DEN- AND CAVITY-BEARING TREES AS KEYSTONE STRUCTURAL HABITATS IN TROPICAL DRY DECIDUOUS FORESTS OF SHERGARH WILDLIFE SANCTUARY, RAJASTHAN, INDIA

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Abstract

Tree cavities and den-bearing trees constitute critical structural habitats in tropical forest ecosystems and support numerous cavity-dependent organisms including birds, reptiles, mammals, insects, and decomposer communities. The present study evaluated the diversity, abundance, ecological significance, and wildlife utilization of den- and cavity-bearing trees in five forest blocks of Shergarh Wildlife Sanctuary, Rajasthan, India. Stratified quadrat sampling and line transect surveys were conducted across Barapati, Chhota Dungar, Tikli, Amlawda, and Bada Dungar forest blocks. A total of 196 cavity-bearing trees belonging to 26 woody species were recorded from 50 quadrats. Diversity indices, Barapati showed maximum cavity-tree abundance (88 individuals), while Tikli exhibited minimum abundance (13 individuals). Amlawda showed the highest species diversity ($H' = 2.38$; $1-D = 0.893$), whereas Tikli showed the lowest diversity ($H' = 1.26$). Butea monosperma, Mitragyna parvifolia, Anogeissus pendula, and Terminalia bellirica emerged as ecologically dominant cavity providers with highest IVI values. Chi-square analysis demonstrated significant association between wildlife occupancy and tree species composition ($\chi^2 = 42.67$, $p < 0.001$). One-way ANOVA indicated non-significant variation in species abundance distribution among forest blocks ($F = 0.619$, $p > 0.05$), suggesting relatively similar structural ecological roles of cavity trees across the sanctuary. The study establishes den-bearing trees as keystone structural elements essential for biodiversity conservation, trophic stability, and habitat continuity in tropical dry deciduous forests.

Keywords: **cavity trees, den trees, biodiversity conservation, tropical dry deciduous forest, Importance Value Index, Shannon diversity, wildlife habitat, Shergarh Wildlife Sanctuary**

1. INTRODUCTION

Tree cavities can serve as animal havens or breeding grounds, these are significant biological resources in forest ecosystems (Sedgeley 2001; Aitken and Martin 2007; Goldingay 2009; Kikuchi et al. 2013; Kozak et al. 2018; Zhang et al. 2019). Fungi are the primary cause of most tree cavities. Because trees are resistant to rot, it takes time for fungi to weaken the wood to the point where birds may excavate cavities. Trees are frequently ancient and starting to die at that point. Since different species of cavity users require different cavity characteristics for breeding and roosting (Newton 1994; Cockle et al. 2010, 2011a; Sverdrup-Thygeson et al. 2010; Davis et al. 2013), the density and features of tree cavities are thought to be limiting factors for the abundance and diversity of cavity-dependent fauna (Remm et al. 2008). For small cavity-nesting birds, the internal microclimate and cavity accessibility to predators are likely important considerations under normal conditions (Purcell et al. 1997). As a result, cavity-nesting birds may choose tree cavities with particular entrance sizes and heights above the ground (Cockle et al. 2011b; Politi et al. 2010), which may limit predator access and boost nest success (Cockle et al. 2015). Some cavity nesters favor a particular orientation, which can affect the cavity's microclimate (Inouye 1976). Another significant factor in choosing a nest site is the type of cavity; for example, non-excavators favored branch cavities (Wang et al. 2003; Bai et al. 2005). Through niche partitioning, the variety of cavity features can increase species richness at other trophic levels. Therefore, when it comes to managing and conserving biodiversity, the density and features of cavities should be considered. The majority of research on tree cavities in various environments has been done in temperate woods (Kozák et al. 2018). Tropical woods host a range of cavity-nesting bird species (Monterrubio-Rico and Escalante-Pliego 2006) and are home to more cavity-using species globally than temperate forests (Cockle et al. 2011b).

