughout the state.	Prefers rocky country adapts itself to other situations found in forests and open country of moist and dry areas.	Identified as <u>Hystrix leucura</u> , and is found throughout India.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
11	Tiger	<u>Panthera tigris</u> Linnaeus, 1758	Found in the Western Ghats, as well as the north and eastern part of the state.	Restricted to the eastern districts of Vidarbha area, and a small forest area in south west.	Found wherever large tracts of forest or grass-jungle exist.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016),

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
						(Menon, 2014)
12	Leopard	<u>Pantherapardus</u> Linnaeus, 1758	Found throughout state.	The species is capable of wider distribution but has lost ground in most parts of the state.	Recorded all throughout.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
13	Desert cat/wildcat	<u>Felissilvestrisornate</u> Schreber, 1777	Sighted at the Shere village in Pune.	Recently recorded in Poona (Pune) district.	Sind to Nagpur, not extending.	(Menon, 2014)
14	Jungle cat	<u>Felischausu</u> Schreber, 1777	Found throughout state.	The species was at one time widely distributed in the state.	The species is found throughout the country from Himalaya to Cape Comorin.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
15	Caracal	<u>Caracal caracal</u> Schreber, 1776	Recorded from Melghat, and northern parts of the state.	<i>Not documented</i>	Central India and greater part of peninsula except Malabar coast.	
16	Leopard cat	<u>Prionailurusbenigalensis</u> Kerr, 1792	Found throughout forested areas.	Found along forested tracts of the Western Ghats and Vidarbha.	Presence recorded Syhadri range or Western Ghats, perhaps all forest regions of the peninsula though not very abundant. Not in central province and Bombay presidency.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
17	Rusty spotted	<u>Prionailurusrufiginossus</u> Hilaire, 1831	Found throughout the state.	Found only along Western Ghats from Dangs southwards, in grassland, scrub and jungle.	Distributed in southern India.	(Sayyed, 2016), (Menon, 2014)

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
18	Fishing cat	<u>Prionailurus viverrinus</u> Bennett, 1833	Coastal as well as central and eastern Maharashtra.	<i>Not documented</i>	<i>Not documented</i>	
19	Small indian civet	<u>Viverricula indica</u> Hilaire, 1803	Found throughout the state.	Found throughout the state.	Found throughout India except Sind Punjab and western Rajputana.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
20	Common palm civet	<u>Paradoxurus hermaphroditus</u> Pallas, 1777	Closest recorded at Bhimashankar WLS.	Has a wide distribution and prefers wooded areas.	Identified as <u>Paradoxurus niger</u> , and found throughout peninsula India.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
21	Brown palm civet	<u>Paradoxurus jerseydoni</u> Blanford, 1885	<i>Not documented</i>	May occur in the forests adjoining north Kanara (Karnataka).	Only known from Palni hills and Nilgiris.	
22	Grey	<u>Herpestes edwardsi</u> E. Geoffroy Saint-Hilaire, 1818	Identified as <u>Herpestes edwardsi</u> and is found throughout the state.	Open scrubland and cultivated area.	Identified as <u>Herpestes mungo</u> , and is throughout peninsula India from Himalayas to Cape Comorin.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
23	Ruddy	<u>Herpestes smithi</u> Gray, 1837	Found in forested areas.	<i>Distribution not documented</i>	Wide ranging in India, throughout the peninsula.	(Lavate and Mule, 2009), (Menon, 2014)
24	Striped neck mongoose	<u>Herpestes vitticollis</u> Bennett, 1835	<i>Not documented</i>	<i>Not documented</i>	Found on hills near the west coast of India from near Bombay to Cape Comorin.	(Lavate and Mule, 2009)

