

Micro hotspots of new species discoveries in India: flora and fauna

India is one of the ‘mega biodiversity’ countries with high endemism and species richness. In 2019, the Botanical Survey of India assessed plant diversity in the country and reported about 18,666 species of angiosperms, of which 4791 (25.7%) are endemic¹. In 2019, the Zoological Survey of India assessed 98,156 species of Animalia, of which 29,787 (30.3%) are endemic². Habitat loss and habitat degradation have been identified as the major drivers of species decline³. Endemic species in particular, suffer from disturbances as their distribution range is limited⁴.

The term ‘biodiversity hotspot’ specifically refers to 36 biologically rich areas around the world that have at least 1500 endemic species of vascular plants and lost at least 70% of their primary native vegetation⁵. ‘Micro hotspots’ are endemic, species-rich areas that have been used to delineate hotspots within a hotspot⁶. A nationwide study indicated 28% natural forest cover loss in India from 1930 to 2013 (ref. 7). With the current trend of disturbances to natural ecosystems, there is an urgent need to generate a spatial database of distribution of localities of new species to search for biodiversity-rich regions and conservation-oriented requirements. This study

appraises decadal species discoveries from 2009 to 2018, distribution of new species, micro hotspots and hotspot congruence.

New species data of India were collected from the literature^{1,2}. Geographical coordinates for each type locality were assigned using published data on species occurrence. The locations have been geotagged to the nearest possible site for the species whose exact coordinate is not available using vegetation type, elevation and habitat-related information^{8,9}. The species richness hotspot was developed using spatial point location data. Optimized Hot Spot analysis tool was used to obtain a representation of micro hotspots at 5 km grid level. For count incidents within fishnet grid, an appropriate polygon cell size is computed which is then positioned over the incident points and the points within each polygon cell are counted. Getis-Ord Gi* was used to calculate the GiZ score of each grid to identify the spatial clustering of high values (hotspots) with statistical significance¹⁰. For statistically significant positive z-scores, the larger the z-score is, the more intense clustering of high values (hotspot). For statistically significant negative z-scores, the smaller the z-score the more intense is the clustering of low values

(cold spot). The Gi* statistic is two-tailed; a score of ±2 represents strong clustering, as 95% of the data under normal distribution should be within two standard deviations of the mean⁹.

$$Gi^* = \frac{\sum_{j=1}^n W_{i,j} x_j - \bar{X} \sum_{j=1}^n W_{i,j}}{S \sqrt{\frac{n \sum_{j=1}^n W_{i,j}^2 - \left(\sum_{j=1}^n W_{i,j} \right)^2}{n-1}}}$$

where x_j is the attribute value for the feature j , $w_{i,j}$ the spatial weight between features i and j , and n is the total number of features.

$$\bar{X} = \frac{\sum_{j=1}^n x_j}{n}, \quad S = \sqrt{\frac{\sum_{j=1}^n x_j^2}{n} - (\bar{X})^2}$$

Gi* is a z-score and no further calculation is required.

Overall, the number of new plant and animal species showed an increase during 2009–2018 (refs 1, 2). The number of angiosperm species in India reached to 18,666 in 2018, with an overall addition of 4.4% of new species (Table 1).

Table 1. New plant species described in India from 2009 to 2018 (ref. 1)

Group	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Average discoveries/yr	Increase in species discoveries (%)
Algae	4	2	7	25	2	9	9	2	13	5	78	7.8	1.1
Lichens	30	4	14	24	4	13	8	8	4	7	116	11.6	4.5
Bryophytes	0	7	3	8	7	2	1	4	3	13	48	4.8	1.7
Pteridophytes	0	3	4	1	0	3	13	0	3	9	36	3.6	2.8
Angiosperms	62	69	56	76	68	82	73	101	129	103	819	81.9	4.4
Total	96	85	84	134	81	109	104	115	152	137	1097	109.7	3.4

Table 2. New animal discoveries in India from 2009 to 2018 (ref. 2)

Phylum/ Class	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Average discoveries/yr	Increase in species discoveries (%)
Invertebrata	48	24	161	104	196	127	226	268	232	311	1697	169.7	1.9
Vertebrata													
Pisces	1	4	7	19	36	23	26	27	27	21	191	19.1	5.6
Amphibia	5	0	23	2	5	24	6	12	18	9	104	10.4	24.9
Reptilia	0	0	2	2	2	2	4	6	12	30	60	6	9.8
Aves	1	0	0	1	0	0	0	0	0	0	2	0.2	0.1
Mammalia	0	0	0	0	0	0	0	0	0	1	1	0.1	0.2
Total	55	28	193	128	239	176	262	313	289	372	2055	205.5	2.1

