



STUDIES ON DIVERSITY, DISTRIBUTION, AND CONSERVATION OF THE BAT FAUNA IN MAHARASHTRA STATE, INDIA

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Abstract

Maharashtra state is the third largest by area in India. Maharashtra's bat fauna comprises eight families, 23 genera, and 41 species, most of which are insectivorous microchiropterans. Eleven of the 41 bat species are found throughout the state whereas 21 species have few colonies with restricted distribution. Five species endemic to South Asia occur in the state. Maharashtra is separated into six divisions in this paper on the basis of geography, topography, and agro-climatic conditions; the presence of bat species and their roosting sites are reported per division. The IUCN status of bat species is listed, as well as endemism. Types of forests in the state and forest cover in each of the six divisions are considered for discussion in the context of bat distribution. Bat species richness and evenness are compared using the Shannon-Weaver (S-W) Index and Simpson's indices (Reciprocal and Diversity). The results are discussed from the viewpoint of conservation of bat fauna in forest areas in general and the Western Ghats region of the state in particular.

Key words: biogeography, Chiroptera, ecology, roosting, species richness, Western Ghats

Introduction

The mammalian fauna of India was surveyed and results published by the Bombay Natural History Society in the early 20th century. The project accumulated 50,000 specimens over 12 years, especially of the smaller mammals, and the information was published in 47 papers. Robert Charles Wroughton and coworkers reported region-wide data of mammalian species including from Order Chiroptera. For the bats, the contributions of Brosset (1962a–c) and Khajuria (1953), based on their fieldwork

in central and western India in the mid-20th century, are noteworthy. More recently, Bates and co-workers surveyed Chiroptera in India. Several published studies are also available on the reproductive biology, taxonomy, and distribution of the bats of Maharashtra. The present study is based on the literature available on the diversity and distribution of bat species in the state of Maharashtra available in publications by Ellerman & Morrison-Scott (1951), Corbet & Hill (1992), Bates & Harrison

(1997), the CAMP Report (2002), Wilson & Reeder (2005), Simmons (2005), Talmale & Pradhan (2009), Pradhan & Talmale (2012), Gaikwad *et al.* (2012), and others. After delineation of the list of species present and their roosting sites within the state, the most recent IUCN conservation opinions on individual species are considered, local risk factors analyzed, and conservation priorities discussed.

Materials and Methods

Study area: Maharashtra state has an area of 307,713 km² and stretches from the central western coast of India to central India. The Western Ghats mountain range, also known as the Sahyādri, runs north-south and constitutes the backbone of the state (Fig. 1). It separates the inland Deccan plateau from the coastal strip of land known as Konkan. The Konkan division is narrow coastal lowland, barely 50 km wide, which runs along the entire western border of the state. The Konkan alternates between narrow steep-sided valleys and low laterite plateau.

The western aspect of the Western Ghats forms steep cliffs with an average elevation of 1,000m but its slopes then gently descend towards the east and south-east. These hills are basaltic in composition but, towards the southern and western sides, the basalt is overlain by laterite. Both basalt and laterite rocks are prone to erosion and cave formation and the caves range from small in size to large. The basalt rocks, in particular, show shallow to deep crevices, depressions of various dimensions and shapes, and high cliffs. Tunnel formations are common and these very often open up into a single chamber or inter-connect several chambers.

Gallery forest is a feature of the Western Ghats and this variety of topography, vegetation, and, consequently, climate makes for rich wildlife habitat and, indeed, bat habitat. The tropical monsoon blows from June to September and precipitation is heavy on the crest of the Sahyādri (average 400cm) and heavier still in the Konkan region. Rainfall in the state declines northwards and diminishes to 70cm in the Deccan plateau. Later in the season, the rains increase slightly eastwards in the Marathwada and Vidarbha regions. The Krishna, Bhima, Godavari, Tapi-Purna, and Wardha-Wainganga are the major river systems

and have their impact on the ecology of the state.

According to the India State Forest Report, Forest Survey of India (2011), in Maharashtra forest and tree cover comprise about 59,725 km². Maharashtra's forests run a gamut *viz.*, tropical semi-evergreen forest, tropical moist deciduous forest, tropical dry deciduous forest, tropical thorn forest, littoral and swamp forest, and subtropical broad-leaved hill forest (Champion & Sheth, 1968). The tropical dry deciduous forest is the most common forest type comprising 57.4% of forest cover, while tropical thorn forest (1.02%) and subtropical broad-leaved hill forest (1.54%) are uncommon in the state. Several very large cities such as Mumbai, Pune, Aurangabad, and Nagpur are in Maharashtra state and the total human population is about 113 million (2011).

Data collection and analysis: Maharashtra was categorized into six divisions for the purpose of our data collection and analysis on the basis of the geographical position, topography, and agro-climatic conditions. Divisions of the state (Fig. 2) were as follows:

Division	Talukas (Subdivision)	Region
Nashik	Nandurbar, Dhule, Jalgaon, Nashik, Ahmadnagar	—
Pune	Pune, Satara, Sangli, Kolhapur, Solapur	—
Konkan	Thane, Mumbai city, Mumbai suburbs, Raigad, Ratnagiri, Sindhudurg	—
Aurangabad	Aurangabad, Jalna, Parbhani, Hingoli, Beed, Nanded, Latur, Osmanabad	Marathwada
Amaravati	Amaravati, Akola, Buldhana, Washim, Yavatmal	Vidarbha
Nagpur	Gondia, Bhandara, Nagpur, Wardha, Chandrapur, Gadchiroli	

To compare bat species diversity richness and evenness in each division of the Maharashtra state, two methods were followed: (1) the Shannon-Weaver (S-W) Diversity Index (eH'); and, (2) Simpson's Index (Simpson's Diversity Index, 1-D and Simpson's Reciprocal Index, 1/D). To understand risk factors for the bat fauna and the preference of bat species for particular habitats, types of forests found in the

state and forest cover in each division of the state were taken into consideration. The results are discussed in order to assign priorities for the conservation of bats in Maharashtra state.

While it is recognized that bat taxonomy has recently undergone great change owing to knowledge obtained from genetic analyses, the old system of Order Chiroptera being divided into sub-Orders Megachiroptera and Microchiroptera is used here because that was the paradigm current during the study. The new sub-Orders Yinpterochiroptera and Yangochiroptera are a mix of the old sub-Orders and show newly determined relationships. The Yinpterochiroptera include the families Pteropodidae, Rhinolophidae, Rhinopomatidae, Hipposideridae, and Megadermatidae that occur in Maharashtra while the Yangochiroptera take in all the other bat families including the Emballonuridae, Vespertilionidae, Miniopteridae, and Molossidae (Tsagkogeorga *et al.*, 2013). We would also like to point out that although we recognize *Rhinolophis cognatus* as occurring in Maharashtra (see Korad *et al.*, 2008) most authorities (see, for example, Molur & Srinivasalu, 2008) delineate the species as occurring only in the Andaman Islands.