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
25	Small indian mongoose	<u>Herpestesauropunctatus</u> Illiger, 1811		Though there is no record, it is likely to occur in north western districts of the state.		
26	Hyaena	<u>Hyaenahyaena</u> Linnaeus, 1758	Found in suitable habitats of Maharashtra.	Believed to be on the verge of extinction. Found in areas of low hills and ravines, commoner in open country than in heavy forests.Were known to occur in Salsette(Bombay) island about 30 years ago.	Throughout peninsula India, abundant in hilly open country.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
27	Golden jackal	<u>Canis aureus</u> Linnaeus, 1758	Closest record from Bhimashankar WLS.	Found in the Nasik areas.	Recorded through the whole of India, hills and plains, forest and open country.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
28	Grey wolf	<u>Canis lupus</u> Linnaeus, 1758	Recorded from the drier areas of Maharashtra.	Not uncommon in Deccan and Vidarbha districts. Records near Poona (Pune) and Aurangabad, may still occur in remote regions of the state.	Identified as <u>Canispallipes</u> , and is found in Indian peninsula south of Himalayas, not occurring on the Malabar coast	(Sayyed, 2016), (Menon, 2014)
29	Dhole	<u>Cuonalpinus</u> Pallas, 1811	Recorded from the northern and eastern parts of the state.	Presence in any particular forest is not predictable, now rare in Maharashtra state	Called <u>Cyondukhunensis</u> is throughout north India and larger forests of Indian peninsula	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
30	Indian fox	<u>Vulpesbengalensis</u> Shaw, 1800	Found in suitable habitats of Maharashtra.	Found in open scrub country.	Commonly found throughout India, from Himalaya to Cape Comorin except in thick forest.	(Sayyed, 2016), (Menon, 2014)

S. No	Name	Species	Fauna of Maharashtra ZSI (Annon, 2012)	Gazetteer of Maharashtra fauna (Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
31	Red fox	<u>Vulpes Vulpes</u> Linnaeus, 1758	Found in isolated pockets in suitable habitats.	Recently recorded in Poona (Pune) district.	<i>Does not exist</i>	
32	Sloth bear	<u>Melursus ursinus</u> Shaw, 1791	Recorded from suitable habitats in Western Ghats.	Frequents areas with out cropping of rocks and tumbled boulders, becoming rare in Maharashtra.	found throughout the country from Himalayas to Cape Comorin.	(Lavate and Mule, 2009), (Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
33	Smooth coated otter	<u>Lutra perspicillata</u> I. Geoffroy Saint-Hilaire 1826	Recorded from suitable habitats in Maharashtra.	Found throughout India, and is mostly a plains animal.	Identified as <u>Lutra ellioti</u> throughout India, from the lower Himalayas and has only lately been clearly distinguished but relative distribution not precisely ascertained.	(Sayyed, 2016), (Menon, 2014)
34	Rattal	<u>Mellivora capensis</u> Schreber, 1776	Recorded in the eastern Maharashtra.	Not uncommon throughout India, especially in broken hilly country, but rarely seen, not found in heavy rainfall areas.	Identified as <u>Mellivora indica</u> , from the base of Himalayas to the extreme south, exception of the Malabar coast.	(Menon, 2014)
35	Wild pig	<u>Sus scrofa</u> Linnaeus, 1758	Found throughout the state.	Widely distributed from Europe to Malaya, in grass scrub jungle. Found in all forested districts of the state. Numbers greatly reduced in most parts owing to destruction, poaching and slaughter by tribes.	Identified as <u>Sus cristatus</u> , throughout india.	(Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
36	Mouse deer	<u>Moschiola indic</u> Gray, 1843	Identified as <u>Moschiola meminna</u> , found in suitable habitats in forested areas.	Occurs only in peninsular India below latitude 24° north.	Found in southern India along Western Ghats upto north Bombay.	(Abdar, 2013), (Sayyed, 2016), (Menon, 2014)