The number of known vertebrate species in India reached 6199 in 2018 (ref. 2). Of the 2055 new species from 2009 to 2018, 1697 are invertebrates and 358 are vertebrates (Table 2). The number of vertebrates includes 191 species of fishes, 104 species of amphibians, 60 species of reptiles, two species of birds and one species of mammals. Analysis of the last ten years data revealed that about 5.8% discoveries to Indian vertebrates were made. The highest number of new angiosperm species was discovered from Kerala (28.7%), followed by Arunachal Pradesh (14%), Tamil Nadu (11.5%), Maharashtra (6.8%), Andaman and Nicobar Islands (6.5%), Karnataka (4.9%), Uttarakhand (3.6%) and Meghalaya (3.5%).

Of the 3152 new species of flora and fauna, a spatial database on the distribution of localities of 1701 (54%) species has been prepared. The spatial analysis of species richness micro hotspots covered 1007 new species of animals and 694 new species of plants. Figure 1 shows the geographical distribution of new plant and animal species locations in India. Of the 1007 new species, the highest number of animal species was described from Kerala (193), followed by West Bengal (119), Karnataka (108), Tamil Nadu (78), Maharashtra (59), Arunachal Pradesh (49), Meghalaya (39), Andaman and Nicobar Islands (36) and Assam (35). Analysis of land-use/land-cover types indicates that 88% of locations of new plant species fall under forests. About, 41% of locations of new animal species are distributed in forests, followed by 18% in wetlands¹¹. Most of the new species have been reported from wet evergreen forests, semi-evergreen forests and moist deciduous forests of the Western Ghats, the Himalaya, North East India, Andaman and Nicobar Islands and the Deccan peninsula.

Micro hotspots of floristic richness are found mainly in protected areas, i.e. Periyar, Mundanthurai, Khangchendzonga, Mehao, Thattekadu Bird, Eravikulam, Mukurthi, Saddle Peak, Malabar, Kalakad, Neyyar, Peppara, Mundanthurai, Shendurney, Idukki, Kurinjimala, Indira Gandhi (Anamalai), Eravikulam, Parambikulam, Chimmony, Peechi-Vazanthi, Silent Valley, Kottiyoor, Pushpagiri, Kudremukh, Shettihalli, Bhadra, Mookambika, Sharavathi Valley, Bhimgad, Mollem, Anshi, Radhanagari, Pawalgarh, Buxa, Gorumara, Pakke, Sonai-Rupai,

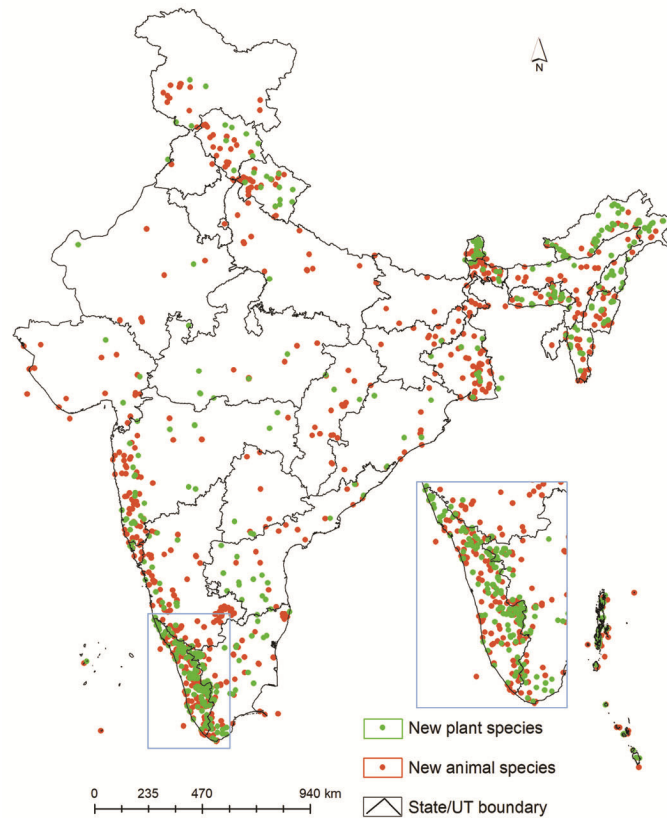


Figure 1. Distribution of new animal and plant species in India.