Results

Bat fauna reported from Maharashtra: The total number of bat species reported from the state comes to 41 (Appendix 1). Of this number, four species were from the sub-Order Megachiroptera and they belonged to three genera (*Rousettus*, *Cynopterus*, *Pteropus*) and one family (Pteropodidae). The Microchiroptera were far more taxonomically diverse and were represented in the state by 37 species which belonged to 20 genera and seven families of which the Vespertilionidae had the most number of genera (nine) and species (17) (Appendix 1, Fig. 3).

Of the total of 41 species 34 are of 'Least Concern' (LC) in the IUCN assessment whilst four spp. are 'Near Threatened' (NT), and three species are 'Vulnerable' (VU) (Fig. 4). Five spp. (*Hipposideros speoris* (Schneider, 1800); *H. lankadiva* Kelaart, 1850; *Scotozous dormeri* (Dobson, 1875); *Rhinolophus beddomei* Andersen, 1905; and *R. cognatus* (Andersen, 1906) are endemic to South Asia and their

conservation status ranges from LC to NT to VU (also see Appendix 1).

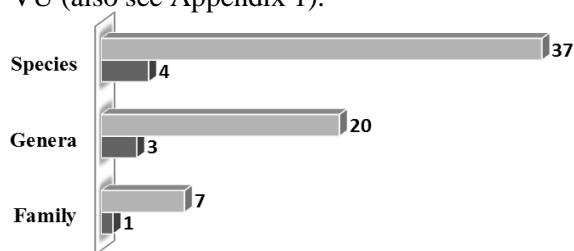


Figure 3: Diversity of bat fauna in Maharashtra state; light gray shows microchiropterans and dark gray shows megachiropterans.

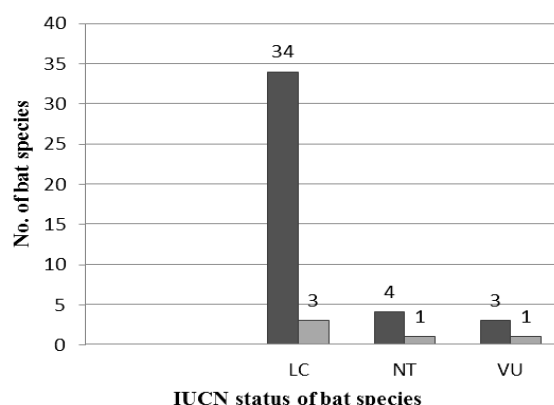


Figure 4: IUCN status of bat species reported from Maharashtra state; dark gray shows the number of bat species and light gray shows number of endemic bat species.

Eleven bat species are 'widely' distributed in Maharashtra (Table 1) which means that these species were found in at least five of the six divisions of the state. Amongst the pteropodids found in Maharashtra the Indian flying fox *Pteropus giganteus* had the largest number of roost sites. Indeed, the highest number of roost sites for *P. giganteus* in all of the Indian states is in Maharashtra. The reported numbers of roosting sites of *Cynopterus sphinx* and *Megaderma lyra* in Maharashtra state is also remarkably high.

However, of the 41 bat species reported from the state 21 are reported from only one or two divisions; moreover, each of these bat species represent barely 1% to 2% of the total number of reported roosting sites in the state (Table 2). For example, *Rhinopoma hardwickii* is known only from a single division and that, too, from just one roost site. The same goes for *Myotis formosus*, *Myotis montivagus*, and *Pipistrellus pipistrellus*. The horseshoe bat *Rhinolophus rouxii* and Savi's pipistrelle *Hypsugo savii*, on the other hand, although confined to the

Western Ghats, have high numbers of roosting sites although within a relatively small geographic space.

Table 1: Widely distributed bat species of

Bat species	No. of roosting sites	Roosting sites in %	Presence in division/s
<i>Rousettus leschenaulti</i>	36	6.84	5
<i>Pteropus giganteus</i>	51	9.69	6
<i>Cynopterus sphinx</i>	43	8.17	6
<i>Taphozous longimanus</i>	20	3.8	6
<i>Taphozous melanopogon</i>	11	2.1	5
<i>Megaderma lyra</i>	42	7.98	5
<i>Hipposideros fulvus</i>	22	4.8	6
<i>Scotophilus heathii</i>	28	5.32	6
<i>Scotophilus kuhlii</i>	15	2.85	6
<i>Pipistrellus tenuis</i>	13	2.47	6
<i>Pipistrellus ceylonicus</i>	28	5.32	6

Maharashtra state

The roosting sites of bat species reported from Maharashtra state are categorized by division (Appendix 1, Figs. 5, 6). This comparison indicates that the highest number of bat species is in Pune division (36 bat species and 54% of total reported roosting sites in the state). The number of bat species and roosting sites reported from Konkan, Aurangabad, and Nagpur divisions are also relatively high, while the Nashik and Amaravati divisions are relatively poor.

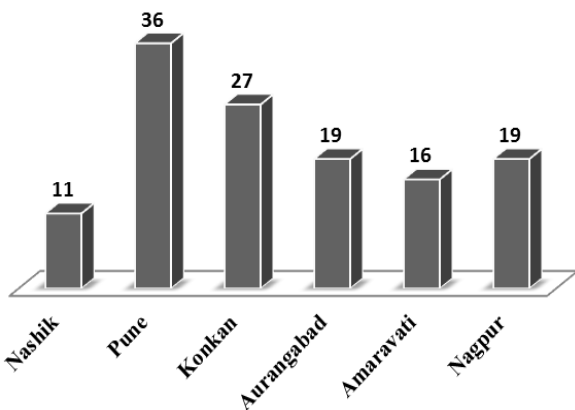


Figure 5: Number of bat species reported from divisions of Maharashtra state

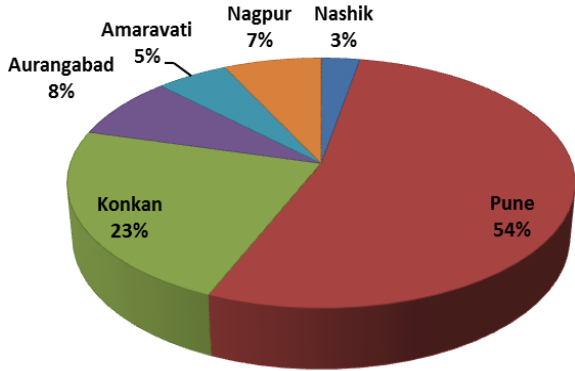


Figure 6: Bat species of Maharashtra state: Locations of bat species reported from divisions

