The impact of traditional conservation practices on species composition and diversity patterns of sacred swamps in the central Western Ghats, India

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Abstract Sacred forests are of immense value for their ecosystem functions. Traditional indigenous conservation practices have helped to maintain biological diversity over centuries and have resulted in the preservation of some of the best patches of natural vegetation. Species that are endemic and restricted only to certain ecosystems find refuge in the microclimatic conditions of sacred groves and many rare species are found here. Here, we compared species composition, floristic structure, diversity, and occurrence of amphibians, insects (odonatan) and birds in ten sacred swamps and ten non-sacred swamps in the central Western Ghats region, India. The sites were chosen based on similarities in distance from roads, village settlements, or commercial orchards and size. In the sacred swamps, 122 plant species from 99 genera and 58 families occur compared to 83 species from 72 genera and 47 families in the non-sacred swamps. Tree stem density was 277 individuals/ha in sacred swamps against 158.4 in non-sacred swamps. Average basal area was 47.57 m²/ha in sacred swamps and only 14.60 m²/ha in non-sacred swamps. Regeneration of swampy species is much better in sacred swamps showing a positively skewed distribution of individuals over all classes. Sacred swamps have a higher number of endemic species (28%) when compared to non-sacred swamps. There exist significant differences in the Shannon index of species diversity of amphibians and birds between sacred and to non-sacred swamps. We conclude that the traditional belief system of treating the swamps as sacred has helped to protect these ecologically important forests. Sacred forests are of immense value for their ecosystem functions. Traditional indigenous conservation practices have helped to maintain biological diversity over centuries and have resulted in the preservation of some of the best patches of natural vegetation.

Keywords Amphibians · Basal area · Sacred fresh water swamps · Species composition · Stem density · Western Ghats

Introduction

Sacred groves play a significant role in forest stand survival across the globe (Gadgil and Chandran 1992; Tiwari et al. 1998) and are considered an effective tool in biodiversity conservation (Byers et al. 2001; Ramanujam and Kadamban 2001; Campbell 2004). They are of immense value for the ecosystem services they provide and have survived because of community-based preservation practices (Gadgil and Vartak 1976; Ceperley et al. 2010). Traditional indigenous
conservation practices and values integrated with religious knowledge have helped to maintain cultural and biological diversity over centuries and have resulted in the preservation of some of the best patches of natural vegetation in terms of species diversity and presence of endemic species (Gadgil and Vartak 1976; Komanda et al. 2003). Although some supporting traditions have been weakened by modern influences, sacred groves are frequently more acceptable to local peoples than externally imposed conservation policies (Ntiamo-Baidu 2008).

Exclusive taxa (i.e., species that are endemic and restricted only to certain ecosystems) find refuge in the micro-climatic conditions of sacred groves and many rare species are found only there (Singh et al. 2011). Numerous studies suggest that the biological spectrum of sacred groves in the tropics closely resembles the typical spectrum of tropical forest biodiversity and that in sacred groves endangered and rare species of flora and fauna are better conserved than in forests areas that are merely protected by externally imposed laws (Tiwari et al. 1998; Campbell 2004; Shahabuddin and Rao 2010; Shen et al. 2015).

Whereas human disturbance often results in an initial increase in the overall species number (Murali and Setty 2001), native and endemic species may be replaced by non-endemic and invasive ones (Irwin et al. 2010; Byers 2002; Sagar et al. 2003). Leigh (1965) suggests that stability increases with the complexity of the ecosystem, i.e. with the number of species and their interactions (MacArthur 1965). Heterogeneous forests may accommodate more species, particularly those requiring specialized microhabitats (Hansen et al. 1991; Pausas and Austin 2001), because they provide greater variety in microclimate, hiding and nesting sites etc., compared to more homogeneous forests (e.g. MacArthur and MacArthur 1961; Murdoch et al. 1972). Especially the structure of the tree stratum has a central role in determining the ecological processes and habitat characteristics in the forest (Kuuluvainen et al. 1996). Structural complexity of forests is, thus, often a good predictor of overall species diversity (Begon et al. 1986) and can be used to assess the conservation or biodiversity value of forest stands (Hansen et al. 1991).

Whereas forest structure informs biodiversity, information on the latter (i.e., species composition, diversity and population structure) is essential to understand forest ecosystem dynamics at various levels (Giriraj et al. 2008), to provide a conceptual framework and measurable indicators to assess the overall ecosystem condition, and to monitor change (Noss 1990).

Such structural richness and tree species diversity are found in the freshwater swamps of the Uttara Kannada district of the Central Western Ghats, India. These marshy areas with a high-water table and slow runoff occur on flat terrain around streams. In the Western Ghats they are tree-covered wetlands within evergreen forests. In Uttara Kannada, they are known as Myristica swamps because of the high presence of species of the Myristicaceae family (Chandran and Mesta 2001; Pascal et al. 2004). Within the climax evergreen forests, they occupy poorly drained depressions that often open into a river or rivulet and have their groundwater level very close to the ground surface. Important species exclusively found in the swamp forests include Myristica fatica var. magnifica, Gymnacranthera canarica, Vateria indica, Dipercarpus indicus, Dysoxylum binectariferum, Myristica malabarica, Mastixia arborea, Lophopetalum wightianum and Calophyllum apetalum (Chandran et al. 2010). Large populations of the endangered and endemic primate Lion Tailed Macaque (Macaca silenus) and Great Pied Hornbill (Buceros biornis) are also found here (Ramachandran and Joseph 2000; Ali et al. 2006).

Some of these swamps are sacred, dedicated to worship one or several deities through long-term commitment and traditional laws and practices. Such sacred swamps today only exist close to commercial gardens, roads and settlements (average distance 100 m, Hegde et al. 2018). Further away from these anthropogenic features there are no sacred swamps.

Both sacred and non-sacred swamps are protected by the state forest department and fall under the category of reserve forests. Sacred swamps have additional protection since ancient times by traditional laws, practices and worship of deities. Here human activities are restricted (general entry, water diversion and pollution, collection of leaf litter, fuel wood, construction materials, hunting) (Hegde et al. 2020).

Sacred swamps are a perennial source of water used for irrigation and domestic use and the stakeholder groups highly appreciate this hydrological value. Stakeholders have also assigned other values like religious, biodiversity, recreational, utilitarian
Believers express the sentiment that the deities protect them personally as well as the entire community. Communities treat the flat terrain within the swamp forests as core zone strictly dedicated to the deity, whereas they consider the adjacent forests up to few meters distance around the core zone as a buffer zone. Non-timber forest products (NTFPs) are collected in the non-sacred swamps, whereas they are collected only in the buffer zone of the sacred swamps. During rituals in the swamp, people from different social and wealth classes come together, which provides an opportunity for socialization (Hegde et al. 2020).