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
37	Spotted deer	<u>Axis axis</u> Erxleben, 1777	Found in suitable habitats of forested areas in the state.	Exclusively Indian an animal, once common throughout the state and used to be seen till recently even on Salsette island (Bombay), is now restricted to larger forests.	Distributed nearly throughout India, Himalayas, and ascends the hills of south India in places to about 3500 or 4000 feet.	(Menon, 2014)
38	Sambar	<u>Rusa unicolor</u> Kerr, 1792	Found in suitable habitats forested areas.	A typical forest species restricted in scanty numbers to well forested areas of the state.	Throughout oriental region wherever there is undulating ground or hilly country with forest. Common on summits of the ranges in southern India.	(Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
39	Barking deer	<u>Muntiacus muntjac</u> Zimmermann, 1780	Closest recording is from Bhimashankar WLS.	Greatly reduced in numbers during the last few decades.	Found throughout India.	(Abdar, 2013), (Sayyed, 2016), (Menon, 2014)
40	Blackbuck	<u>Antilope cervicapra</u> Linnaeus, 1758	Found in suitable habitats in the state.	Exclusively an Indian Antelope. Found in open scrub covered and cultivated plains. Once common in herds of hundreds throughout the Deccan, poaching and extensive cultivation have diminished their numbers to only a few pockets of population.	Found from Himalayas to Cape Comorin, not found on hills nor in thickly wooded tracts and is scarce in Malabar coast south of Surat.	(Menon, 2014)

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
41	Gazel	<u>Gazellabennetti</u> i Sykes, 1831	Found in suitable habitats.	Prefers broken country with nullahs and ravines, with scrub or thin jungle. Little information on present position in state, but once not uncommon in Vidarbha and areas of Deccan above Krishna river.	Occupies plains and low hills of central India, and considerable part of peninsula, and the whole Bombay presidency, except Western Ghats and Concan (Konkan).	(Menon, 2014)
42	Nilgai	<u>Boselaphustrag</u> <u>ocamelus</u> Pallas, 1766	Found in suitable habitats.	Avoids dense forests.	Peninsula India from base of Himalaya to south of Mysore, not near Malabar coast, inhabits Concan (Konkan) near Bombay.	(Menon, 2014)
43	Four-horned antelope	<u>Tetracerusquad</u> <u>ricornis</u> de Blainville, 1816	Found in suitable forested habitats in Maharashtra.	Occupies forested country throughout the state.	Peninsula region, where wooded and hilly but not dense jungleand not the Malabar coast. Common throughout Bombay presidency, and the central provinces.	(Sayyed, 2016), (Menon, 2014)
44	Gaur	<u>Bosgaurus</u> C. H. smith, 1827	Found in suitable habitats.	Found in few heavily forested districts in the Vidarbha areas, and Ghats forests adjoining the Kanara district of Mysore (Karnataka).Prefers hilly country and rarely if ever enters cultivation.	Found in all hilly forest tracts. In the Indian peninsula region, it is seen throughout Western Ghats wherever it has not been exterminated or driven away.	(Abdar, 2013), (Sayyed, 2016), (Menon, 2014)

S. No	Name	Species	Fauna of Maharashtra ZSI(Annon, 2012)	Gazetteer of Maharashtra fauna(Gazetteer of India, 1974)	Fauna of British India (Blanford, 1888)	Other publications
45	W buffalo	<u>Bubalus bubalis</u> Kerr, 1792	Found in suitable habitats in eastern Maharashtra.	Formerly occurred in peninsular India as far as 80° east longitude, now confined to small area in Madhya Pradesh. Possible few may be seen in Bhamragarh area of Chanda district adjoining Bastar in MP.	Only along the fringes of eastern Maharashtra.	(Menon, 2014)

Appendix II: Comprehensive list of herpetofauna of STR and its surrounding forest areas in the region.