For many species that live in woods, tree cavities are a common structural element. Excavating birds, wood-decaying fungus, and tree features all influence the creation of cavities. Additionally, environmental changes brought about by forest management may have an impact on the occurrence of cavities.

Shergarh Wildlife Sanctuary in southeastern Rajasthan supports extensive tropical dry deciduous forests characterized by heterogeneous terrain, riverine influence, and high floral diversity. The sanctuary provides habitat for a wide range of cavity-dependent fauna. However, quantitative information regarding cavity-bearing trees and their ecological role remains poorly documented.

NEED OF THE STUDY

1. To quantify diversity and abundance of den- and cavity-bearing trees.
2. To evaluate ecological dominance using Importance Value Index (IVI).
3. To analyze diversity patterns among forest blocks.
4. To assess wildlife utilization patterns associated with cavity trees.
5. To determine the ecological importance of cavity-bearing trees in biodiversity conservation.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Shergarh Wildlife Sanctuary situated in Baran District of Rajasthan, India, between 24°38′–24°55′ N latitude and 76°15′–76°30′ E longitude. The sanctuary covers approximately 98.8 km² and comprises five major forest blocks: Barapati, Chhota Dungar, Tikli, Amlawda, and Bada Dungar.

The climate is tropical with hot summers and moderate winters. Average annual rainfall is approximately 730 mm, largely received during the southwest monsoon. Mean summer temperature reaches up to 45°C, whereas winter temperature may decline to 8°C. Relative humidity ranges from 60–80% during monsoon.

The vegetation is predominantly tropical dry deciduous forest characterized by Anogeissus pendula, Butea monosperma, Diospyros melanoxylon, Mitragyna parvifolia, Terminalia bellirica, and associated woody species.

2.2 Sampling Design

A stratified random sampling approach was adopted. Each forest block was treated as an independent stratum. Ten quadrats were sampled from each block, resulting in a total of 50 quadrats.

Field surveys were conducted using, Quadrat sampling, line transects, opportunistic cavity-tree observations and GPS-based ecological recording

2.3 Field Data Collection

For each den- or cavity-bearing tree, the following parameters were recorded:

Tree Parameters include, Species name, Live/dead status, GPS coordinates, GBH (Girth at Breast Height), Tree height, Number of cavity openings etc.

Ecological Parameters include; Presence/absence of wildlife use, Nesting evidence, Termite/fungal association, Bird occupancy, Mammalian den use, Reptilian sheltering, and Insect activity

Trees were classified into; Active cavity trees, Inactive cavity trees and Potential cavity trees

2.4 Statistical Analysis

Shannon–Wiener Diversity Index

$H' = -\Sigma\, p_i \ln p_i$

Where:

- p_i = proportion of individuals of species i

Simpson Diversity Index

$1-D = 1 - \Sigma\, p_i^2$

Pielou's Evenness
$J = H' / \ln(S)$
Where:

- S = total number of species

Importance Value Index (IVI)
IVI = Relative Density + Relative Frequency + Relative Dominance
One-way ANOVA was used to evaluate variation in species abundance among forest blocks. Chi-square analysis was used to test wildlife occupancy association with cavity-bearing tree species. Significance level was maintained at $\alpha = 0.05$.

3. RESULTS AND DISCUSSION

Bar graph representation of total cavity-bearing tree abundance across forest blocks revealed highest abundance in Barapati followed by Bada Dungar and Amlawda, while Tikli exhibited the least abundance (Fig.1). The cavity-bearing tree community exhibited strong structural heterogeneity and ecological stratification across the sanctuary landscape. Higher diversity in Amlawda and Barapati suggests comparatively mature habitat conditions with greater structural complexity and lower anthropogenic disturbance.