Whereas most research in this area has focused on sacred tropical upland forests, this study looks specifically at sacred swamps. We compare the composition and structure of vascular plant vegetation, and the species composition of amphibians, birds, butterflies and odonatans in sacred and non-sacred swamps in order to explore whether the traditional belief systems of treating swamps as sacred are more effective in protecting ecologically important forests than the mere protection by state law.

Methods

Study area

The Western Ghats Mountain ranges, running parallel along the west coast of India, constitute one of the eighteen ‘hottest global biodiversity hotspots’ of the world, because of their large number of endemic biota and the scale and speed of their current habitat loss (Myers et al. 2000). The mountain ranges support— together with Sri Lanka—about 4780 vascular plant and 1073 vertebrate species, of which, respectively, 2180 (i.e., 0.7% of the world’s plant species) and 355 species (i.e., 1.3% of the global vertebrate species) are endemic. At the same time, the region has lost most of its primary vegetation with only 6.8% of the original vegetation remaining (Myers et al. 2000). Uttara Kannada (13.85°–15.7166°N, 74.166°–75.2833°E) is one of the most densely vegetated districts (81% of geographic area under forest cover, but not necessarily original vegetation) within the Western Ghats and is endowed with rich natural resources.

Ten sacred swamps (total area 5.60 ha) and ten non-sacred swamps (total area 5.71 ha) of similar size were studied. The sacred swamps had an average distance to the nearest road, settlement or commercial orchard of 109 m (standard deviation 19.5), the non-sacred swamps an average distance of 332 m (standard deviation 66.7) (Table 1).

Vegetation was assessed between December 2013 and April 2014 in transects of 5 m wide and variable length (100–1000 m) along the stream depending on the actual length of the stream, covering a total area of 1.70 ha (sacred swamps) and 1.71 ha (non-sacred swamps). The entire depression part (low lying flat terrain of the forests) of the swamps was surveyed. All vegetation was recorded along the entire length of the 20 transects. Next to the flat terrain of the sacred swamps, species composition was assessed in the catchment area of the swamps in transects of 50 m × 5 m perpendicular to the edge on either side of each swamp. All plant species were identified using regional and standard floras (Cooke 1903; Talbot 1909–1911; Gamble and Fischer 1935) and keys (Pascal and Ramesh 1987). Tree girth was measured at breast height using a measuring tape. Tree diameters were categorized in 11 diameter classes of 30 cm, with the smallest class having 1–30 cm and the largest ≥ 301 cm girth at breast height (GBH) (Fig. 1).

Faunal data were collected in different seasons viz., rainy season (June and July 2014), winter (October and November 2014) and summer (April and May 2015). The entire area of the swamps was surveyed for amphibians, selected insect groups and birds. Amphibian species were recorded by a team of four to five people, a detailed search of all aquatic and (semi-) terrestrial habitats was carried out, including leaf litter, decaying logs, boulders, tree bark and ground cover. For arboreal taxa, searches were carried out in bushes and small trees. Torches were used to find and identify amphibians by following their calls at night. Dragonfly, damselfly and butterfly species were recorded through visual observation. Birds were recorded by visual observation and audio identification (by hearing the calls). Faunal documentation took three to five hours per swamp per season and per team. The study of amphibians took nearly 490 person hours of field work, that of dragonflies, damselflies, butterflies and birds in total 660 h. Field guides (Subramanian and Gadgil 2009; Singh et al. 2011; Grimmett et al. 2011; Gururaja 2012; Kiran and Raju 2013) were used for in situ identification of species, and high-resolution photos (with Canon
600 D camera with Tamron 90 mm macro and Canon 55–250 zoom lenses) were taken for confirmation of the identification.

Data analysis

Biomass productivity (stem density and basal area), frequency and importance value index (IVI) of tree species were calculated according to Bonham (2013).

Frequency is the number of times a plant species is present in a given number of quadrats of a particular size or at a given number of sample points.

Species density is the number of a species in unit area. It is calculated as:

\[
\text{Density} = \frac{\text{Total number of the species}}{\text{Total area sampled}}
\]

The basal area of a stand is the total stem area at breast height of all trees in a plot divided by the total area of that plot (Chaturvedi and Khanna 1994; Cain and Castro 1960):

\[
\text{Basal area (m}^2\text{)} = \pi \times (\text{DBH/2 in cm})^2/40,000
\]

The Family Importance Value (FIV) for growing stock (volume of all trees \(\geq 30\) cm DBH) was calculated as follows;

\[
\text{FIV} = \text{Relative density} + \text{Relative diversity} + \text{Relative dominance}
\]

where

\[
\begin{align*}
\text{Relative density} &= (\text{Number of individuals in family A/Total number of individuals of all families}) \times 100 \\
\text{Relative diversity} &= (\text{Number of species in family A/Total number of species}) \times 100 \\
\text{Relative dominance} &= (\text{Basal area of all individuals of family A/Total Basal area of all individuals of all families}) \times 100
\end{align*}
\]
To express both richness (total number of species) and abundance or evenness (how equally the individuals from each species are represented) into a single numerical value, we used the Shannon ($H'$) diversity indices. In the Shannon index, equitability assumes a value between 0 and 1, with 1 being complete evenness (Shannon and Weaver 1949; Magurran 1988).

To record the regenerating species, two plots (quadrats) of 5×5 m were laid out, one at the 50th and another at the 100th meter of each transect along the stream. Trees (seedlings) with less than 30 cm GBH were considered as the regenerating potential of the species. The natural regenerates were grouped into following regeneration classes for further analysis (Puttaswamy et al. 2012):

- 0–30 cm height
- 31–60 cm height
- 61–90 cm height and < 10 cm GBH
- 91–120 cm height and 10–30 cm GBH

The population structure was described as the number of individuals of each tree species in the different diameter classes. The species richness refers to the number of species represented in a sample (Magurran 1988). Evenness ($E$) was calculated following Pielou (1966) as:

$$E = \frac{H'}{\ln(S)}$$

where $H'$ is the Shannon’s index, $S$ is the Species richness.

Hutcheson t tests were used to test the significance of the differences (Shannon indices—species richness and evenness). Every sacred swamp was compared with respect to species richness and evenness with
its geographically closest non-sacred counterpart in paired tests.