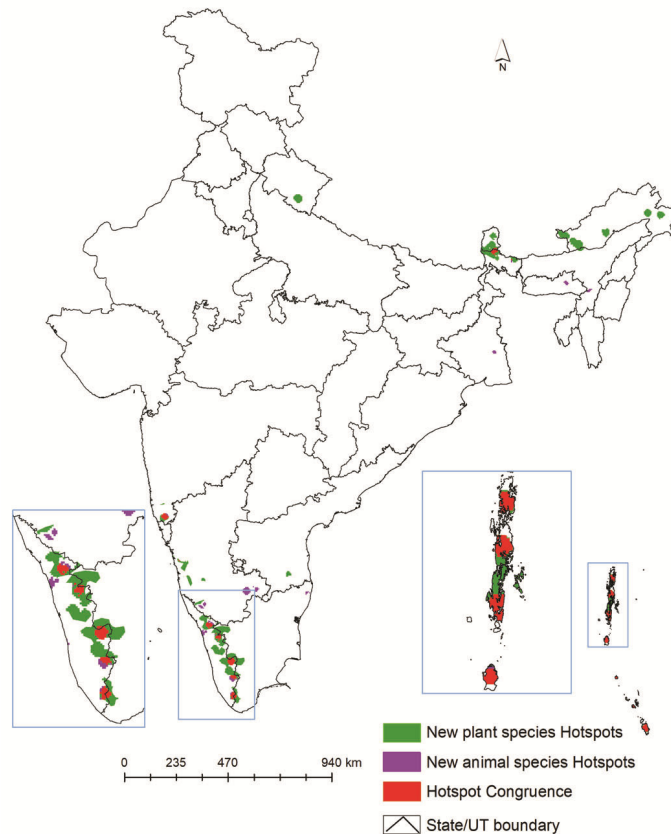


Figure 2. Distribution of micro hotspots of new species richness in India.

Kane, Namdapha, Yordi-Rabe-Supse, Murlen, Seshachalam-Cuddapah and Trishna. Micro hotspots of faunal richness are distributed in Periyar, Mundanthurai, Jaldapara, Eravikulam, Khangchendzonga, Mukurthi, Gorumara, Indira Gandhi (Anamalai), Mount Harriett, Buxa, Neora Valley, Nokrek, Rajaji, Mahatma Gandhi Marine, Thattekadu Bird, Parambikulam, Nokrek, Saddle Peak, Malabar, Silent Valley, Kudremukh, Sharavathi Valley, Wayanad, Peppara, Shendurney, Pangolakha, Mehao and Great Nicobar. Combined analysis of the species richness indicates that the highest number of new species of flora and fauna is from Periyar (23), Mundanthurai (22), Khangchendzonga (20), Mehao (15), Thattekadu Bird (15), Eravikulam (15), Mukurthi (11), Saddle Peak (10), Malabar (10), Indira Gandhi (Anamalai) (10), Jaldapara (10), Mahatma Gandhi Marine (9), Wayanad (8), Nokrek (8), Mount Harriett (8), Kudremukh (7), Neora valley (5), Peppara (5), Silent Valley (5), Sharavathi Valley (5), Pangolakha (5) and Great Nicobar (5).

At a regional level, highest congruence of both plant and animal richness hotspots are found in Kerala, and Andaman and Nicobar Islands (Figure 2). Many of these are localized and have patchy distribution. Similar to Madagascar, Indian endemic fauna is characterized by narrow distribution range and areas with high levels of endemism and thus entire species are likely to be threatened by medium- to small-scale habitat loss^{12,13}. Field-level information is required to assess vegetation degradation, fire adaptations and post-fire ecological effects on

the localities of newly discovered species. In this study we identify micro hotspots of new species richness and congruence hotspots of new flora and fauna which would support in prioritization of landscapes for conservation. The new species discoveries are often associated with the amount of inventorization effort taken in a specific region. A region might have high potential for new discoveries, but due to lack of exploration as well as selection of 54% of newly reported species may not emerge as a micro hotspot in the present study.

Conflict of interest. The authors declare that there is no conflict of interest.

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