



Roosting and Breeding Ecology of Birds in Shola Sky Island Forests: A Systematic Review and Analysis

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Abstract: The Shola Sky Island forests, located in the Western Ghats of India, are unique ecosystems renowned for their high elevation, isolated patches of evergreen forests, and rich avian biodiversity. Understanding the roosting and breeding ecology of birds in these forests is essential for their conservation and management. However, a comprehensive synthesis of the existing literature on this topic is lacking. This systematic review aims to fill this knowledge gap by analyzing and summarizing the available research on the roosting and breeding ecology of birds in the Shola Sky Island forests. The review focuses on various aspects of bird ecology, including roosting site selection, roosting strategies, breeding phenology, nest site selection, nesting behaviors, and factors influencing non-roosting and breeding behaviors. The literature search encompasses studies conducted in the Shola Sky Island forests, covering a wide range of bird species and their ecological requirements. Findings from the review highlight the importance of specific habitat characteristics, such as vegetation structure, microclimate, and resource availability, in influencing bird roosting and breeding behaviors. The availability of suitable roosting sites and nesting habitats within the forest plays a crucial role in determining the distribution and abundance of bird species. Factors such as food availability, altitudinal movements, social interactions, and territoriality also impact non-roosting and breeding behaviors in these forests. Furthermore, the review emphasizes the challenges posed by habitat fragmentation, climate change, and human activities to the roosting and breeding ecology of birds in the Shola Sky Island forests. Understanding these threats and their implications for bird populations is essential for effective conservation and management strategies.

Keywords: Roosting Ecology, Breeding Ecology, Avian Behaviour, Shola Sky Island Forests, Breeding Phenology, Foraging Strategies

1. Introduction

The Shola Sky Island forests, nestled within the Western Ghats mountain range in India, are unique ecosystems characterized by their high elevation, isolated patches of evergreen forests, and distinct climatic conditions [1, 3]. These forests provide crucial habitats for a diverse avian community, playing a vital role in the roosting and breeding ecology of birds [2]. Understanding the factors influencing bird roosting and breeding behaviors in these forests is of utmost importance for their conservation and effective management.

The avian assemblage in the Shola Sky Island forests consists of numerous species, including several endemic and threatened ones [1]. These forests offer essential resources such as food, shelter, and nesting sites, which directly impact

the survival, reproductive success, and overall population dynamics of bird species [3]. Investigating the roosting and breeding ecology of birds in this unique habitat can provide valuable insights into their ecological requirements, behavior, and the conservation challenges they face.

While some studies have explored various aspects of bird ecology in the Shola Sky Island forests, a comprehensive and systematic review focusing specifically on roosting and breeding behaviors is lacking. Therefore, this systematic review aims to synthesize the existing literature and provide a comprehensive analysis of the factors influencing bird roosting and breeding behaviors in the Shola Sky Island forests.

2. Methodology

This systematic review employed a rigorous approach to synthesize the existing literature on roosting and breeding behaviour of birds in Shola Sky Island Forest. A comprehensive search strategy was implemented to identify relevant studies, and data collection followed predefined inclusion and exclusion criteria.

The selected articles were critically analysed, and key findings were synthesized to provide a comprehensive understanding of the subject matter. A systematic search of relevant literature was conducted using electronic databases such as PubMed, Scopus, and Web of Science. Keywords and phrases related to roosting behaviour, breeding patterns, Shola Sky Island Forest and bird species were used to ensure the inclusion of relevant studies.

Studies were included if they focused on roosting and breeding behaviour of bird species in Shola Sky Island Forest. Peer-reviewed articles published in English were considered. Studies that lacked primary data, focused solely on captive or non-Shola Sky Island Forest species, or had a limited sample size were excluded.

Data from selected articles were extracted using a predefined template, including study objectives, methods, key findings, and limitations. The extracted data were critically evaluated for study quality and relevance to the research article.

3. Results and Discussions

3.1. Habitat Use and Daily Movements in Shola Sky Island Forest Birds

The Shola Sky Island forests exhibit a wide range of vegetation structures, including dense understory, tree canopies, and open areas. Different bird species in these forests show specific habitat preferences based on their foraging strategies, nesting requirements, and roosting behaviors. Studies have documented preferences for specific vegetation types, such as dense shrubbery for understory insectivores or tall trees for canopy-dwelling frugivores [20, 24]. Understanding the habitat preferences of birds in these forests is important for conservation and management efforts.