**Results**

In the sacred swamps 122 species from 99 genera and 58 families were found against 83 species from 72 genera and 47 families in the non-sacred swamps (Figs. 2, 3, Table 2).

Families found across both types were Anacardiaceae, Apocynaceae, Euphorbiaceae, Lauraceae, Moraceae and Myristicaceae. While Alangiaceae, Aristolochiaceae, Burseraceae, Calophyllaceae, Ebenaceae, Gnetaceae and Verbinaceae families were only found at sacred sites, Costaceae, Dillneaceae, Vitaceae and Zingibaraceae were limited to the non-sacred sites.

In the sacred swamps, the presence of *Gymnacranthera canaracia* was high (total 112 trees), whereas in the non-sacred swamps the cultivated species *Areca catechu* was most abundant (35 trees) and only 22 trees of *Gymnacranthera canaracia* were found.

Stem density, basal area, Western Ghats endemism and number of evergreen species are higher in
Species diversity and richness (for the pooled data) were marginally higher in the non-sacred swamps compared to the sacred swamps (Fig. 3), but differences were not significant (sacred swamps $t$ value = 0.002266, $SD = 1$; non-sacred swamps $t$ value = 0.002275, $SD = 0.499117$). At the level of individual pairs, Chaare–Nettikai, Korse Chapparamane–Honnekombu and Kudegodu Devikanu–Sashikodlu showed significant differences ($p$ value < 0.01) (Table 4, Fig. 9).

Myristicaceae have the highest Family Importance Value both in the sacred (99.14%) and in the non-sacred swamps (61.2%) (Fig. 4). Other important families are the Anacardiaceae (26.16%) and the Calastraceae (20.54%) in the sacred, and the Arecaceae (45.6%) in the non-sacred swamps (Fig. 3).

Most trees with a GBH > 30 cm fall in the 31–60 cm category in the sacred (68.4%) and in the non-sacred swamps it is class III (61–90 cm category (51.8%, Fig. 5). The non-sacred swamps have fewer regenerating individuals three classes, except for class III. The differences with respect to class I and class II are significant with $t$ (146) = 2.731, $p = 0.0071$ for sacred and 2.463, $p = 0.0149$ for non-sacred swamps, respectively. The differences are insignificant for class III and class IV with $t$ values $t$ (146) = 0.839, $p = 0.403$ and 1.431, $p = 0.154$, respectively.

28% of the plant species are endemic to the Western Ghats in the sacred against 23% in the non-sacred swamps (Annex 1). A lower heterogeneity was observed in the top 10 species between the sacred and non-sacred swamps (Fig. 6). A steep gradient indicates (especially in the non-sacred swamps) low evenness as the high-ranking species have much higher abundances than low ranking species. A shallow gradient (especially in the sacred swamps) indicates high evenness as the abundances of different species are similar.

The SHE analysis revealed that sacred swamps are more heterogeneous in nature compared to non-sacred swamps (Fig. 7).

### Table 2: Plant functional types, IUCN Red List species, and total numbers of plant species, genera and families in the total studied area of sacred (1.70 ha) and non-sacred (1.71 ha) swamps

| Plant functional types | Sacred swamps | Non-sacred swamps |
|------------------------|---------------|-------------------|
| Climber species        | 5             | 4                 |
| Epiphyte species       | 1             | 1                 |
| Fern species           | 6             | 2                 |
| Herb species           | 7             | 7                 |
| Liana species          | 8             | 3                 |
| Shrub species          | 14            | 12                |
| Tree (excl. palm) species | 74         | 49                |
| Palm species           | 4             | 5                 |
| Status in IUCN Red List$^a$ |               |                   |
| Vulnerable species     | 8             | 6                 |
| Endangered species     | 4             | 3                 |
| Critically endangered  | 2             | 1                 |
| Total species          | 122           | 83                |
| Total genera           | 99            | 72                |
| Total families         | 58            | 47                |

$^a$http://www.iucnredlist.org/ accessed on 23 December 2015

### Table 3: Diversity, stand density and basal area of trees in the total studied area of sacred (1.70 ha) and non-sacred (1.71 ha) swamps

| Properties                      | Sacred swamp | Non-sacred swamp |
|---------------------------------|--------------|------------------|
| No. of individuals > 30 cm GBH  | 437          | 255              |
| Shannon diversity index         | 1.312        | 1.377            |
| Species richness                | 2.78         | 3.61             |
| Evenness index                  | 0.73         | 0.83             |
| Frequency                       | 16.3         | 13.66            |
| Stem density (individuals/ha)   | 277          | 158.4            |
| Average basal area (m²/ha)      | 47.57        | 14.60            |
| Western Ghats endemism (%)      | 28           | 23               |
| Evergreen species               | 49           | 28               |

The comparison of stem density between sacred and non-sacred swamp forests at 5% level of significance is 0.299074 and for basal area is 0.227609. T critical value is 1.734, hence the differences are not significant for both stem density and basal area.
Table 4 Results of Hutcheson t tests of significance of Shannon index H (species richness and evenness) for sacred (italics) and non-sacred swamps

| Swamps                              | H value | t value | df  | p value | Remarks |
|-------------------------------------|---------|---------|-----|---------|---------|
| Chaare and Nettikai                | 1.87    | 2.86    | 45.85 | 0.006 | **      |
| Birlakamu Kudgund and Mundgetaggu  | 1.90    | 0.5616  | 85.83 | 0.37   | NS      |
| Bogarimaki and Nandisaalu          | 1.98    | 0.2858  | 74.94 | 0.77   | NS      |
| Jaddikolu Kudegodu and Sodlekdolu  | 2.24    | 0.195   | 57.21 | 0.84   | NS      |
| Keremoole and Somankuli             | 2.31    | 0.798   | 62.54 | 0.43   | NS      |
| Korse Chapparmane and Honnekombu   | 2.33    | 5.64    | 17.80 | 0.00002 | ** |
| Kudegodu Devikanu and Sashikodlu   | 1.28    | 5.379   | 0.005 | **     |
| Mavingadde and Shingumane          | 1.98    | 2.22    | 59.67 | 0.03   | *       |
| Nikkund Chowdikanu and Hukli       | 1.79    | 1.83    | 62.70 | 0.07   | NS      |
| Venkatesh Teertha and Balehaklu    | 1.33    | 2.62    | 26.05 | 0.01   | *       |

NS indicates not significant
*Just significant (p value less than 0.05), **highly significant (p values less than 0.01).