SL No	Class	Family	Species Name	IUCN Red List Status	E. W.G	E.N W.G	Reference
1	Amphibia	Indotyphlidae	<i>Indotyphlus maharashtraensis</i> Giri, Gower & Wilkinson, 2004	Data Deficiency	+	+	Padhye & Ghate 2012, TCP, 2014
2			<i>Ichthyophis bombayensis</i> Taylor, 1960	Least Concern	+	-	Padhye & Ghate 2012 and Yadav et al.2014
3		Bufonidae	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	Least Concern	-	-	Padhye & Ghate 2012
4			<i>Duttaphrynus stomaticus</i> (Lütken, 1864)	Least Concern	-	-	J. C. Daniel, 1974
5			<i>Xanthophryne koynayensis</i> Soman, 1963	Endangered	-	+	Padhye & Ghate 2012
6			<i>Pedostibes tuberculosus</i> Günther, 1876	Endangered	+	-	Dahanukar et al., 2004 & Padhye & Ghate 2012
7		Dicroglossidae	<i>Euphlyctis cf. karaavali</i> Priti, Naik, Seshadri, Singal, Vidisha, Ravikanth and Gururaja 2016	Not Assessed	+	-	
9			<i>Euphlyctis cf. mudigere</i> Joshy, Alam, Kurabayashi, Sumaida & Kuramoto, 2009	Not Assessed	+	-	
10			<i>Fejervarya cepfi</i> Garg & Biju, 2017	Not Assessed	+	-	
11			<i>Fejervarya cf.caperata</i> Kuramoto, Joshy, Kurabayashi and Sumida, 2007	Not Assessed	+	-	
12			<i>Fejervarya syhadrensis</i> (Annandale, 1919)	Least Concern	-	-	Padhye & Ghate 2012
15			<i>Hoplobatrachus tigerinus</i> (Daudin, 1802)	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
16			<i>Hoplobatrachus crassus</i> (Jerdon, 1854 "1853")	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
17			<i>Sphaerotheca pashchima</i> Pathye, Dahanukar, Sulakhe, Dandekar, Limaye & Jamdade 2017	Not Assessed	+	-	
18			<i>Sphaerotheca breviceps</i> (Schneider, 1799)	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
19			<i>Sphaerotheca dobsonii</i> (Boulenger, 1882)	Least Concern	-	-	Padhye & Ghate 2012

SL No	Class	Family	Species Name	IUCN Red List Status	E. W.G	E.N W.G	Reference
20		Microhylidae	<i>Microhyla laterite</i> Seshadri, Singal, Priti, Ravikanth, Vidisha, Saurabh, Pratik & Gururaja 2016	Not Assessed	+	-	
21			<i>Microhyla ornata</i> (Duméril & Bibron, 1841)	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
22			<i>Microhyla rubra</i> Jerdon, 1854	Least Concern	-	-	Padhye & Ghate 2012
23			<i>Uperodon mormorata</i> (Rao, 1937)	Endangered	+	-	
25			<i>Uperodon variegatus</i> (Stoliczka, 1872)	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
26			<i>Uperodon globulosus</i> (Günther, 1864)	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
27		Ranidae	<i>Hydrophylax bahuvistara</i> Padhye et al., 2015	Not Assessed	+	-	Padhye et al.2015
29			<i>Indosylvirana caesari</i> Biju, Garg, Mahony, Wijaiyathilaka, Senevirathne & Meegaskumbura 2014	Not Assessed	+	+	
30		Ranixalidae	<i>Indirana leithii</i> (Boulenger, 1888)	Vulnerable	-	+	J. C. Daniel, 1974 and Padhye & Ghate 2012
32			<i>Indirana chiravasi</i> Padhye, Modak & Dahanukar 2014	Not Assessed	+	-	
33		Rhacophoridae	<i>Raorchestes ghatei</i> Padhye, Sayyed, Jadhav & Dahanukar 2013	Not Assessed	+	-	
34			<i>Raorchestes bombayensis</i> (Annandale, 1919)	Vulnerable	+	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
36			<i>Polypedates maculatus</i> (Gray, 1830)	Least Concern	-	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
37			<i>Pseudophilautus amboli</i> (Biju & Bossuyt, 2009)	Critically Endangered	-	+	Padhye & Ghate 2012
38		Nyctibatrachidae	<i>Nyctibatrachus</i> Sp.		-	-	
39			<i>Nyctibatrachus humayuni</i> Bhaduri & Kripalani, 1955	Vulnerable	+	-	J. C. Daniel, 1974 and Padhye & Ghate 2012
40			<i>Nyctibatrachus danieli</i> Biju, Bocxlaer, Mahony, Dinesh, Radhakrishnan, Zachariah, Giri & Bossuyt	Not Assessed	-	+	Padhye & Ghate 2012