The Shola Sky Island forests span a wide altitudinal range, which influences the distribution and availability of habitats for birds. Studies have observed altitudinal movements and variations in bird species composition along these gradients, with specific species occupying different elevation zones [4, 17]. Altitudinal migration and habitat selection are influenced by factors such as temperature, food availability, and nesting requirements, highlighting the importance of habitat diversity within the forests.

Habitat fragmentation and the presence of forest edges can significantly impact the habitat use of bird species in the Shola Sky Island forests. Studies have shown that edge effects, including increased predation risk, altered microclimate, and changes in resource availability, can affect bird distribution, abundance, and behavior near forest edges

[28, 21]. Understanding how birds utilize different habitat types and respond to edge effects is crucial for effective conservation and management of the forests.

Human activities and disturbances, such as logging, agriculture, and tourism, can alter the habitat structure and availability of resources for birds in the Shola Sky Island forests. Studies have examined the impacts of human disturbance on bird communities, highlighting changes in species composition, shifts in foraging behavior, and reduced breeding success [6]. Understanding the effects of human disturbance on habitat use is vital for implementing sustainable practices that minimize negative impacts on bird populations.

3.2. Foraging Strategies and Food Availability in Shola Sky Island Forest Birds

Birds in the Shola Sky Island forests exhibit a diverse range of foraging strategies based on their dietary preferences and the availability of food resources. Studies have shown that bird species in these forests feed on a variety of food items, including fruits, seeds, nectar, insects, and small vertebrates [9, 21]. The composition and abundance of food resources within the forest habitat play a crucial role in shaping the foraging strategies of bird species.

The vertical stratification of vegetation in the Shola Sky Island forests provides different foraging niches for birds. Studies have indicated that birds exploit different vertical layers of the forest, with some species predominantly foraging in the understory, while others utilize the mid-canopy or upper canopy regions [15, 2]. The availability of specific food resources and the presence of suitable perching or hunting sites influence the vertical distribution of foraging activities.

Some bird species in the Shola Sky Island forests exhibit group foraging behaviors and engage in cooperative foraging strategies. This includes species forming mixed-species foraging flocks, where different bird species forage together, benefiting from increased foraging efficiency and predator detection [4, 11]. Cooperative behavior, such as cooperative hunting or mobbing of predators, is also observed in certain bird species.

The availability of food resources in the Shola Sky Island forests can vary seasonally, influencing the foraging strategies and behavior of birds. Studies have investigated seasonal changes in food availability and its impact on bird foraging patterns [21, 2]. Understanding the relationship between food availability, seasonal variation, and bird foraging strategies is essential for assessing the ecological dynamics of the forest ecosystem.

3.3. Sheltering Patterns and Microhabitat Selection of Shola Sky Island Forest Birds

Birds in the Shola Sky Island forests exhibit diverse sheltering patterns and roosting site preferences. Studies have documented the use of various roosting sites, including tree cavities, leaf clusters, tangled vegetation, and rock crevices

[23, 22]. Birds select roosting sites based on factors such as protection from predators, shelter from harsh weather conditions, and thermoregulation. Microhabitat characteristics, such as vegetation density, structure, and microclimate, play a crucial role in roost site selection.

Certain bird species in the Shola Sky Island forests exhibit communal roosting behavior, where multiple individuals of the same or different species gather and roost together. These communal roosts provide advantages such as enhanced predator detection, information sharing, and thermoregulatory benefits [14, 31]. Social behavior and roosting aggregations contribute to the overall sheltering patterns and have implications for social dynamics and conservation strategies.

The sheltering patterns of birds in the Shola Sky Island forests are influenced by various habitat characteristics. Studies have investigated the relationship between roosting associations and habitat features, such as forest structure, tree species composition, and proximity to water bodies [14, 27]. Understanding the link between habitat characteristics and roosting patterns can provide insights into the habitat requirements and conservation needs of different bird species.

Roosting patterns can vary seasonally and temporally in response to changing environmental conditions. Studies have observed shifts in roosting sites and sheltering behavior during different seasons, such as monsoon periods or breeding seasons [22, 30]. Factors such as food availability, thermoregulation, and reproductive requirements influence these temporal variations in roosting behavior.

3.4. Breeding Success and Nesting Ecology in Shola Sky Island Forest Birds

Nesting ecology plays a critical role in the reproductive success and population dynamics of birds in the Shola Sky Island forests. Studies have examined the nest site selection preferences and characteristics of various bird species in these forests. Factors such as vegetation structure, height, proximity to resources, and predator avoidance influence nest site selection [20]. Understanding the nest site preferences and characteristics provides insights into the habitat requirements and nesting behaviors of different bird species.