Table 2: Sparsely distributed bat species of Maharashtra state

Bat species	Total roosting sites	%	Presence in division/s
<i>Cynopterus brachyotis</i>	2	0.39	1
<i>Rhinopoma hardwickii</i>	1	0.2	1
<i>Taphozous nudiventris</i>	3	0.59	1
<i>Saccolaimus saccolaimus</i>	2	0.39	1
<i>Rhinolophus rouxii</i>	27	5.13	2
<i>Rhinolophus cf. cognatus</i>	4	0.76	1
<i>Hipposideros pomona</i>	5	0.95	2
<i>Hipposideros lankadiva</i>	3	0.57	3
<i>Tadarida aegyptiaca</i>	6	1.14	2
<i>Chaerephon plicata</i>	5	0.95	1
<i>Myotis formosus</i>	1	0.19	1
<i>Myotis montivagus</i>	1	0.19	1
<i>Myotis horsfieldii</i>	8	1.52	2
<i>Pipistrellus pipistrellus</i>	1	0.19	1
<i>Pipistrellus javanicus</i>	5	0.95	2
<i>Pipistrellus coromandra</i>	5	0.95	2
<i>Pipistrellus kuhlii</i>	3	0.57	1
<i>Hypsugo savii</i>	12	2.28	2
<i>Falsistrellus affinis</i>	7	1.33	1
<i>Hesperoptenus tickelli</i>	6	1.14	2
<i>Miniopterus schreibersii</i>	4	0.76	1
<i>Kerivoula picta</i>	9	1.71	2

Maharashtra's bats were further analyzed statistically applying the S-W Index and Simpson's indices such as Reciprocal Index and Diversity Index (Figs. 7, 8). These comparative studies help us understand the 'species richness' (the number of species in a given area, here a division) as well as the 'evenness' (the relative abundance of different species that make up the diversity richness in a given area) of bat species found in various divisions of the state.

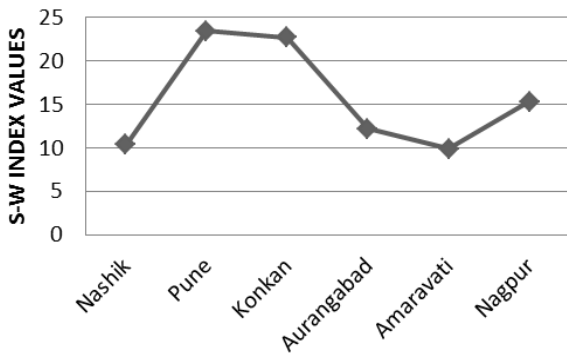


Figure 7: Species diversity and evenness of bat species from divisions of Maharashtra state, analysed using S-W index.

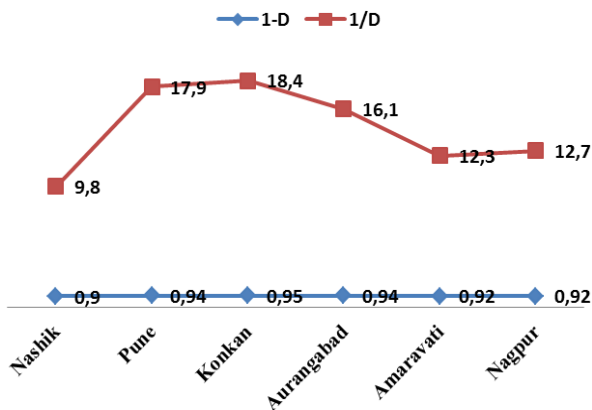


Figure 8: Bat species diversity and evenness analysed using Simpson's indices for divisions of Maharashtra state.

Analyses performed applying the S-W Index for richness and evenness of diversity of bat species in the state indicate that the Pune and Konkan divisions are rich in diversity of bat species and that these species are distributed evenly within these divisions. Nagpur division shows moderate values, as does Aurangabad. Amaravati and Nashik divisions show least values and hence are relatively poor in bat species diversity richness and evenness (Figs. 5-7).

Analyses performed after applying Simpson's indices for richness and evenness of the bat species in the state (Fig. 8), both the reciprocal (1/D) and diversity (1-D) indices, indicate similar results. However, the values for richness and evenness of bat species are found to be a little higher in Konkan division as compared to those of Pune division. The results are expressed more effectively in Fig. 8 with Simpson's reciprocal index than with the diversity index.

To understand the trend of distribution of bat fauna in the state of Maharashtra, the habitat preferences shown by bat species are considered for analysis (Fig. 9). Though forest is preferred as the habitat of 80% of the bats, 60% are quite at home in urban or semi-urban settings most probably due to abundance of food and the availability of day-roosting sites. About 58% of bat species are seen to prefer caves as roost sites.

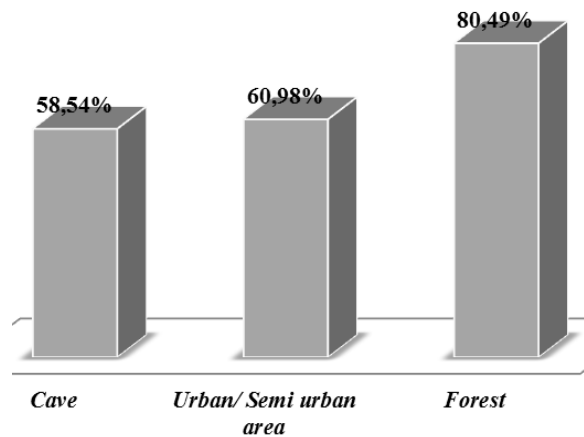


Figure 9: Habitat preference shown by bat species reported from Maharashtra state.

According to the year 2011 state forest report of the Forest Survey of India, very dense forests are found over 8,736 km² of Maharashtra or just 2.84% of the area of the state. Moderately dense forest is found over 20,815km² or 6.76% of the area of the state. Non-forest areas, on the other hand, are spread over 252,892 km² or 82.19% of the area of Maharashtra. These data indicate a reduction in natural forest areas and increased agricultural planting in urban and suburban areas. In terms of the divisions used in this paper, Konkan and Nagpur are well endowed with forest cover whereas the Aurangabad, Pune, and Nashik divisions have poor forest cover (Fig. 10).

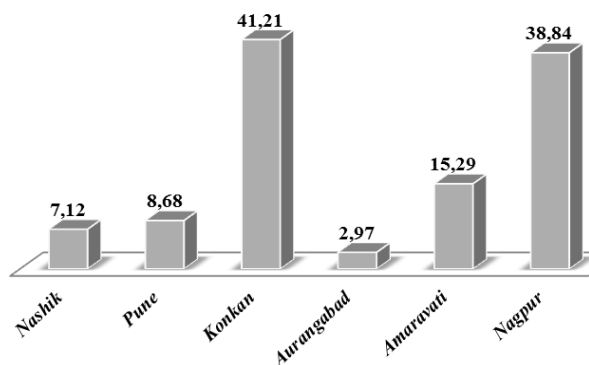


Figure 10: Forest area (%) calculated on basis of geographic area in divisions of Maharashtra state

Discussion

The total Indian bat fauna according to Talmale & Pradhan (2009) includes eight families, 39 genera, 117 species, and 100 subspecies. In this context the diversity of bat fauna in Maharashtra state is high; it shows eight families, 23 genera, and 41 species. Order Chiroptera, to which the bats belong, comprises 31% of the total mammalian species reported from the state of Maharashtra (Pradhan & Talmale, 2012).