SL No	Class	Family	Species Name	IUCN Red List Status	E. W.G	E.N W.G	Reference
			2011				
41	Reptilia	Crocodylidae	<i>Crocodylus palustris</i> (Lesson, 1831)	Vulnerable	-	-	J. C. Daniel, 1974 & TCP 2014
42		Geoemydidae	<i>Melanochelys trijuga</i> (Schweigger, 1812)	Near Threatened	-	-	J. C. Daniel, 1974 & TCP 2014
43		Trionychidae	<i>Lissemys punctata</i> (Lacépède, 1788)	Least Concern	-	-	J. C. Daniel, 1974 & TCP 2014
44			<i>Nilssononia leithii</i> (Gray, 1872)	Vulnerable	-	-	J. C. Daniel, 1974 & TCP 2014
45		Gekkonidae	<i>Hemidactylus frenatus</i> Duméril & Bibron, 1836	Least Concern	-	-	J. C. Daniel, 1974 & TCP 2014
46			<i>Hemidactylus prashadi</i> Smith, 1935	Least Concern	+	-	J. C. Daniel, 1974 & TCP 2014
47			<i>Hemidactylus flaviviridis</i> Rüppell, 1835	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
48			<i>Hemidactylus cf. gleadowi</i> Murray, 1884	Not Assessed	-	-	
49			<i>Hemidactylus murrayi</i> Gleadow, 1887	Not Assessed	-	-	
50			<i>Hemidactylus maculatus</i> Duméril & Bibron, 1836	Least Concern	-	-	J. C. Daniel, 1974 & TCP 2014
51			<i>Hemidactylus leschenaultii</i> Duméril & Bibron, 1836	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
52			<i>Hemidactylus triedrus</i> (Daudin, 1802)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
53			<i>Cyrtodactylus deccanensis</i> (Günther, 1864)	Least Concern	-	+	J. C. Daniel, 1974 & TCP 2014
54			<i>Cyrtodactylus albofasciatus</i> (Boulenger, 1885)	Not Assessed	-	+	J. C. Daniel, 1974 & TCP 2014
55			<i>Cnemaspis girii</i> Mirza, Pal, Bhosale & Sanap, 2014	Not Assessed	-	+	

SL No	Class	Family	Species Name	IUCN Red List Status	E. W.G	E.N W.G	Reference
56			<i>Cnemaspis kolhapurensis</i> Giri, Bauer & Gaikwad, 2009	Data Deficiency	-	+	J. C. Daniel, 1974 & TCP 2014
57		Agamidae	<i>Calotes cf. versicolor</i> (Daudin, 1802)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
58			<i>Calotes rouxi</i> Dumeril & Bibron, 1837	Not Assessed	+	-	J. C. Daniel, 1974 & TCP 2014
59		Scincidae	<i>Eutropis carinata</i> (Schneider, 1801)	Least Concern	-	-	J. C. Daniel, 1974 & TCP 2014
60			<i>Eutropis allapallensis</i> (Schmidt, 1926)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
61			<i>Lygosoma guentheri</i> (Peters, 1879)	Least Concern	-	-	J. C. Daniel, 1974
62			<i>Lygosoma lineata</i> (Gray, 1839)	Least Concern	-	-	J. C. Daniel, 1974
63			<i>Lygosoma punctata</i> (Gmelin, 1799)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
64		Lacertidae	<i>Ophisops beddomei</i> (Jerdon, 1870)	Least Concern	+	-	J. C. Daniel, 1974 & TCP 2014
65			<i>Ophisops cf. jerdonii</i> Blyth, 1853	Least Concern	-	-	
66		Varanidae	<i>Varanus bengalensis</i> (Daudin, 1802)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
67		Uropeltidae	<i>Uropeltis macrolepis</i> (Peters, 1862)	Least Concern	+	+	J. C. Daniel, 1974 & TCP 2014
68			<i>Uropeltis phipsonii</i> (Mason, 1888)	Vulnerable	+	-	J. C. Daniel, 1974 & TCP 2014
69			<i>Uropeltis ellioti</i> (Gray, 1858)	Least Concern	-	-	J. C. Daniel, 1974
70		Typhlopidae	<i>Indotyphlops braminus</i> (Daudin, 1803)	Not Assessed	-	-	J. C. Daniel, 1974
71			<i>Grypotyphlops acutus</i> (Duméril, Bibron & Duméril, 1844)	Least Concern	-	-	J. C. Daniel, 1974 & TCP 2014
72		Erycidae	<i>Eryx conicus</i> (Schneider, 1801)	Not Assessed	-	-	J. C. Daniel, 1974