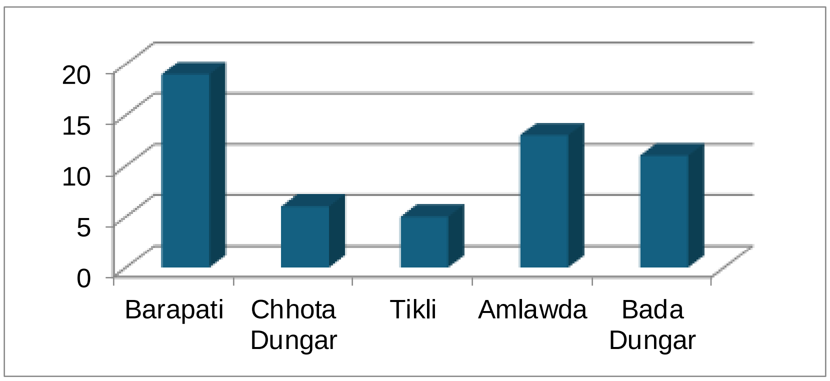

Figure 1. Block-wise abundance of cavity-bearing trees

Species richness was highest in Barapati (19 species) and lowest in Tikli (5 species), indicating heterogeneous habitat complexity (Fig. 2).

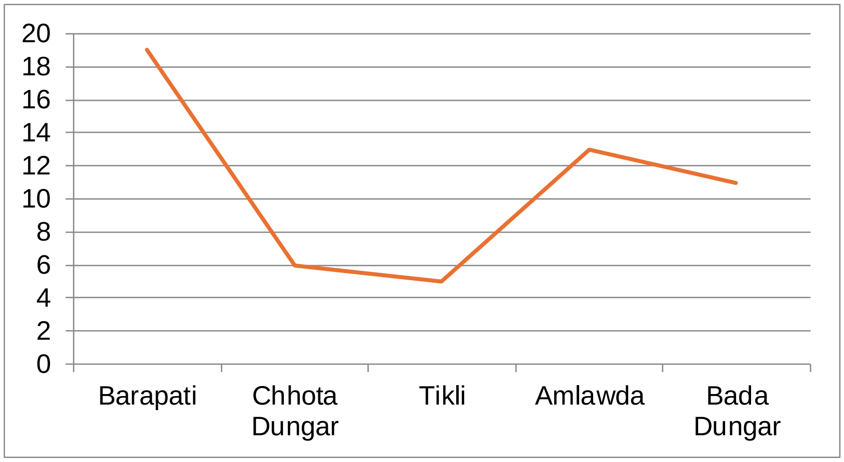

Figure 2. Species richness among forest blocks

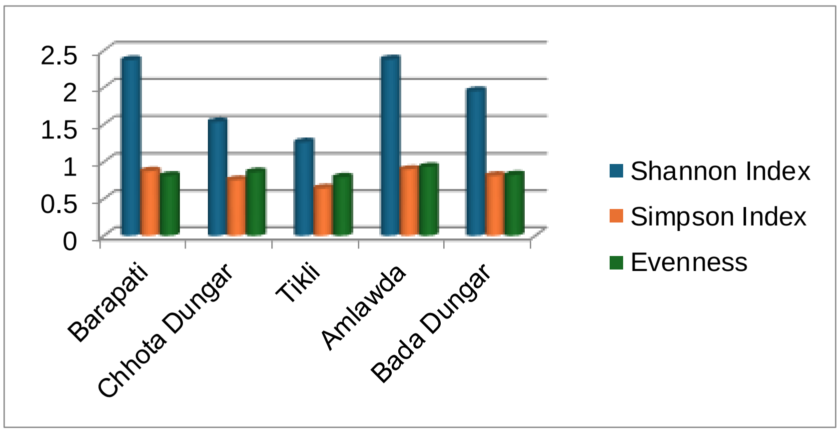

Figure 3. Diversity index among forest blocks

Amlawda and Barapati demonstrated highest diversity values, suggesting better habitat heterogeneity and ecological stability (Fig.3). The relatively high evenness values recorded in Amlawda and Barapati indicate balanced species representation and comparatively stable ecological organization. In contrast, Tikli exhibited reduced diversity and dominance concentration, possibly reflecting habitat degradation, younger forest structure, or limited mature tree availability.