Twenty of the 41 bat species of Maharashtra are found in less than 10 known roost sites across the entire state and some, such as *Pipistrellus pipistrellus*, are found in only a single roost. These species, therefore, appear to lead a marginal existence in Maharashtra and deserve urgent conservation attention. According to the mammal survey of the Maharashtra, 28% of the state's mammal species are comprised of microchiropterans but at present not a single species is protected under the Wildlife (Protection) Act (1972), 2006 (Pradhan & Talmale, 2012).

Some bat species reported from the state require specialized habitats; for example, the Burmese whiskered bat (*Myotis montivagus*) which occurs only in the Mahabaleshwar area favours roosting in the vicinity of streams in the hills and feeding on insects in semi-evergreen forest (Korad, *et al.*, 2005). Tickell's bat (*Hesperoptenus tickelli*) is found at high altitudes and lives singly or in pairs in the foliage of large, densely-leafed euphorbs, agave, mango, and banyan (Phillips, 1980; Mitchell, 1980). The painted bat (*Kerivoula picta*), reported only from the southern part of Pune division, prefers to roost singly or, occasionally, in pairs in dead, down-hanging

dried leaves of wild banana and sugarcane (Phillips, 1980) or even in half-built nests of Baya weaver birds *Ploceus philippinus* (Sharma, 1986). Because of the specialized habitat requirements of such species they are restricted to the Western Ghats region. The decline in tropical semi-evergreen forest and subtropical broadleaved hill forest in the Western Ghats constitute a major threat to these bats.

On the basis of statistical analyses it is clear that the Pune and Konkan divisions of the state should be the focus of conservation measures because bat species diversity and evenness indices therein are high. Further underlining the need for concern and protection is the fact that the Western Ghats are a globally recognized biodiversity hotspot (Myers, *et al.*, 2000). This Western Ghats ecosystem harbours about 52 bat species nearly 35% of which are threatened globally or nationally (Korad, *et al.*, 2007). Loss of habitat and habitat fragmentation are the two major contributors to population decline and continuing restriction in distribution of India's bats (Nameer, *et al.*, 2001).

The extent of forest cover in the vicinity of the Western Ghats is variable with Konkan division having the greatest amount of forest and Aurangabad division bringing up the rear (Fig. 10). Thus forests on the western side of the Western Ghats are still in good condition but are much reduced on the eastern side. This has alarming implications not only for the conservation of bats but for other mammal and plant taxa in an acclaimed global biodiversity hotspot. Based on figures in the Forest Survey of India (2011), very dense to moderately dense forest cover covers just 9.6% of the area of Maharashtra. It is essential then to protect such essential habitat by strong conservation policies, strict enforcement of regulations, and public education.

Chiropterans in Maharashtra by and large favour forest habitats; the many caves in these areas are ideal as roost sites. Unfortunately, these forests are being cut down. About 61% of the state's bat species, especially hipposiderids, now live in areas of human disturbance showing a high degree of adaptability in these bats.

Statistical evidence points to a paucity of bat species diversity richness and evenness in Nashik division but this is rather anomalous in that Nashik division is physically near the species-rich Western Ghats; greater effort should be made, therefore, to obtain a clearer picture of bat occurrence and distribution in that division. Similarly, Nagpur division has remarkably high forest cover (38.84% of area) but a poorly known bat fauna and more surveys are recommended to determine bat species richness in that area.

Cynopterus brachyotis (Muller, 1838), *Saccolaimus saccolaimus* Temminck, 1838, *Rhinolophus rouxii* Temminck, 1835, *Rhinolophus lepidus* Blyth, 1844, *Rhinolophus* cf. *cognatus* Andersen, 1906, *Hipposideros pomona* Andersen, 1918, *Myotis montivagus* (Dobson, 1874), *Pipistrellus pipistrellus* (Schreber, 1774), *Pipistrellus javanicus* (Gray, 1838), *Pipistrellus coromandra* (Gray, 1838), *Pipistrellus kuhlii* (Kuhl, 1819), *Falsistrellus affinis* Dobson, 1871, *Hesperoptenus tickelli* (Blyth, 1851), and *Kerivoula picta* (Pallas, 1767) occur exclusively in the Western Ghats and almost all of these bats occupy only a few colonies per species in Maharashtra. Therefore, it is recommended that they be given priority conservation attention regardless of their global IUCN status.

This study shows that Maharashtra is rich in bat species diversity. The particular species richness in the Konkan and Pune divisions of the state, on the western and eastern aspects of the Western Ghats, should make them priorities for conservation efforts. Unfortunately, forest cover in the eastern slopes of the Western Ghats is declining precipitously and requires urgent conservation action to halt terminal decline. It is recommended that more well planned surveys be undertaken in the relatively unexplored Nashik and Nagpur divisions of the state which both show significant potential for harbouring wildlife.

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Appendix I: Bat species of Maharashtra state