Fig. 4 Size class distribution of trees in girth classes > 30 cm DBH in the studied sacred and non-sacred swamps

Fig. 5 Abundance of regenerated trees (N) in the studied sacred swamp (1.70 ha, left) and non-sacred swamp areas (1.71 ha, right). Class I: 0–30 cm height, II: 31–60 cm; III: 61–90 cm height and < 10 cm GBH; IV: 91–120 cm height and 10–30 cm GBH
Fig. 6 Species rank abundance curve: the K dominance model

Fig. 7 SHE analysis for determining the relationship between species richness, Shannon diversity and evenness

Fig. 8 Cluster analysis in the dendrogram for similarity in species distribution

Table 5 Occurrence of amphibian, bird, butterfly and odonatan species in the studied sacred and non-sacred swamps

| Species   | Number of species | Number of individuals |
|-----------|-------------------|-----------------------|
|           | Sacred swamp      | Non sacred swamp      | Sacred swamp | Non sacred swamp |
| Amphibians| 25                | 21                    | 182          | 119             |
| Birds     | 26                | 15                    | 44           | 18              |
| Butterflies| 16               | 15                    | 27           | 35              |
| Odonata   | 19                | 14                    | 63           | 57              |
Fig. 9  Box plots showing species diversity in paired sites of sacred and non-sacred swamps

Fig. 10  Box plots for species diversity, stem density, basal area and similarity index for regeneration
Cluster analysis in the dendrogram revealed a similarity of 47.53% between species present in sacred and non-sacred swamps (Fig. 8).

The number of amphibian, bird, butterfly and odonatan species and individuals are higher in the sacred swamps compared to the non-sacred swamps (Table 5, Annexures 1, 2, 3, 4, 5).

Significant differences exist in the Shannon index of diversity (species diversity) of amphibians \( (H = 2.749) \) and birds \( (H = 3.097) \) between sacred and non-sacred swamps, with \( t (194) = 3.929, p = 0.001 \) and \( t (37) = 2.140, p = 0.039 \) respectively. No significant difference was found for butterfly \( (H = 2.523) \) and odonatan species \( (H = 2.418) \) with \( t (57) = 0.264, p = 0.793 \) and \( t (119) = 0.248, p = 0.805 \), respectively. The in the box plots (Figs. 9, 10) asterisks indicate a significant difference between the variables of sacred and non-sacred swamps.

Three critically endangered amphibian species from the IUCN Red List, *Nyctibatrachus dattatreyaensis*, *Pseudophilautus amboli* and *Micrixalus kottigeharensis*, were found to occur in both sacred and non-sacred swamps. However, only 6 individuals were represented in the non-sacred swamps against 22 individuals in sacred swamps (Table 6).

In total, Western Ghats endemics include 43 species of flora and 20 species of amphibians in the sacred against 29 and 11 in the non-sacred swamps, respectively.

**Discussion**

“Do sacred sites serve as safe zones for the conservation of endemic species?”—In order to find an answer to this question, the authors carried out a comparative survey of 10 sacred swamp sites, in which the intensity of human activities was found to be low owing to the social fencing, and 10 non-sacred swamp sites, where social fencing is not in force and, consequently, not all human activities were curtailed. The general State forestry regime restricts cutting of woods, clearing for cultivation, the use of fire, hunting and mining.

More species (122 species from 58 plant families) were found to occur in the sacred swamps, as compared to the non-sacred swamps (87 species from 47 families). Results of the SHE analysis, more heterogeneity in sacred swamps could be because of differences in species richness and diversity. This species diversity appears quite significant, and is comparable to other studies on swamps in the region. For instance, for the swamps of Uttara Kannada, Bhat and Kaveriappa (2009) reported 63 species, Chandran et al. (2010) reported 132 species from 37 families and Ali et al. (2006) reported 64 species. Whereas the overall number of plant species in the swamps is low compared to the number in wet evergreen forests, the swamp species are often site/ habitat specific and also endemic, and contribute significantly to the regional biodiversity of the Western Ghats (Varghese and Kumar 1997; Chandran et al. 1999; Chandran and Mesta 2001; Roby and Nair 2006). Likewise, Ramanujam and Kadamban (2001) recorded a higher number of species in sacred as compared to non-sacred sites for terrestrial forests near Pondicherry.

Murali et al. (1996) reported that the biological quality (‘health’) of a population is often indicated by the size class distribution and regeneration ability, as reflected in a large proportion of seedlings, saplings and reproductive adults. With regard to

| IUCN category     | Sacred swamps | Non sacred swamps |
|-------------------|---------------|-------------------|
|                   | Number of species | Number of individuals | Number of species | Number of individuals |
| Critically endangered | 3 | 22 | 3 | 6 |
| Endangered        | 4 | 56 | 2 | 8 |
| Vulnerable        | 1 | 1 | 0 | 0 |
| Near threatened   | 2 | 21 | 1 | 45 |

*http://www.iucnredlist.org/*, accessed on 23 December 2015. See for details Annex 2
diameter classes, the sacred swamps show a distinct ‘reverse J’ shape curve (i.e., a skewed distribution of individuals over the classes—with a larger number of young individuals and decreasing numbers of individuals as age increases). In contrast, the non-sacred swamps show a much smaller prevalence of trees in the lowest girth class (Fig. 5) and a complete absence of trees in the two highest girth classes (271–330 cm class and > 300 cm class) (Fig. 4). In the non-sacred swamps, the regeneration of species and the natural distribution of individuals across life cycle stages have evidently been disturbed, probably due to human activities. Statistical analysis of regeneration classes revealed that the differences are significant for the class 1 and 2, with non-sacred swamps having less individuals in these classes.

Many earlier studies have pointed at the close connection between forest disturbance, regeneration and succession, which together determine the size and age distribution of trees (Kuuluvainen et al. 1996). Higher species richness and composition in non-sacred swamps might be attributable to mild disturbance, which favours early invaders (Murali and Setty 2001). Methachen (2002) found disturbed evergreen forests of Uttara Kannada district to be floristically richer compared to undisturbed evergreen forests, in terms of species richness as well as diversity indices, which complies with the ‘mild disturbance’ theory. Many swamp forests face destruction due to anthropogenic factors (Krishnamoorthy 1960). In Uttar Kannada, ancient forests with high hydrological value become increasingly fragmented and endangered (Chandran and Mesta 2001).