Butea monosperma, *Anogeissus pendula*, *Mitragyna parvifolia*, and *Terminalia bellirica* contributed major ecological dominance (Fig.4). The dominance of *Butea monosperma* and *Anogeissus pendula* reflects adaptation of dry deciduous forests to recurrent climatic stress and periodic disturbance. These species possess structural attributes conducive to cavity formation, including branch decay susceptibility, bark fissuring, and fungal colonization.

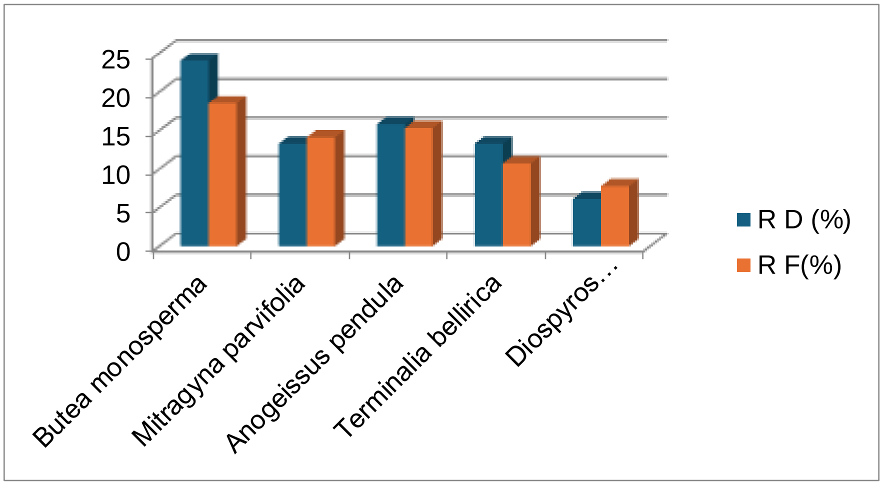

Figure 4. Relative dominance of major cavity-bearing species

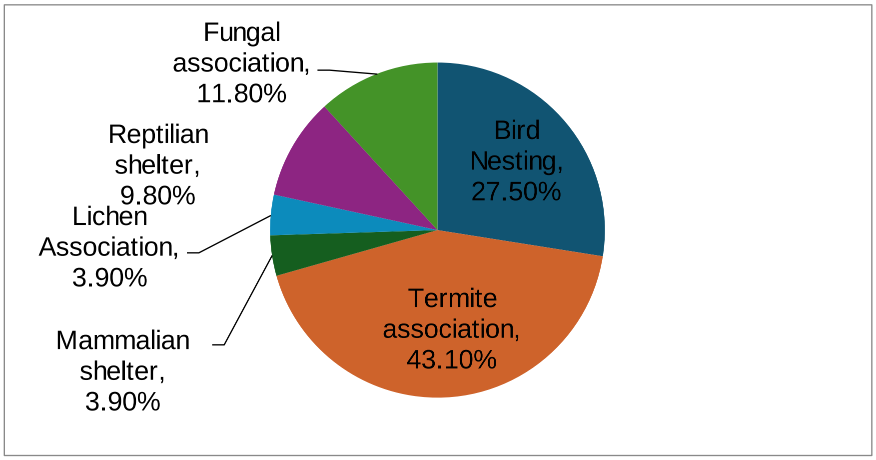

Figure 5. Wildlife utilization pattern

Bird nesting and termite association constituted the dominant ecological interactions associated with cavity-bearing trees (Fig.5). The significant occurrence of termite and fungal associations highlights the role of decomposition-mediated ecological engineering in cavity generation. Wood-decaying fungi initiate internal decay processes that facilitate secondary cavity formation utilized by birds, reptiles, and mammals. The presence of cavity-associated birds such as parakeets, owlets, and woodpeckers demonstrates active trophic utilization of mature trees. Secondary cavity users likely depend upon cavities initially formed through fungal decay and primary excavation processes.