Species	Recorded locations in the state of Maharashtra
Sub-Order Megachiroptera	
Family Pteropodidae (Old World fruit bats)	
<i>Rousettus leschenaulti</i> (Desmarest, 1820) ^{LC}	Ghatmatha (Wroughton, 1916); Chikhald, Elephanta, Jogeshwari, Kanheri, Khandara, Alibag, Aurangabad, Ratnagiri (Brosset, 1962a); Ellora (Brosset, 1962a; Bates <i>et al.</i> , 1994a); Mahabaleshwar (Brosset, 1962a; Korad, 2005; Korad <i>et al.</i> , 2006; Korad & Gaikwad, 2008; Korad, 2009); Marathwada (Gopalakrishna & Madhavan, 1970); Satara (Agrawal & Sinha, 1973); Kandri Mines (Karim & Gupta, 1986); Mansar (Bhide & Gupta, 1986); Pune (Bates & Harrison, 1997); Khindsi (Ghosh, 2005); Maval, Mulshi, Junnar, Bhor, Saswad; Khopoli, Wai, Raigad (Korad, 2005); Malshej Waterfall, Lonavala (Gaikwad, 2007); Sinhgad, Purandar, Mendha village, Lakhani (Talmale, 2007); Lonar Crater & Wildlife Sanctuary (Pradhan & Talmale, 2008); Phaltan, Mangalvedha, Kegaon road, Naldurg Fort, Paranda Fort (Gaikwad <i>et al.</i> , 2012).
<i>Pteropus giganteus</i> Brunnich, 1782 ^{LC}	Pili Sipna Valley (Wroughton, 1912b, Pradhan, 2005); Asirgarh, Siwal (Wroughton, 1912b); Karla, Patan (Wroughton, 1916); Poona (Wroughton & Davidson, 1920; Korad & Yardi, 2004a; Korad <i>et al.</i> , 2006; Korad & Gaikwad, 2008; Korad <i>et al.</i> , 2010a); Ahmednagar, Bombay, Malad, Thane, Belapur, Kalyan (McCann, 1934); Amravati (Moghe, 1951); Nagpur (Moghe, 1951; Talmale, 2007); Satara (Bastawde & Mahabal, 1976); Chandrapur, Chanda (Sinha, 1980); Sanjay Gandhi NP, Borivali (Yazdani <i>et al.</i> , 1992); Pench NP (Pradhan, 2004); Junnar, Khed, Maval, Mulshi, Haveli, Shirur, Daund, Indapur, Saswad, Velhe, Bhor, Poladpur, Raigad (Korad, 2005; Korad & Gaikwad, 2008); Deola, Usgaon village, Gadkhangaon, Amalner (Talmale, 2007); Natepute, Akluj, Malinagar, Maloli, Bhalvani, Pandharpur, Rambaug, Tembhurni, Karmala, Barshi, Pangaon, Solapur, Kati, Sindfal, Kini, Jagji, Mangalvedha (Gaikwad <i>et al.</i> , 2012).
<i>Cynopterus sphinx</i> (Vahl, 1797) ^{LC}	Nashik (Andersen, 1912); Poona (Wroughton & Davidson, 1920; Korad & Yardi, 2004a), Chanda (Wroughton, 1913i); Nagpur (Das & Sinha, 1971); Bandra (Andersen, 1912; Yazdani <i>et al.</i> , 1992); Sanjay Gandhi NP, Borivali (Yazdani <i>et al.</i> , 1992); Ajanta (Bates <i>et al.</i> , 1994a); Pench NP (Pradhan, 2004); Mulshi, Velhe, Junnar, Bhor, Saswad; Malshej (Korad, 2005; Korad <i>et al.</i> , 2006; Gaikwad, 2007; Korad & Gaikwad, 2008); Dhakna, Semadoh in Melghat

	TR (Pradhan, 2005); Tadoba-Aandhari TR (Pradhan, 2006); Lakhani, Nalganga, Khandala (Talmale, 2007); Dimbhe, Supe, Patas, Daund, Nimbalk, Baramati, Natepute, Indapur, Karmala, Nira-Narsingpur, Malshiras, Malinagar, Tembhurni, Maloli, Bhalavani, Pandharpur, Mangalvedha, Solapur, Kati, Pangaon, Barshi, Kini, Jagji, Osmanabad (Gaikwad <i>et al.</i> , 2012).
<i>Cynopterus brachyotis</i> (Muller, 1838) ^{LC}	Khandala, Mahabaleshwar (Pradhan & Kulkarni, 1997).
Sub-Order Microchiroptera	
Family Rhinopomatidae (Mouse-tailed bats)	
<i>Rhinopoma microphyllum</i> (Brunnich, 1782) ^{LC}	Bombay (Hill, 1977); Nagpur (Sinha, 1980); Osmanabad (Khajuria, 1953; Gopalakrishna, 1986); Songir, Bhamer (Bates & Harrison, 1997); Apsinga, Tuljapur, Naldurg Fort (Gaikwad <i>et al.</i> , 2012).
<i>Rhinopoma hardwickii</i> Gray, 1831 ^{LC}	Tadoba-Andhari TR (Pradhan, 2006).
Family Emballonuridae (Sheath-tailed bats)	
<i>Taphozous longimanus</i> Hardwicke, 1825 ^{LC}	Chanda (Wroughton, 1913); Chandrapur (Wroughton & Ryley, 1913); Khed (Wroughton, 1916); Nagpur, Amaravati (Gopalakrishna, 1954); Arnala, Elephanta; Khandala, Ratnagiri (Brosset, 1962a); Raigad Fort area, Karjat (Korad, 2005; Korad <i>et al.</i> , 2010a); Wadgaon (Talmale, 2007); Lonar (Pradhan & Talmale, 2008); Patas, Dhamangaon, Solapur, Osmanabad, Apsinga, Naldurga, Ahmednagar, (Gaikwad <i>et al.</i> , 2012).
<i>Taphozous melanopogon</i> Temminck, 1841 ^{LC}	Narnala (Wroughton, 1912; Sapkal & Khamre, 1984); Chikalda in Melghat TR (Wroughton, 1912; Pradhan, 2005); Kanheri caves in Sanjay Gandhi NP, Ellora, Pittalkora, Alibag (Brosset, 1962a); Aurangabad (Ray-Chaudhari <i>et al.</i> , 1971); Nagpur (Naidu & Thakare, 1980); Daulatabad, Helwak, Rajpur (Bates & Harrison, 1997).
<i>Taphozous nudiventris</i> Cretzschmer, 1830 ^{LC}	Ajanta (Wroughton, 1912; Brosset, 1962a); Aurangabad, Ellora (Brosset, 1962a); Kharosa caves (Talmale, 2007).
<i>Saccolaimus saccolaimus</i> Temminck, 1838 ^{LC}	Mumbai (Brosset, 1962a; Talmale, 2007); Malvan (Talmale, 2007).
Family Megadermatidae (False vampire bats)	
<i>Megaderma lyra</i> Geoffroy, 1810 ^{LC}	Ghodasgaon (Wroughton, 1912a; Brosset, 1962b); Belapur, Chichpalli (Wroughton & Ryley, 1913); Ramane Wadi, Khed (Wroughton, 1916); Pune (McCann, 1934); Powai lake, Ellora, Aurangabad; Ajanta, Aurangabad; Kanheri, Borivali (Brosset, 1962b); Nashik, Nagpur, Devikop, Ratnagiri (Sinha, 1980); Bandra (Gopalakrishna & Badwaik, 1989); Sanjay Gandhi NP (Yazdani <i>et al.</i> , 1992); Vijaydurg (Bates & Harrison, 1997); Pipariya, Ranidoh in Pench NP (Pradhan, 2004); Chinchani, Khandala-Satara, Bhimashankar, Maval, Junnar, Panshet, Mulshi, Haveli, Bhor, Rajewadi- Satara; Karjat, Mahad (Korad, 2005; Gaikwad, 2007; Korad <i>et al.</i> , 2010a); Parul village near Mahabaleshwar, Samewada village, Lakhani, Sindewahi (Talmale, 2007); Supe, Daund, Baramati, piliv-Sangola, Bhalavani-Pandharpur, Indapur, Kurbavi-Malshiras, Bhalavani-Mangalvedha, Pothare-Karmala, Osmanabad (Gaikwad <i>et al.</i> , 2012).
<i>Megaderma spasma</i> Linnaeus, 1758 ^{LC}	Khandala (Brosset, 1962b); Mumbai Suburban Dist.: Kanheri, Sanjay Gandhi National Park- Borivali (Brosset, 1962b; Topal, 1974; Yazdani <i>et al.</i> , 1992); Thana- Rajpur; Chanda (Bates & Harrison, 1997); Amaravati Dist.: Tarubanda in Kolkaz area, Melghat Tiger Reserve (Pradhan, 2005); Mahabaleshwar (Korad, 2005; Korad, 2009); Kolhapur Dist.: Pundre (Talmale, 2007).
Family Rhinolophidae (Horseshoe bats)	
<i>Rhinolophus rouxii</i> Temminck, 1835 ^{NT}	Nerur, Sawantwadi, Asgani (Andersen, 1917); Bassein, Borivli, Vihar Lake, Jogeshwari, Borivali, Kanheri caves (Brosset, 1962b; Yazdani <i>et al.</i> , 1992); Bhaja caves, Khandala, Lohogad Fort, Karnala (Brosset, 1962b); Mahabaleshwar (Brosset, 1962b; Topal, 1974; Korad, 2005; Korad <i>et al.</i> , 2006; Korad <i>et al.</i> , 2010a); Pune (Modak & Kamat, 1968); Sangmeshwar (Muni <i>et al.</i> , 1994); Pebkila near Matheran, Koturde (Korad, 2005; Talmale, 2007); Sinhadgad-Pune, Maval, Mulshi, Karjat, Harishchandragad, Bhimashankar, Raigad Fort, Poladpur, Bajire (Korad, 2005; Korad <i>et al.</i> , 2008; Korad <i>et al.</i> , 2010a); Devrukh (Talmale, 2007).