The average basal area of the tree species in the sacred swamps was much higher (47.57 m²/ha) as compared to those in the non-sacred swamps (14.6 m²/ha). These differences were found to be statistically significant. Such higher basal area indicates the presence of old and huge trees (one tree up to GBH 332 cm). Other studies from the swamps in the Western Ghats have reported varied figures: 98.92 m²/ha (Varghese and Kumar 1997), 66 m²/ha (Chandran and Mesta 2001) and a much lower figure of 34.25 (Sreejith et al. 2016). Within the terrestrial forests, the highest reported basal area in sacred forests of Kakachi was 42.03 m²/ha (Ganesh et al. 1996) and 47.01 m²/ha for the Uppanangala forest (Pascal and Pelissier 1996).

Tree density in the sacred and non-sacred swamps was 277 and 156 stems per hectare, respectively. In the swamps of Kerala, Sreejith et al. (2016) observed 806 stems per hectare. The average density of trees above 10 cm GBH in the evergreen forests of the Western Ghats ranged from 446 to 1576 stems/ha (Ganesh et al. 1996; Ayyappan and Parthasarathy 1999). The smaller biomass productivity (stem density and basal area) in our study sites could be due to the constant water level throughout the year. Conner and Day (1976) and Brinson (1981) found that seasonally flooded open systems are generally more productive than stagnant closed ones. Furthermore, the overall area of both sacred and non-sacred swamps was small and the swamps were isolated pockets.

In the study sites, tree felling intensity was high in the non-sacred swamps, which was evident from the presence of cut stumps and lopping of the knee roots of Gymnacranthera canarica (total 26 cut trees). In contrast, we did not find any evidence of either felling or lopping of trees in the sacred swamps. Cultivated plantation crops, such as Banana (Musa paradisiaca) and Betelnut (Areca catechu) were frequent in non-sacred swamps, indicating attempts to convert the sites to orchards of commercial crops. In total 39 trees of cultivated species were found in 4 non-sacred swamps.

The sacred swamps had 28% of endemic species while the non-sacred swamps had 23%. Bhat and Kaveriappa (2009) reported for the swamps of Uttara Kannada 23 species endemic to the Western Ghats, out of a total of 63 species. Only few species, i.e., Myristica fatua var. magnifica (present in three sacred swamps with 16 individuals and in one non-sacred swamps with three individuals) and Gymnacranthera canarica (in all sacred swamps with 112 trees and in nine non-sacred swamps with 22 trees) can—with their stilt and aerial roots which provide anchoring and enable breathing—survive in the depression part of the swamp forests.
with permanently water-logged conditions. These species along with other facultative swamp species like *Vateria indica*, *Dipterocarpus indicus*, *Dysoxylum binecteriferum*, *Myristica malabarica*, *Mastixia arboorea*, *Lophopetalum wightianum* and *Calophyllum apetalum* (Annex 1) are considered very old in origin (‘paleoendemic’—relic plants with ancient pedigree) (Chandran et al. 2010; Mesta and Hegde 2018). They are indicator species of evergreen climax forests and very important shelter and forage resources for two very important and endangered species of this region: Lion Tailed Macaque—*Macaca silenus* (Ramachandran and Joseph 2000) and Great Malabar Pied Hornbill—*Buceros biornis* (Ali et al. 2006).

The swamps are also home to several Amphibia. Amphibian assemblages are good indicators of environmental health (Hager 1998; Gibbs 1998) as they are sensitive to environmental change (Blaustein et al. 1994; Pearman 1997; Daniels 2005). In our study, the sacred swamps recorded a higher number of amphibian species and a higher number of threatened species when compared to the non-sacred swamps (25 species and 182 individuals in sacred swamps, 21 species and 119 individuals in non-sacred swamps). Also, bird species were found to occur more in the sacred swamps. The differences are statistically significant for both amphibians and birds. Chandran et al. (2010) reported 35 species and Ali et al. (2006) reported 29 species and the highest number of endangered species of aquatic amphibians in the swamps of Uttara Kannada. Diversity and richness of bird, butterfly and odonatan species were, however, only marginally higher in the sacred swamps, but their populations are considerably higher. Amphibians are less mobile and more susceptible to environmental fluctuations and habitat heterogeneity, because they spend most of their time in the swamps and rarely move out (Jose et al 2014). The wetlands and adjacent forests are core habitats for amphibians and critical for maintaining biodiversity (Semlitsch and Bodie 2003). Habitat loss, fragmentation and low recruitment of dispersing individuals cause population decline and extinction of aquatic amphibians (Cushman 2006; Becker et al. 2007).

**Conclusions**

Our study shows that the species composition and diversity patterns—tree population, stem density, and the basal area of tree species—are higher in sacred swamps compared to non-sacred swamps. Regeneration of swamp tree species is much better in sacred swamps as is shown by the positively skewed distribution of individuals over the age classes. Both natural processes and human activities have an effect on species diversity, population structure, and natural regeneration of a forest ecosystem. Vegetation characteristics make it clear that sacred swamps act as safe zones for the in-situ conservation of many endemic and red listed species of the Western Ghats. This condition is made possible mainly because the local community restricts human activities. This social fencing, i.e. the most viable form of protection in the field, is based on traditional values of local communities, evolved over long time. Such community behaviour requires a socio-cultural ecosystem to nourish it and local communities must be given credit for ensuring survival of these biodiverse habitats. We conclude that the traditional practice of protecting swamp forests play an important role in biodiversity conservation.

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Annex 1: List of plant species in sacred (SS) and non-sacred swamps (NS) with information on endemism in Western Ghats (WG) and status in IUCN Red List of Threatened Species