Birds in the Shola Sky Island forests utilize diverse nesting substrates and construct various nest types. Studies have documented nests built in tree cavities, leaf clusters, vegetation tangles, or constructed using materials such as twigs, leaves, moss, and feathers (Ramesh & Pascal, 2011; Sridhar et al., 2012). The choice of nesting substrate and nest type may vary among species based on their size, behavior, and environmental conditions.

The timing of nesting activities, including nest initiation, incubation, and fledgling periods, varies among bird species in the Shola Sky Island forests. Studies have investigated nesting phenology and breeding seasons to understand the seasonal patterns and synchrony of breeding events [15, 20]. Factors such as food availability, weather conditions, and resource abundance influence the timing and duration of the breeding season.

Nest predation is a significant factor influencing nesting ecology in the Shola Sky Island forests. Studies have examined nest predation rates, predator identity, and the impact of predation on nest success [12, 16]. Predation risk can vary with habitat characteristics, nest location, and proximity to forest edges. Understanding nest predation dynamics is crucial for evaluating the reproductive success and population dynamics of bird species.

Some bird species in the Shola Sky Island forests are susceptible to brood parasitism, where parasitic birds lay their eggs in the nests of other bird species. Studies have explored brood parasitism rates, host-parasite interactions, and nest defense behaviors [12, 16]. Host species may exhibit various defensive strategies to minimize the impact of brood parasites on their reproductive success.

3.5. Factors Influencing Non-Roosting and Breeding Behaviour in Roof Top Mountain Forest Birds

Food availability is a crucial factor influencing the non-roosting and breeding behaviors of birds in the Shola Sky Island forests. Studies have investigated the relationship between food availability and breeding success, with fluctuations in food resources impacting reproductive output [8, 10]. Limited food resources during certain seasons or years may result in delayed breeding, reduced clutch sizes, or skipped breeding attempts.

Habitat fragmentation and loss can have detrimental effects on the non-roosting and breeding behaviors of birds in the Shola Sky Island forests. Studies have shown that fragmented landscapes reduce habitat quality, disrupt connectivity between suitable habitats, and increase the risk of edge effects and nest predation [12, 31]. Fragmentation can influence the ability of birds to find suitable nesting sites, access resources, and engage in successful breeding.

Climate change can affect the timing of biological events, including breeding, migration, and resource availability. Studies have explored the impacts of climate change on the non-roosting and breeding behaviors of birds in the Shola Sky Island forests, with altered phenology observed in response to changing climatic patterns [18, 30]. Shifts in breeding phenology can disrupt synchronization with resource availability and affect reproductive success.

Predation pressure is a significant factor influencing non-roosting and breeding behaviors in the Shola Sky Island forests. Studies have examined nest predation rates, predator identity, and their impacts on nesting success [16, 12]. Increased predation risk can lead to reduced breeding attempts, nest abandonment, or changes in nest site selection to minimize predation threats.

Human activities such as habitat modification, land-use change, and disturbance from tourism can impact the non-roosting and breeding behaviors of birds in the Shola Sky Island forests. Studies have documented the negative effects of human disturbance on breeding success, nest survival, and nesting behaviors [6, 29]. Understanding the impacts of anthropogenic activities on bird populations is crucial for implementing effective conservation measures.

3.6. Conservation Implications and Management Strategies for Shola Sky Island Forest Birds

Designating and effectively managing protected areas is crucial for the conservation of birds in the Shola Sky Island forests. Studies have emphasized the importance of protected areas in maintaining habitat quality, reducing anthropogenic disturbances, and providing refuge for bird populations [5, 31]. The establishment and proper management of protected areas help safeguard critical habitats and provide a framework for conservation efforts.

Restoring degraded habitats and enhancing habitat connectivity are essential strategies for conserving bird populations in the Shola Sky Island forests. Studies have highlighted the positive effects of habitat restoration on avian communities, including increased species richness, abundance, and breeding success [13, 29]. Restoration efforts can focus on reforestation, removing invasive species, and creating corridors to promote habitat connectivity and reduce fragmentation.

Engaging local communities in conservation efforts is vital for the long-term sustainability of bird populations in the Shola Sky Island forests. Studies have demonstrated the positive outcomes of community-based conservation initiatives, including habitat protection, awareness programs, and sustainable livelihood practices [6, 7]. Collaborating with local communities can foster stewardship, reduce human-wildlife conflicts, and promote the conservation of bird habitats.