<i>Rhinolophus lepidus</i> Blyth, 1844 ^{LC}	Helwak (Wroughton, 1916); Kanheri caves, Nashik Road (Brosset, 1962b); Pundre (Talmale, 2007); Khandala, Lonavla, Lohogad Fort, Karnala, Ratnagiri, Panchgani, Mahabaleshwar (Brosset, 1962b; Korad <i>et al.</i> , 2006; Korad <i>et al.</i> , 2008); Khopoli (Tiwari <i>et al.</i> , 1971); Mulshi, Junnar, Bhimashankar, Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2010a).
<i>Rhinolophus cognatus</i> Andersen, 1906 ^{VU}	Khreshwar-Harishchandragad, Bhimashankar, Mulshi, Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2008).
<i>Rhinolophus beddomei</i> Andersen, 1905 ^{NT}	Khandala, Karla, Bhaja, Bedsar (Brosset, 1962b); Nagpur (Naidu & Murhar, 1979); Ramgad (Bates & Harrison, 1997); Junnar, Maval, Mulshi, Mahad, Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2008; Korad <i>et al.</i> , 2010a); Salsette (Talmale, 2007).
Family Hipposideridae (Leaf-nosed bats)	
<i>Hipposideros ater</i> Templeton, 1848 ^{LC}	Marathwada, Dongarkhed, Shirol (Gopalakrishna & Madhavan, 1977); Nanded (Bates & Harrison, 1997); Maval, Ambegaon, Junnar, Karjat, Mahad, Khopoli, Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2010b).
<i>Hipposideros fulvus</i> Gray, 1838 ^{LC}	Shirgaum (Wroughton, 1916iii); Elephanta (Ali, 1953); Panchgani (Khajuria, 1953; Korad, 2005); Chikalda, Aurangabad, Nashik, Bombay-Vihar Lake, Karla, Lonaval, Mahabaleshwar, Ratnagiri (Brosset, 1962b); Nagpur (Sabnis, 1973); Bhaja (Topal, 1974); Nanded, Marathwada (Madhavan <i>et al.</i> , 1978); Bandra (Bates & Harrison, 1997); Junnar, Ambegaon, Maval, Mulshi, Karjat, Mahabaleshwar (Korad, 2005; Korad, 2009; Korad <i>et al.</i> , 2010b); Pandharpur (Talmale, 2007).
<i>Hipposideros pomona</i> Andersen, 1918 ^{LC}	Mulshi, Maval, Junnar, Mahad (Korad, 2005; Korad <i>et al.</i> , 2010b).
<i>Hipposideros galeritus</i> Cantor, 1846 ^{NT}	Chikhald, Ellora, Mumbai- Kanheri, Bedsar Caves (Brosset, 1962b); Ajanta (Topal, 1975); Shivtharghal near Mahad (Korad, 2005; Korad <i>et al.</i> , 2010b).
<i>Hipposideros speoris</i> (Schneider, 1800) ^{LC}	Chanda (Blanford, 1988-91); Alibag, Borivali, Kanheri (Brosset, 1962b); Pune, Khandala (Brosset, 1962b; Korad & Yardi, 2004a); Elephanta (Topal, 1974); Near Satara (Hill, 1976); Chandrapur (Gopalakrishna & Bhatia, 1982); Nanded (Gopalakrishna <i>et al.</i> , 1991); Ellora (Bates <i>et al.</i> , 1994c); Bhuleshwar, Yavat (Korad, 2005; Talmale, 2007); Bhimanagar, Indapur, Nira Narsingpur, Bhaje, Karle, Karjat, Junnar, Shirur; Matheran (Korad, 2005, Korad <i>et al.</i> , 2010b; Gaikwad, 2007); Pothare, Karmala, Bhalavani, Pandharpur, Osmanabad caves, Kurduwadi (Gaikwad <i>et al.</i> , 2012).
<i>Hipposideros lankadiva</i> Kelaart, 1850 ^{LC}	Chandrapur (Sapkal & Bhandarkar, 1984); Sangameshwar (Muni <i>et al.</i> , 1994); Tadoba-Andhari TR (Pradhan, 2006).
Family Molossidae (Free-tailed bats)	
<i>Tadarida aegyptiaca</i> (Geoffroy, 1818) ^{LC}	Aurangabad (Brosset, 1962c); Pune (Korad & Yardi, 2004a); Khondai, Mulshi (Korad, 2005; Korad <i>et al.</i> , 2010a); Sinhagad (Talmale, 2007); Dhamangaon, Solapur, Kunthalgiri, Osmanabad (Gaikwad <i>et al.</i> , 2012).
<i>Chaerephon plicata</i> (Buchanan, 1800) ^{LC}	Karla (Bates & Harrison, 1997); Pune (Korad & Yardi, 2004a); Patas, Daund, Lonavla (Korad, 2005; Korad <i>et al.</i> , 2010a).
Family Vespertilionidae (Vesper or Evening bats)	
<i>Myotis formosus</i> (Hodgson, 1835) ^{LC}	Nagpur (D'Abreu, 1925).
<i>Myotis montivagus</i> (Dobson, 1874) ^{VU}	Mahabaleshwar (Korad <i>et al.</i> , 2005).
<i>Myotis horsfieldii</i> (Temminck, 1840) ^{LC}	Pune (Thomas, 1915); Elephanta Island (Brosset, 1962c); near Satara (Hill, 1976); Lonavla, Lonikalbhor, Shirur, Mahad, Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2010a).
<i>Scotophilus heathii</i> Horsfield, 1831 ^{LC}	Nagpur, Panchgani (Khajuria, 1953); Thana, Ajanta (Brosset, 1962c); Elephanta caves (Brosset, 1962c; Topal, 1974); Andheri, Bandra, Chandrapur, Allapalli, Poona, Dhulia (Bates & Harrison, 1997); Sillari in Pench NP (Pradhan, 2004); Semadoh in Melghat TR (Pradhan, 2005); Alandi, Khed-Shivapur, Bhor, Karjat, Poladpur (Korad, 2005; Korad <i>et al.</i> , 2010a; Gaikwad, 2007); Kolsa in Tadoba-Andhari TR (Pradhan, 2006); Sindewahi, Nira Narsingpur, Indapur (Talmale, 2007); Bhima Koregaon, Daund, Nira Narsingpur, Jamb- Indapur, Dhamangaon, Solapur (Gaikwad <i>et al.</i> , 2012).