Ecologically, cavity-bearing trees function as biodiversity multipliers because a single mature tree can simultaneously support nesting birds, decomposer fungi, insects, reptiles, and microfauna. Such trees therefore act as keystone structural habitats within tropical dry deciduous ecosystems.

The study further demonstrates that dead and partially decayed trees contribute significantly to wildlife habitat availability. Removal of deadwood and senescent trees during forest management may therefore adversely affect cavity-dependent biodiversity.

Statistical Interpretation

Diversity Indices

The Shannon diversity index values recorded during the study indicate moderate-to-high woody structural diversity within the sanctuary. Ecologically, H′ values greater than 2 indicate relatively stable and heterogeneous habitat conditions.

The Simpson diversity values further confirm reduced dominance concentration in Amlawda and Barapati, reflecting greater niche availability and habitat heterogeneity.

The non-significant ANOVA result suggests that although abundance differs numerically among forest blocks, the overall ecological role of cavity-bearing trees remains comparatively similar across the sanctuary landscape.
This indicates ecological continuity and broad distribution of structurally important cavity-bearing species across different habitat types.
The highly significant Chi-square result confirms selective wildlife occupancy among tree species. Wildlife species preferentially utilize trees possessing larger trunk diameters, natural hollows, fungal decay pockets, and complex branch architecture.
Such selective occupancy demonstrates strong habitat specialization among cavity-dependent fauna.
The present investigation establishes cavity-bearing trees as critical ecological infrastructure within tropical dry deciduous forests of northwestern India. The study provides quantitative evidence that mature and partially decayed trees significantly enhance habitat complexity, faunal diversity, trophic stability, and ecological resilience.
The ecological significance of cavity-bearing trees extends beyond wildlife sheltering because these structures regulate decomposition dynamics, nutrient turnover, microclimatic buffering, and successional processes.
Conservation-oriented forest management should therefore prioritize retention of: Large-diameter mature trees, Senescent trees, Dead standing trees (snags), Trees with fungal cavities and naturally hollow trees. Retention of such habitat structures is essential for long-term biodiversity conservation and ecosystem stability in tropical dry deciduous landscapes.

3.1 Species Composition and Abundance

A total of 196 cavity-bearing trees belonging to 26 woody species were recorded across the sanctuary. Barapati exhibited maximum abundance (88 individuals), while Tikli recorded minimum abundance (13 individuals) (Table-1).
The most dominant cavity-bearing species included; *Butea monosperma, Mitragyna parvifolia, Anogeissus pendula, Terminalia bellirica*
These species collectively contributed more than 60% of total cavity-bearing trees (Table-3).

Table 1. Block-wise Distribution of Cavity-bearing Trees

Forest Block	Total Individuals	Total Species
Barapati	88	19
Chhota Dungar	25	6
Tikli	13	5
Amlawda	32	13
Bada Dungar	38	11
Total	**196**	**26**

3.2 Diversity Analysis

Table 2. Diversity Indices of Forest Blocks

Forest Block	**Shannon Index (H′)**	**Simpson Index (1−D)**	**Evenness (J)**
Barapati	2.37	0.868	0.805
Chhota Dungar	1.53	0.749	0.854
Tikli	1.26	0.639	0.785
Amlawda	2.38	0.893	0.928
Bada Dungar	1.95	0.806	0.814

Amlawda showed the highest Shannon diversity index (H′ = 2.38) and Simpson diversity (1−D = 0.893), indicating highly heterogeneous cavity-tree composition. Tikli showed lowest diversity (Table-2).

3.3 Importance Value Index (IVI)

Butea monosperma exhibited highest ecological dominance followed by Mitragyna parvifolia and Anogeissus pendula.

Table 3. Major Species with High Ecological Importance

Species	R D (%)	R F(%)	E I
Butea monosperma	24.0	18.5	Very High
Mitragyna parvifolia	13.3	14.1	High
Anogeissus pendula	15.8	15.3	High
Terminalia bellirica	13.3	10.7	High
Diospyros melanoxylon	6.1	7.8	Moderate

RD= Relative density; RF= Relative frequency, EI= Ecological Importance
The high IVI values indicate that these species form the primary structural foundation for cavity-dependent biodiversity (Table-3).