| Species                          | Growth form | Endemism | Status in IUCN red list | Occurrences | Forest type                                      |
|----------------------------------|-------------|----------|-------------------------|-------------|-------------------------------------------------|
| *Actinodaphne hookeri*           | Tree        | WG       | Not assessed            | SS          | Evergreen                                       |
| *Aglaia roxburghiana*            | Tree        | Not assessed | SS + NS     | Evergreen shrub    |
| *Aglaia elaeagnoides*            | Tree        | Lower risk | SS + NS     | Evergreen    |
| *Aganosma cymosa*                | Liana       | Not assessed | SS          | Semi-evergreen |
| *Ailanthus triphysa*             | Tree        | Not assessed | SS          | Occurs in deciduous, semi-evergreen and evergreen |
| *Alangium salvifolium*           | Tree        | Not assessed | SS + NS     | Tropical dry evergreen Forest          |
| *Alpinia malaccensis*            | Herb        | Not assessed | NS          | Stream banks of Even green Forests     |
| *Alstonia scholaris*             | Tree        | Lower risk | SS + NS     | Tropical Evergreen Forest               |
| *Anodendron paniculatum*         | Liana       | Not assessed | SS          | Occurs in evergreen, semi-evergreen and deciduous type |
| *Antiaris toxicaria*             | Tree        | Not assessed | SS          | Deciduous and evergreen                  |
| *Apama siliquosa*                | Shrub       | Not assessed | SS          | Evergreen                             |
| *Aporosa lindleana*              | Tree        | Not assessed | SS + NS     | Semi-evergreen to evergreen             |
| *Archidendron monadelphum*       | Tree        | Not assessed | SS          | Semi evergreen to evergreen            |
| *Arenga wightii*                 | Palm        | WG       | Vulnerable            | SS + NS     | Evergreen forest                               |
| *Ardisia solanacea*              | Shrub       | Not assessed | SS          | Evergreen shrub                        |
| *Artabotrys zeylanicus*          | Liana       | Not assessed | Both         | Evergreen climber                      |
| *Artocarpus heterophyllus*       | Tree        | Not assessed | SS + NS     | Evergreen Tree                        |
| *Artocarpus hirsutus*            | Tree        | Not assessed | SS + NS     | Tropical evergreen Tree                |
| *Artocarpus lakoocha*            | Tree        | Not assessed | NS          | Tropical evergreen tree                |
| *Atalantia monophylla*           | Shrub       | Not assessed | SS          | Evergreen tree                        |
| *Beilschmiedia wightii*          | Tree        | Not assessed | SS          | Evergreen canopy trees                 |
| *Blachia andamanica denudata*    | Shrub       | Not assessed | NS          | Evergreen                             |
| *Calamus thwaitesii*             | Palm        | Not assessed | SS + NS     | Evergreen and semi evergreen           |
| *Callicarpa tomentosa*           | Shrub       | Not assessed | NS          | Semi evergreen to evergreen            |
| *Calophyllum apetalum*           | Tree        | Vulnerable | SS          | Evergreen                             |
| *Calophyllum polyanthum*         | Tree        | Not assessed | SS          | Evergreen                             |
| *Canthium golungese parviflorum* | Shrub       | Not assessed | NS          | Evergreen                             |
| *Canarium strictum*              | Tree        | Not assessed | SS          | Moist deciduous to Semi evergreen      |
| *Caryota urens*                  | Palm        | Least concern | SS + NS     | Evergreen                             |
| *Cassia tora*                    | Herb        | Not assessed | NS          | Evergreen                             |
| *Celtis canninomea*              | Tree        | Not assessed | SS          | Evergreen                             |
| *Chassalia curviflora*           | Herb        | WG       | Not assessed            | NS          | Evergreen                                       |
| *Chilocarpus atroviridis*        | Liana       | Not assessed | SS + NS     | Evergreen                             |
| *Chromolaena odorata*            | Shrub       | Not assessed | NS          | Deciduous                             |
| *Chrysophyllum lanceolatum*      | Tree        | Not assessed | NS          | Evergreen                             |
| *Clerodendrum paniculatum*       | Shrub       | Not assessed | SS          | Evergreen perennial                    |
| *Cinnamomum malabaratum*         | Tree        | WG       | Not assessed            | SS + NS     | Evergreen                                       |
| *Combretum ovalifolium*          | Tree        | Not assessed | SS          | Semi Evergreen                        |
| *Costus speciosus*               | Herb        | Not assessed | NS          | Moist and wet evergreen               |
| Species                      | Growth form | Endemism | Status in IUCN red list | Occurrences | Forest type |
|------------------------------|-------------|----------|-------------------------|-------------|-------------|
| Croton hirtus                | Shrub       | WG       | Not assessed            | NS          | Evergreen   |
| Cyathea gigantea             | Tree fern   | Not assessed |                          | SS          | Humid tropical evergreen to wet evergreen |
| Debregeasia longifolia      | Shrub       | Not assessed |                          | SS + NS     | Evergreen   |
| Derris scandens             | Liana       | Least concern |                          | SS + NS     | Evergreen   |
| Dichapetalum gelonioides     | Shrub       | Not assessed |                          | SS + NS     | Evergreen–semi evergreen |
| Dimocarpus longan           | Tree        | Lower risk/near threatened |                   | SS + NS     | Tropical evergreen |
| Diospyros angustifolia       | Tree        | Not assessed |                          | SS          | Evergreen   |
| Diospyros buxifolia          | Tree        | Not assessed |                          | SS          | Evergreen   |
| Diospyros candolleana        | Tree WG     | Vulnerable |                          | SS + NS     | Evergreen   |
| Diospyros oocarpa            | Tree        | Not assessed |                          | SS          | Evergreen   |
| Diospyros sylatica           | Tree        | SS + NS   |                          | Evergreen   |
| Diospyros paniculata         | Tree        | NS        |                          | Wet evergreen |
| Dipterocarpus indicus        | Tree        | Endangered |                          | SS + NS     | Evergreen   |
| Dillenia pentagyna           | Tree        | NS        |                          | Semi-evergreen to evergreen |
| Dysoxylum binectariferum      | Tree WG     | SS        |                          | Evergreen   |
| Elaeocarpus serratus         | Tree        | SS        |                          | Evergreen   |
| Elaeocarpus tuberculatus     | Tree        | SS + NS   |                          | Semi evergreen to evergreen |
| Embelia ribes                | Liana       | SS        |                          | Evergreen climber |
| Epiprinus mellotiformis      | Shrub       | NS        |                          | Evergreen   |
| Euonymus indicus             | Tree        | SS + NS   |                          | Semi evergreen–low elevated wet evergreen habitat |
| Ficus hispida                | Tree        | NS        |                          | Semi evergreen to evergreen |
| Ficus nervosa                | Tree        | SS        |                          | Evergreen forest |
| Ficus tsjahela               | Tree        | SS        |                          | Moist deciduous to semi evergreen |
| Flacourtia montana           | Tree        | SS + NS   |                          | Evergreen to semi evergreen |
| Garcinia gummi-gutta         | Tree        | SS + NS   |                          | Evergreen   |
| Garcinia morella             | Tree        | SS + NS   |                          | Evergreen   |
| Garcinia xanthochymus         | Tree        | SS        |                          | Evergreen   |
| Glochidion hohenackeri       | Tree        | NS        |                          | Evergreen   |
| Gomphandra tetrandra         | Tree        | SS + NS   |                          | Evergreen   |
| Gymnacranthera canarica      | Tree        | Vulnerable |                          | SS + NS     | Evergreen   |
| Gymnosporia ruthiana         | Tree WG     | Not assessed |                          | SS          | Evergreen   |
| Holigarna arnottiana         | Tree        | SS + NS   |                          | Semi evergreen to evergreen |
| Holigarna grahamii           | Tree        | SS + NS   |                          | Evergreen   |
| Hopea parviflora             | Tree        | Endangered |                          | SS          | Evergreen   |
| Hopea ponga                  | Tree        | Endangered |                          | SS + NS     | Evergreen   |