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<i>Scotophilus kuhlii</i> Leach, 1821 ^{LC}	Pareli (Thomas, 1897), Ajanta, Bhodwad (Wroughton, 1912a); Poona (Wroughton & Davidson, 1920; Korad & Yardi, 2004a); Nagpur, Panchgani (Khajuria, 1953); Aurangabad, Bombay, Satara (Brosset, 1962c); Chanda, Sultanpur (Bates & Harrison, 1997); Sipna river near Semadoh in Melghat TR (Pradhan, 2005); Khed, Karjat, Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2010a).
<i>Pipistrellus pipistrellus</i> (Schreber, 1774) ^{LC}	Pune City (Korad & Yardi, 2004b).
<i>Pipistrellus javanicus</i> (Gray, 1838) ^{LC}	Panchgani (Khajuria, 1953); Pune City (Korad & Yardi, 2004a); Khed, Karjat, Matheran (Korad, 2005; Korad <i>et al.</i> , 2010a).
<i>Pipistrellus coromandra</i> (Gray, 1838) ^{LC}	Mumbai, Phonda (Brosset, 1962c), Bandra (Bates & Harrison, 1997), Pune (Korad & Yardi, 2004a; Korad, 2005; Korad <i>et al.</i> , 2010a); Pimpri-Chinchwad (Talmale, 2007).
<i>Pipistrellus tenuis</i> (Temminck, 1840) ^{LC}	Bhodwad (Wroughton, 1912a); Chikalda (Wroughton, 1912c); Chandrapur, Chinchpali; Chanda (Wroughton, 1913ii); Ratnagiri (Sinha, 1980); Mumbai, Karnala (Brosset, 1962c); Pune (Brosset, 1962c; Korad & Yardi, 2004a; Korad, 2005; Korad <i>et al.</i> , 2010a); Nanded (Karim, 1975); Mulshi-jambe farm, Wai, Hiware tank (Talmale, 2007).
<i>Pipistrellus ceylonicus</i> (Kelaart, 1852) ^{LC}	Helwak (Wroughton, 1916); Chikalda, Ajanta, Nasik, Bombay, Satara (Brosset, 1962c); Junnar (Brosset, 1962c; Korad, 2005; Korad, 2009; Korad <i>et al.</i> , 2010a); Panchgani (Tiwari <i>et al.</i> , 1971); Nanded (Madhavan, 1971); Aurangabad, Nagpur (Sabnis, 1973); Lonawala, Karla (Topal, 1974); Bandra, Thana, Lanje, Andhari (Bates & Harrison, 1997); Pune (Brosset, 1962c; Korad & Yardi, 2004a); Maval, Mulshi, Ambegaon, Khed, Karjat, Mahad (Korad, 2005; Korad, 2009; Korad <i>et al.</i> , 2010a); Nalganga, Kopargaon, Talegaon-Dabhade (Talmale, 2007).
<i>Pipistrellus kuhlii</i> (Kuhl, 1819) ^{LC}	Pune City (Korad & Yardi, 2004b; Korad, 2005; Korad <i>et al.</i> , 2010a); Satara, Nimbalk (Gaikwad <i>et al.</i> , 2012).
<i>Hypsugo savii</i> (Bonaparte, 1837) ^{VU}	Pune city (Korad & Yardi, 2004b); Ranjegaon, Mulshi (Korad, 2005; Korad <i>et al.</i> , 2010a); Nimblak, Phaltan, Satara, Kololi, Baramati, Solapur city, Apsinga, Tuljapur; Osmanabad caves (Gaikwad <i>et al.</i> , 2012).
<i>Falsistrellus affinis</i> Dobson, 1871 ^{NT}	Nanded (Pathak & Sharma, 1969); Pune (Korad & Yardi, 2004a); Dehu, Bhimashankar, Shivneri, Bhaje, Saswad; Mahabaleshwar (Korad, 2005; Korad <i>et al.</i> , 2010a).
<i>Scotozous dormeri</i> (Dobson, 1875) ^{LC}	Chanda (Blanford, 1888-91); Ajanta (Wroughton, 1912a); Chikalda (Wroughton, 1912c); Mumbai (Brosset, 1962c); Nanded (Madhavan, 1978); Bassein (Bates & Harrison, 1997); Pune (Korad & Yardi, 2004a); Mulshi (Korad, 2005; Korad <i>et al.</i> , 2010a); Gangakhed, Mandangadh (Talmale, 2007).
<i>Hesperoptenus tickelli</i> (Blyth, 1851) ^{LC}	Mumbai, Pune (Brosset, 1962c); Chahade (Bates & Harrison, 1997); Andheri, Salsette, Kamshet (Talmale, 2007).
<i>Miniopterus schreibersii</i> (Kuhl, 1819) ^{LC}	Mahabaleshwar, Panchgani (Brosset, 1962c; Korad, 2005; Korad <i>et al.</i> , 2006; Korad, 2009; Korad <i>et al.</i> , 2010a); Satara (Hill, 1976); New Karanje, Kolhapur (Talmale, 2007).
<i>Kerivoula picta</i> (Pallas, 1767) ^{LC}	Ghatmatha (Wroughton, 1916a); Mumbai, Borivali, Khandala, Satara (Brosset, 1962c); Santacruz, Juhu, Goregaon, Dahanu (Talmale, 2007).