Raising awareness and promoting conservation education among stakeholders is crucial for the conservation and management of bird species in the Shola Sky Island forests. Studies have highlighted the effectiveness of education and outreach programs in influencing attitudes, behavior, and fostering a sense of responsibility towards bird conservation [15, 29]. Education initiatives can target local communities, tourists, and policymakers to enhance understanding and support for bird conservation.

Continued monitoring and research efforts are essential for assessing the effectiveness of conservation strategies and understanding the dynamics of bird populations in the Shola Sky Island forests. Long-term monitoring programs can provide valuable data on population trends, breeding success, habitat use, and responses to conservation interventions [24, 30]. Research focusing on key knowledge gaps can inform adaptive management and evidence-based conservation decision-making.

3.7. Gaps in Knowledge and Future Research Directions

There is a need for more detailed investigations into the roosting and breeding ecology of specific bird species in the Shola Sky Island forests. While some studies have examined general patterns, there is limited information on the specific requirements, behaviors, and population dynamics of individual species [19, 24]. Future research should focus on studying the roosting and breeding ecology of key endemic and threatened bird species to gain a deeper understanding of

their habitat use, reproductive strategies, and conservation needs.

The potential impacts of climate change on the roosting and breeding ecology of birds in the Shola Sky Island forests warrant further investigation. While some studies have examined phenological shifts and distributional changes [21, 30], more research is needed to understand how changing climatic conditions may affect the timing of breeding, availability of resources, and overall population dynamics. Assessing the vulnerability of bird species to climate change and developing adaptation strategies are important future research directions.

Further research is needed to explore the factors influencing nest predation rates and the dynamics of predator-prey interactions in the Shola Sky Island forests. Studies investigating the identity and behavior of nest predators, their impact on nesting success, and the effectiveness of nest defense strategies are necessary [16, 12]. Understanding predator-prey dynamics can help identify key drivers of nest predation and inform management strategies to reduce predation risks.

Investigating the landscape-level effects, including habitat fragmentation, connectivity, and edge effects, on the roosting and breeding ecology of birds in the Shola Sky Island forests is important. Studies examining how landscape characteristics influence population connectivity, gene flow, and reproductive success are needed [31, 30]. Additionally, assessing the effectiveness of landscape-scale conservation measures, such as creating habitat corridors and managing forest edges, is crucial for the long-term conservation of bird populations.

Integrating remote sensing and GIS technologies can provide valuable insights into the roosting and breeding ecology of birds in the Shola Sky Island forests. Future research can utilize these tools to map and monitor habitat quality, assess land-use changes, and model species distribution and habitat suitability [5, 30]. Applying these technologies can enhance our understanding of the spatial patterns and ecological processes related to roosting and breeding behaviors.

4. Conclusion

Shola Sky Island Forest bird species play a crucial role in maintaining the biodiversity and ecological integrity of Shola Sky Island Forest ecosystems. This systematic review has synthesized the findings from various studies on non-roosting and breeding behaviour of Shola Sky Island Forest birds, highlighting the key factors influencing their behaviour, the challenges they face, and the conservation implications for their long-term survival.

Importance of Habitat Conservation: Habitat conservation is paramount for the conservation of Shola Sky Island Forest bird species. Protecting key habitat features, restoring degraded habitats, and ensuring habitat connectivity are vital for maintaining viable populations and facilitating species movement.

Understanding Environmental Factors: Altitude, climate, and habitat structure significantly influence roosting and breeding behaviour in Shola Sky Island Forest bird species. Future research should focus on understanding the specific effects of climate change and habitat alterations on these species.

Addressing Threats and Disturbances: Effective management strategies should be implemented to mitigate threats such as habitat fragmentation, invasive species, and human disturbance. Conservation efforts should prioritize minimizing anthropogenic impacts and promoting sustainable land-use practices.

Enhancing Community Engagement: Engaging local communities and raising awareness about the importance of Shola Sky Island Forest bird conservation are crucial for successful conservation initiatives. Collaborative efforts involving stakeholders, educational programs, and community-based conservation projects can foster support for conservation actions.

Bridging Knowledge Gaps: Future research should focus on addressing key knowledge gaps, such as understanding the effects of climate change, species interactions, and landscape-scale connectivity on Shola Sky Island Forest bird populations. Integrating conservation genetics into studies can provide valuable insights into their genetic diversity and adaptive potential.

By implementing these findings and implications, conservation efforts can be tailored to effectively protect and manage Shola Sky Island Forest bird species, ensuring their long-term survival and the preservation of Shola Sky Island Forest ecosystems.

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Conflicts of Interest

The authors declare no conflicts of interest.

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