SL No	Class	Family	Species Name	IUCN Red List Status	E. W.G	E.N W.G	Reference
73			<i>Eryx johnii</i> (Russell, 1801)	Not Assessed	-	-	J. C. Daniel, 1974
74			<i>Eryx whitakeri</i> Das, 1991	Not Assessed	+	-	
75		Pythonidae	<i>Python molurus</i> (Linnaeus, 1758)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
76		Colubridae	<i>Ahaetulla cf. nasuta</i> Lacepede, 1789	Not Assessed	-	-	J. C. Daniel, 1974
77			<i>Argyrogena fasciolata</i> (Shaw, 1802)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
78			<i>Ptyas mucosa</i> (Linnaeus, 1758)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
79			<i>Oligodon taeniolatus</i> (Jerdon, 1853)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
80			<i>Oligodon arnensis</i> (Shaw, 1802)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
81			<i>Boiga trigonata</i> (Schneider, 1802)	Least Concern	-	-	J. C. Daniel, 1974
82			<i>Boiga forsteni</i> (Duméril, Bibron & Duméril, 1854)	Least Concern	-	-	J. C. Daniel, 1974
83			<i>Boiga beddomei</i> (Wall, 1909)	Data Deficiency	-	-	TCP 2014
84			<i>Boiga ceylonensis</i> (Günther, 1858)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
85			<i>Coelognathus h. monticollaris</i> (Schulz, 1992)	Not Assessed	+	-	J. C. Daniel, 1974 & TCP 2014
86			<i>Coelognathus helana</i> (Daudin, 1803)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
87			<i>Lycodon aulicus</i> (Linnaeus, 1758)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
88			<i>Xenochrophis piscator</i> (Schneider, 1799)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
89			<i>Dendrelaphis tristis</i> (Daudin, 1803)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014

SL No	Class	Family	Species Name	IUCN Red List Status	E. W.G	E.N W.G	Reference
90			<i>Dendrelaphis girii</i> Vogel & Van Rooijen, 2011	Least Concern	+	-	
91			<i>Dendrelaphis chairecacos</i> (Boie, 1827)	Data Deficiency	+	-	
92		Natricidae	<i>Amphiesma stolatum</i> (Linnaeus, 1758	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
93			<i>Hebius beddomei</i> (Günther, 1864)	Least Concern	+	-	J. C. Daniel, 1974 & TCP 2014
94			<i>Macropisthodon plumbicolor</i> (Cantor, 1839)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
95			<i>Atretium schistosum</i> (Daudin, 1803)	Least Concern	-	-	J. C. Daniel, 1974
96		Viperidae	<i>Daboia russelii</i> (Shaw & Nodder, 1797)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
97			<i>Echis carinatus</i> (Schneider, 1801)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
98			<i>Trimeresurus malabaricus</i> (Jerdon, 1854)	Least Concern	+	-	J. C. Daniel, 1974 & TCP 2014
99			<i>Trimeresurus gramineus</i> (Shaw, 1802)	Least Concern	-	-	J. C. Daniel, 1974 & TCP 2014
100			<i>Naja naja</i> (Linnaeus, 1758)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
101		Elapidae	<i>Bungarus caeruleus</i> (Schneider, 1801)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014
102			<i>Calliophis melanurus</i> (Shaw, 1802)	Not Assessed	-	-	J. C. Daniel, 1974 & TCP 2014