Abbreviations: EN, Endangered; LC, Least Concern; NE, Not Evaluated; NT, Near Threatened; VU, Vulnerable; NP, National Park; TR, Tiger Reserve.

PLATE 9

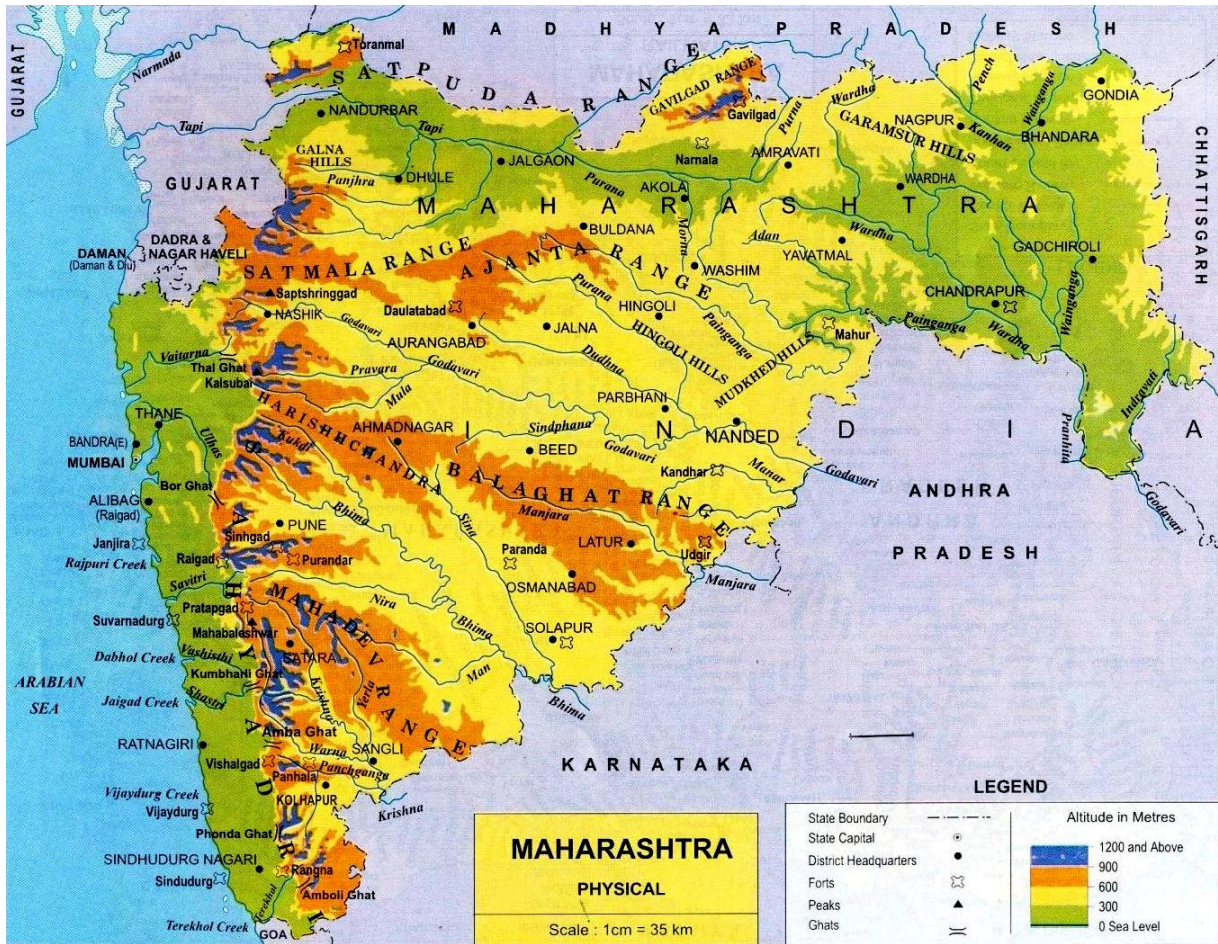


Figure 1: Topographic map of Maharashtra State, India

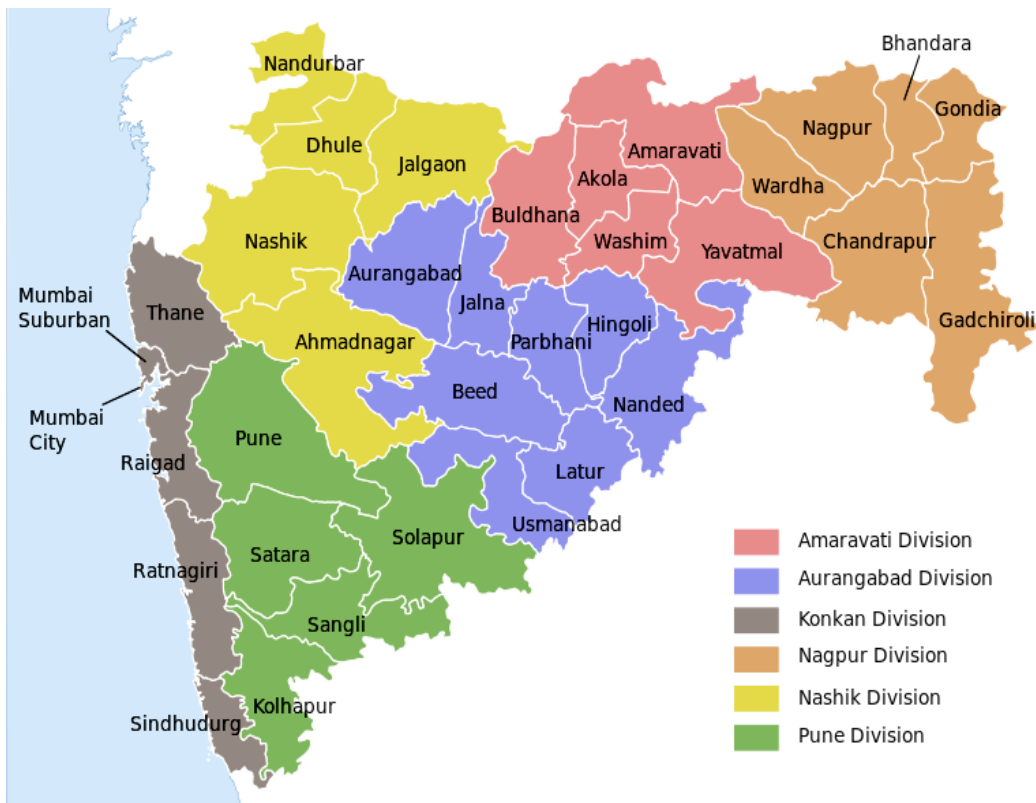


Figure 2: Administration map of Maharashtra State, India showing Divisions and Talukas (Sub Divisions)