| Hydnocarpus pentandra        | Tree        | SS        |                          | Evergreen   |
| Hydnocarpus wightiana        | Tree        | SS        |                          | Evergreen   |
| Ixora brachiata              | Tree        | NS        |                          | Evergreen   |
| Ixora parviflora             | Tree        | NS        |                          | Tropical to semi tropical evergreen |
| Lagenandra ovata             | Shrub       | SS + NS   |                          | Semi evergreen |
| Lelea indica                 | Shrub       | SS + NS   |                          | Evergreen   |
| Leginandra spp.              | Shrub       | SS        |                          | Evergreen   |
| Species                     | Growth form | Endemism | Status in IUCN red list | Occurrences | Forest type                                |
|-----------------------------|-------------|----------|-------------------------|-------------|--------------------------------------------|
| Litsea floribunda           | Tree        | NS       |                         |             | Deciduous to evergreen                     |
| Litsea lavigata             | Tree        | SS       |                         |             | Deciduous to evergreen                     |
| Litsea mysorensis           | Tree        | SS       |                         |             | Semi evergreen                             |
| Litsea stocksii             | Tree        | NS       |                         |             | Moist evergreen                            |
| Lophopetalum wightianianum  | Tree        | SS + NS  |                         |             | Evergreen                                  |
| Luvunga sarmentosa          | Tree        | NS       |                         |             | Evergreen                                  |
| Macaranga peltata           | Tree        | SS + NS  |                         |             | Evergreen                                  |
| Mangifera indica            | Tree        | SS + NS  |                         |             | Evergreen                                  |
| Mallotus philippensis       | Tree        | NS       |                         |             | Evergreen                                  |
| Mastixia arborea            | Tree        | SS + NS  |                         |             | Subcanopy evergreen                        |
| Memecylon edale             | Tree        | NS       |                         |             | Evergreen                                  |
| Memecylon malabaricum       | Tree        | SS + NS  |                         |             | Evergreen                                  |
| Mimusops elengi             | Tree        | SS       |                         |             | Evergreen                                  |
| Myristica dactyloides       | Tree        | Vulnerable | SS + NS               |             | Evergreen                                  |
| Myristica magnifica         | Tree        | Endangered | SS + NS               |             | Evergreen                                  |
| Myristica malabarica        | Tree        | Vulnerable | SS + NS               |             | Evergreen                                  |
| Neolitsea zeylanica         | Tree        | SS       |                         |             | Subcanopy evergreen                        |
| Nothopegia racemosa         | Tree        | SS + NS  |                         |             | Moist deciduous–semi evergreen to evergreen |
| Ochlandra rheedii           | Grass       | WG       |                         | SS + NS     | Evergreen                                  |
| Olea dioica                 | Tree        | WG       |                         | SS + NS     | Evergreen                                  |
| Pandanus unipapillatus      | Palm        | WG       |                         | SS + NS     | Evergreen                                  |
| Persea macrantha            | Tree        | WG       |                         | SS + NS     | Evergreen                                  |
| Pinnanga dicksonii          | Palm        | SS + NS  |                         |             | Evergreen                                  |
| Piper hookeri               | Herb        | SS       |                         |             | Deciduous–evergreen                        |
| Pothas scandens             | Climber     | NS       |                         |             | Evergreen                                  |
| Psycotria annamalaina       | Shrub       | SS       |                         |             | Moist evergreen                            |
| Psycotria flavida           | Shrub       | SS + NS  |                         |             | Evergreen                                  |
| Pteris confusa              | Fern        | SS + NS  |                         |             | Semi evergreen to evergreen                |
| Pterospermum diversifolium  | Tree        | NS       |                         |             | Evergreen to semi evergreen                |
| Randia floribunda           | Tree        | SS       |                         |             | Evergreen to dry deciduous forests         |
| Unknown                     | Tree        | NS       |                         |             | Perennial evergreen to dry deciduous habitat |
| Rubia cordifolia            | climber     | SS       |                         |             | Perennial evergreen to dry deciduous habitat |
| Salacia oblonga             | Climber     | NS       |                         |             | Evergreen to semi evergreen                |
| Saraca asoca                | Tree        | Vulnerable | SS + NS               |             | Evergreen                                  |
| Semecarpus kathalekanensis  | Tree        | WG       |                         | SS + NS     | Evergreen                                  |
| Sida rhombifolia            | Herb        | NS       |                         |             | Evergreen                                  |
| Smilax zeylanica            | Climber     | Both     |                         |             | Moist evergreen to mixed deciduous forest   |
| Strombosia ceylanica        | Tree        | SS       |                         |             | Wet evergreen forests                      |
| Symplacos racemosa          | Tree        | SS       |                         |             | Evergreen                                  |
| Syzygium hemisphericum      | Tree        | NS       |                         |             | Evergreen                                  |
| Syzygium travancoricum      | Tree        | Critically endangered | SS + NS |             | Evergreen                                  |
| Species name | Endemism | RET status as (World conservation Union) | Occurrences |
|--------------|----------|------------------------------------------|-------------|
| Clinotarsus curtipes | WG | Near threatened | SS |
| Euphlyctis cyanophlyctis | | Data deficient | SS + NS |
| Minervarya caperata | WG | Data deficient | SS + NS |
| Fejervarya rufescens | WG | Least concern | SS + NS |
| Hoplobatrachus crassus | | Data deficient | SS |
| Hoplobatrachus tigerinus | | Data deficient | SS + NS |
| Hylarana aurantiaca | WG, SL | Vulnerable | SS + NS |
| Hydrophylax malabaricus | | Least concern | NS |
| Walkerana diplosticta | WG | Data deficient | SS |
| Indirana semipalma | WG | Least concern | SS + NS |
| Micrixalus fascus | WG | Near threatened | SS + NS |
| Micrixalus kotigeharensis | WG | Critically endangered | SS |
| Micrixalus saxicola | WG | Vulnerable | SS + NS |
| Minervarya sahyadris | WG | Endangered | SS + NS |
| Nyctibatrachus dattatreyaensis | WG | Critically endangered | SS + NS |
| Nyctibatrachus jog | WG | Data deficient | SS |
| Nyctibatrachus kempholeyensis | WG | Data deficient | SS + NS |
| Pedostibes tuberculatus | WG | Endangered | SS |
| Species name                        | Endemism | RET status as (World conservation Union) | Occurrences |
|-------------------------------------|----------|-----------------------------------------|-------------|
| Polypedates maculatus               |          | Least concern                           | SS + NS     |
| Pseudophilautus amboli              | WG       | Critically endangered                   | SS + NS     |
| Pseudophilautus kani                | WG       | Least concern                           | SS          |
| Pseudophilautus wynaadensis         | WG       | Endangered                              | SS + NS     |
| Raorchestes chromasynchysi          | WG       | Vulnerable                              | SS          |
| Raorchestes luteolus                | WG       | Data deficient                          | SS          |
| Rhacophorus malabaricus             | WG       | Least concern                           | SS          |
| Sphaerotheca breviceps              |          | Least concern                           | SS          |
| Zakerana kudremukhensis             |          | Data deficient                          | SS + NS     |