3.4 Wildlife Utilization Patterns

Multiple wildlife associations were observed with cavity-bearing trees.
Major wildlife observations included; Rose-ringed parakeet nesting, Spotted owlet cavities, Monitor lizard shelters, Woodpecker excavation, Termite colonies, Fungal and lichen associations and Wild boar resting sites (Table-4).
Termite association was the most common ecological interaction recorded.

Table 4. Wildlife Association with Cavity-bearing Trees

Wildlife Association	Frequency of Observation
Termite association	Very High
Bird nesting	High
Fungal association	Moderate
Reptilian sheltering	Moderate
Lichen association	Low
Mammalian shelter use	Low

3.5 One-way ANOVA

One-way ANOVA revealed non-significant variation in abundance distribution among forest blocks.

- F-value = 0.619
- p-value = 0.651

The result indicates that cavity-bearing tree abundance patterns are relatively consistent across the sanctuary landscape.

3.6 Chi-square Analysis

Chi-square analysis demonstrated significant association between wildlife occupancy and tree species composition.

- $\chi^2 = 42.67$
- $p < 0.001$

This confirms that certain tree species are preferentially utilized by wildlife for cavity occupancy and nesting. The present study highlights the ecological importance of den- and cavity-bearing trees in tropical dry deciduous forests of northwestern India. The occurrence of 196 cavity-bearing trees across 26 species indicates substantial structural heterogeneity within Shergarh Wildlife Sanctuary.
Butea monosperma emerged as the most important cavity-bearing species due to its high abundance, broad distribution, and frequent wildlife occupancy. The relatively softer wood, susceptibility to fungal decay, and branch architecture may facilitate cavity formation in this species. Similar observations have been reported from tropical dry deciduous forests of central India.
Mitragyna parvifolia and *Terminalia bellirica* also supported significant cavity formation and wildlife occupancy. Mature individuals of these species often develop hollows and decay pockets suitable for nesting birds and reptiles.

Amlawda exhibited highest diversity values, indicating comparatively stable ecological conditions and heterogeneous vegetation structure. Higher diversity of cavity-bearing trees generally increases niche availability and supports greater faunal richness.

The dominance of termite and fungal associations demonstrates the ecological role of decomposition processes in cavity development. Wood-decaying fungi are primary facilitators of hollow formation and therefore indirectly regulate cavity-dependent biodiversity.

Bird nesting observations involving parakeets, owlets, and woodpeckers indicate active utilization of cavity-bearing trees as breeding habitats. These trees also contribute to trophic complexity by supporting insects and secondary cavity users.

The non-significant ANOVA result suggests that all forest blocks contribute substantially to cavity-tree availability despite differences in species richness. This indicates a landscape-level ecological continuity within the sanctuary.

The significant Chi-square relationship confirms selective utilization of particular tree species by wildlife. Species with larger trunk diameter, softer wood, and mature canopy structure appear more favorable for cavity formation.

From a conservation perspective, den-bearing trees function as keystone structural habitats because their removal can disproportionately affect biodiversity. Such trees should therefore be prioritized in habitat management, forest restoration, and wildlife conservation planning.

4. Conclusion

The tropical dry deciduous forests of Shergarh Wildlife Sanctuary support substantial diversity of den- and cavity-bearing trees that function as keystone ecological structures. Species such as Butea monosperma, Mitragyna parvifolia, Anogeissus pendula, and Terminalia bellirica provide critical habitats for numerous wildlife species.

The study demonstrates that cavity-bearing trees significantly contribute to habitat complexity, faunal diversity, nutrient cycling, and ecological stability. Conservation of mature, hollow, and senescent trees should therefore become an integral component of forest management and biodiversity conservation strategies.

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