Appendix III: Photo Plate showing the various habitat of Sahyadri Tiger Reserve



Shrub Jungle



Evergreen Forest



Semi-Evergreen Forest



Moist-Deciduous Forest



Plateaus



Grassy lands

Appendix IV: Photo plate of mammals species sightings and signs during the study



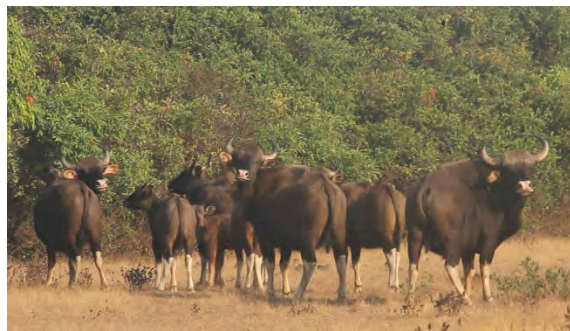
Sambar



Sambar Pellets



Sambar Pellets (Fresh)



Gaur



Barking deer



Barking deer pellets



Barking deer pellets



Mouse deer pellets



Four-horned antelope



Four-horned antelope pellets



Four-horned antelope pellets (Fresh)



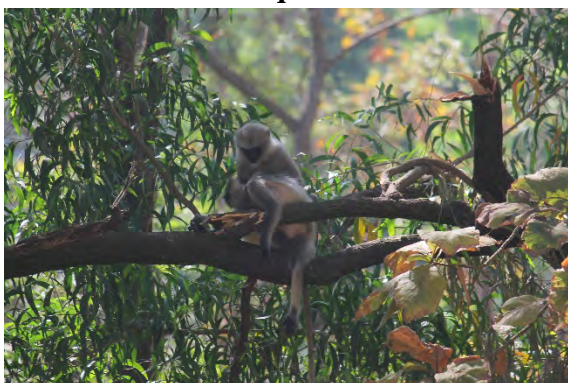
Giant squirrel



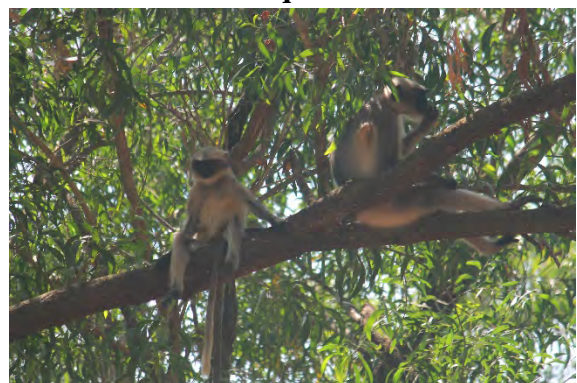
Giant squirrel nest



Giant squirrel nest



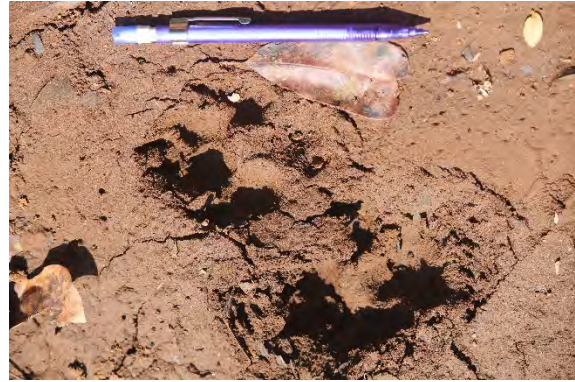
South-western langur



South-western langur



Wild dog pugmark



Wild dog pugmarks



Wild dog scat



Wild dog scat



Wild dog scat



Porcupine urine



Porcupine scat



Porcupine feeding



Sloth bear digging



Sloth bear scat



Sloth bear den



Pangolin burrow



Pangolin burrow



Pangolin digging (Fresh, evident by the drag marks in the soil)