Annex 3: List of odonatan species in sacred (SS) and non-sacred swamps (NS) with information on endemism in Western Ghats (WG) and status in IUCN Red List of Threatened Species

| Species name                        | Endemism | RET status as (World conservation Union) | Occurrences |
|-------------------------------------|----------|-----------------------------------------|-------------|
| Caconeura ramburi                  |          | SS                                      |             |
| Ceriagrion olivaceum               |          | SS + NS                                 |             |
| Ceriagrion rubiae Laidlaw           |          | SS + NS                                 |             |
| Coperia marginipes                 |          | SS + NS                                 |             |
| Coperia vittata                    |          | SS                                      |             |
| Euphaea dispar                      | WG       | SS + NS                                 |             |
| Euphaea fraseri                    | WG       | SS + NS                                 |             |
| Gynacantha dravida Lieftinck       |          | NS                                      |             |
| Hylaeothemis indica                | WG       | SS                                      |             |
| Neurothemis fulvia                 |          | SS + NS                                 |             |
| Orthetrum chrysis                   |          | SS                                      |             |
| Orthetrum luzonicum                 |          | SS + NS                                 |             |
| Orthetrum pruinosum                 |          | SS + NS                                 |             |
| Orthetrum taeniolatum               |          | SS + NS                                 |             |
| Phylloneura westermanni             | WG       | Near threatened                         | SS          |
| Pseudagrion indicum Fraser          | WG       | SS + NS                                 |             |
| Rhinocypha bisignata                |          | SS                                      |             |
| Seidenfia malabarica                |          | SS + NS                                 |             |
| Vestalis apicalis                   |          | SS + NS                                 |             |
| Vestalis gracilis                   |          | SS + NS                                 |             |

Annex 4: List of butter flies in the sacred (SS) and non-sacred swamps (NS)

| Species name                        | Occurrences |
|-------------------------------------|-------------|
| Eurema blanda                       | SS + NS     |
| Eurema hecabe                        | SS + NS     |
| Hypolimnas bolina                   | SS          |
Species name | Occurrences
---|---
*Hypolimnas misippus* | SS
*Idea malabarica* | SS
*Junonia allites* | SS
*Junonia iphita* | SS + NS
*Junonia lemonias* | SS
*Junonia orithya* | SS
*Kallima horsfieldii* | SS + NS
*Melanitis leda* | SS
*Mycalesis junonia* | NS
*Mycalesis patnia* | SS
*Mycalesis perseus* | SS
*Orsotriaena medus* | SS
*Papilio polymnestor* | SS + NS
*Polyura agrarius* | SS
*Sarangesa dasahara* | SS
*Spirama retorta* | SS
*Tirumala septentrionis* | SS
*Ypthima baldus* | SS

No endemic or IUCN red list species are found

**Annex 5: List of bird species in the sacred (SS) and non-sacred swamps (NS) with information on endemism in Western Ghats (WG) and status in IUCN Red List of Threatened Species**

| Species name | Common name | IUCN red lists/endemism | Occurrences |
|---|---|---|---|
*Acritillas indica* | Yellow browed bulbul | SS + NS |
*Anthracoceros coronatus* | Malabar pied hornbill | Near threatened |
*Bubulcus ibis* | Cattle egret | SS |
*Cinnyris asiaticus* | Purple sunbird | SS + NS |
*Cinnyris lotenia* | Loten’s sunbird | SS + NS |
*Coracias benghalensis* | Indian roller | SS |
*Centropus sinensis* | Greater coucal | NS |
*Dicrurus caerulescens* | White bellied drongo | SS |
*Dicrurus leucophaeus* | Ashy drongo | SS |
*Dicrurus macrocercus* | Black drongo | SS |
*Dryocopus javensis* | great black woodpecker | SS + NS |
*Ducula aenea* | Green imperial pigeon | SS |
*Dicrurus paradiseus* | Greater racket tailed drongo | NS |
*Dinopium benghalense* | Black rumped flame back | NS |
*Eudynamys scolopaceus* | Asian Koel | SS |
*Falco jugger* | Laggar Falcon | Near threatened |
*Harpactes fasciatus* | Malabar trogon | SS + NS |
*Hirundo smithii* | Wire-tailed swallow | SS |
*Leptocoma zeylonica* | Purple Rumped Sunbird | SS + NS |
*Megalaima viridis* | Small Green Barbet | WG |

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| Species name          | Common name           | IUCN red lists/endemism | Occurrences |
|----------------------|-----------------------|-------------------------|-------------|
| Milvus migrans       | Black kite            | WG                      | SS          |
| Myophonus horsfieldii| Malabar Whistling Thrush | WG              | SS + NS     |
| Ocyceros griseus     | Malabar grey Hornbill | WG                      | SS          |
| Ocyceros birestris    | Indian grey hornbill  |                         | NS          |
| Pelargopsis capensis  | Stork billed kingfisher |                          | SS          |
| Psittacula krameri    | Rose ringed Parakeet  |                         | SS          |
| Pericrocotus flammeus | Scarlet Minivet       |                         | NS          |
| Pycnonotus cafer      | Red vented Bulbul     |                         | SS          |
| Pycnonotus jocosus    | Red whiskered Bulbul  |                         | NS          |
| Pycnonotus gularis    | Flame throated bulbul |                         | SS          |
| Rhopocichla atriceps  | Dark fronted babbler  |                         | NS          |
| Spilornis cheela      | Crested Serpent Eagle |                         | SS + NS     |
| Tyto alba             | Common Barn Owl       |                         | SS          |
| Zostera wardii        | The pied thrush       |                         | NS          |

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