Appendix V: Showing the micro-habitat and field activities



Rock Puddles



Stream



Searching Aquatic herps



Camping



Caves



Open Habitat

Appendix VI: Present threats observed in the reserve during the study



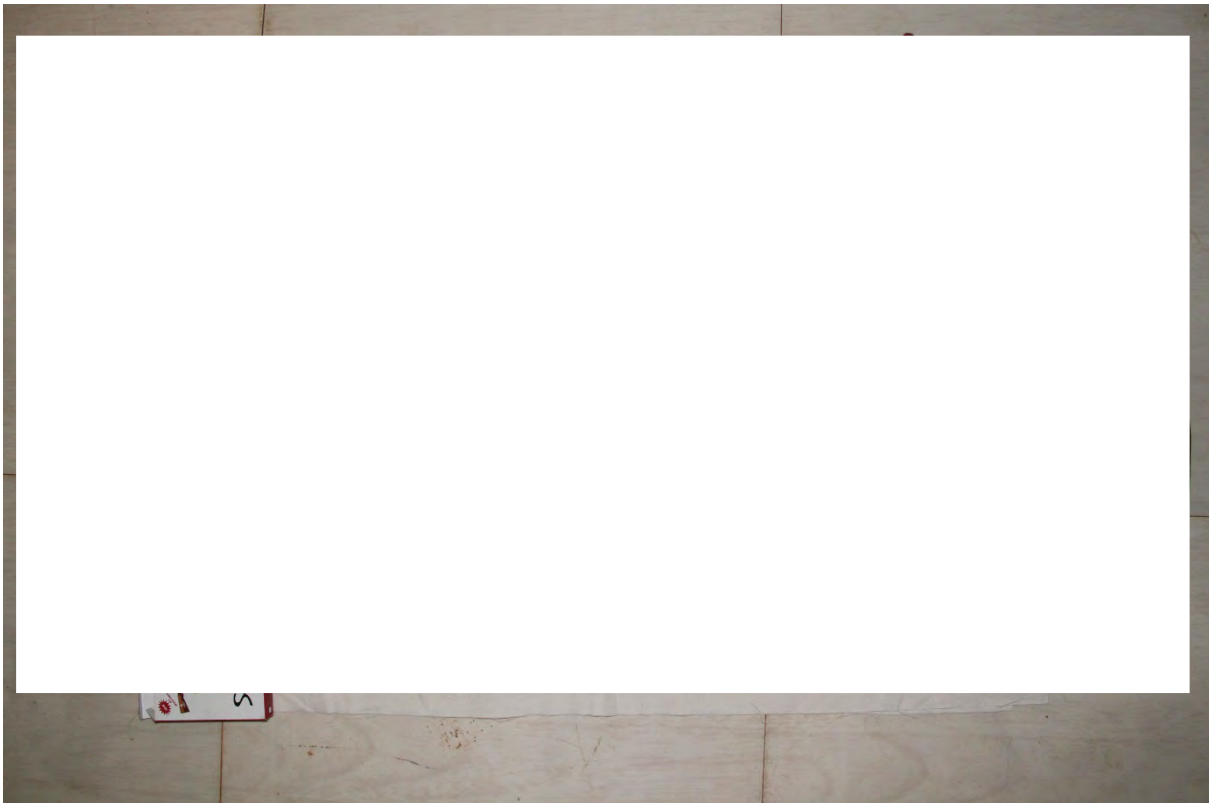
A. Hunting signs on pangolin burrow



B. Sacks of cut wood inside the reserve



C. Villagers carrying wood cut from inside the reserve



D. Weapons recovered by the department from hunting parties inside the reserve



E. Villagers found with weapons inside the protected area



F. Feral cattle inside the reserve



G. Diseased Feral cattle inside the reserve



H. Forest fire inside the protected area



I. villagers collecting honey inside the reserve



J. Leopard release inside the reserve



K. Feral dog and cattle inside the protected area







