



Bird Community Composition and Habitat Association in Tal Chhapar Wildlife Sanctuary

Kailash Chand Dhinwa

Research Scholar,

Dr. Ravi Kant Sharma

Associate Professor,

Dept. of Zoology,

Shri Khushal Das

University

Hanumangarh, Rajasthan

Abstract

Tal Chhapar Wildlife Sanctuary in Churu district, Rajasthan, India, is one of the most important grassland ecosystems of north-western Indian subcontinent. The sanctuary is known for sustaining fairly large populations of Blackbuck (*Antelope cervicapra*) and yet, there has been relatively less scientific attention to its avifaunal diversity which is known to be an important resident and migratory bird habitat. The composition of bird community and its association with the major habitat types of Tal Chhapar Wildlife Sanctuary was studied in the present investigation. The article summarizes the ecological observations reported from grassland ecosystems of Rajasthan together with published studies on birds to assess habitat preferences, seasonal variation in species richness and feeding guild composition, and conservation significance.

The grassland habitat dominated with perennial grasses, scattered *Prosopis cineraria* and *Acacia senegal*, seasonal wetland, and saline depression serves as a habitat to raptors, insectivores, granivores, carnivores, omnivores, and waterbirds. Resident birds provide stability in the ecosystem of the area where they live year-around, while migratory birds increase the diversity of the area in winters. The distribution and abundance of birds are mainly determined by habitat heterogeneity, prey availability, vegetation structure, and water availability. However, these bird assemblages are increasingly being threatened by anthropogenic pressures, invasive plants, grazing intensity, habitat degradation and climate variability. The native grasslands are ecologically important for sustaining the avian diversity. Therefore, the study recommends habitat

Paper Received date

05/08/2026

Publishing Date

10/08/2026

DOI
<https://doi.org/10.5281/zenodo.22031573>


**IMPACT
FACTOR
5.924**

restoration, enforcement of invasive species management, monitoring for longer periods, and planning for and execution of community participation and strengthening conservation planning. The findings enrich the increasing knowledge of ecology of grassland birds and reinforce Tal Chhappar Wildlife Sanctuary as a significant conservation landscape for birds of arid zone of India.

Keywords: Tal Chhappar Wildlife Sanctuary; Bird Diversity; Grassland Birds; Habitat Association; Avian Ecology; Rajasthan; Conservation Biology

1. Introduction

Birds are one of the most sensitive indicators when it comes to ecosystem health. The reason they are sensitive is because they respond quickly to environmental changes. These changes affect vegetation structure, prey abundance, climatic conditions, and habitat quality. They have several ecological functions and not only have biological diversity value. These include pollination, seed dispersal, scavenging, biological pest control, and nutrient cycling. Most probably, the structure of bird species can provide a useful indicator of ecosystem integrity and habitat quality. Studying the composition and habitat associations of bird communities has thus become a central goal of wildlife ecology and conservation biology.

The grassland ecosystems in the world are among the world's most endangered terrestrial environment largely due to agricultural expansion, urbanization, invading plant species, infrastructure development and climate change. Natural grasslands in India have generally been considered wasteland and have been given insignificance in the past. Despite this, they support numerous endemic and globally threatened fauna species. Various flagship bird species like harriers, larks, coursers, sandgrouse, wheatears, shrikes and migratory raptors use them for breeding, feeding and overwintering. The decline of grasslands has led to a sharp decline in the population of many specialist birds in the Indian subcontinent.

The grasslands in Rajasthan which are semi-arid and arid are great habitat for grassland birds. Among these landscapes lies the Tal Chhappar wildlife sanctuary with its own ecology. The Thar Desert Biogeography Zone includes this Sanctuary. The area is found in the

District Churu and has an area of 7.19 km². Covering an area of 300 sq km, the sanctuary consists of open grasslands with scattered trees, saline flats, seasonal wetlands and shrub vegetation. It is home to various fauna despite its small size. The Blackbuck (*Antelope cervicapra*) is internationally recognized for conservation purposes but it is also a resident and migratory bird sanctuary all the year round.

The avifaunal diversity of Tal Chhappar WLS is largely enhanced by seasonal migration. In winter, the sanctuary hosts migratory raptors from Central Asia, Europe and Siberia. These include specially Montagu's Harrier, Pallid Harrier, Marsh Harrier, Steppe Eagle and Imperial Eagle along with many falcons. After the monsoon, waterbirds occupy temporary wetlands, while grassland passerines occupy open grazing areas and native grass patches. Rare and gradual loss of habitat may lead to local population extinction, while permanent habitat loss leads to complete ecosystem degradation.

Habitat association refers to how birds prefer different environmental characteristics. It affects the distribution and abundance of birds, ultimately resulting in their success during reproduction. Subject: Factors affecting habitat suitability

The aforementioned factors namely vegetation height, composition of plant species, canopy cover, availability of nesting substrates and food resources, water resources, predator pressure and human disturbance together determines the suitability of habitat. Bird species occupying different ecological guilds often show different habitat preferences. Open landscapes facilitate prey detection for raptors; insectivorous passerines generally occupy grasslands with moderate vegetation; waterbirds concentrate around temporary ponds and marshes.

Grassland bird communities are shaped by vegetation structure. Thick grass provides nesting habitat for ground-nesting birds and cover from predators. Meanwhile, open patches allow foraging by species that rely on visual detection of prey. The presence of scattered trees like *Prosopis cineraria* and *Acacia senegal* enables raptors, bee-eaters, rollers, shrikes, and owls to nest and roost. As of now, the situation is that the heterogeneous landscape mosaic within Tal Chhappar Wildlife Sanctuary relatively supports high avian diversity as compared to homogeneous grassland habitats.

In spite of being ecologically important, not much meaningful work has been conducted on bird community composition and habitat association in Tal Chhapar Wildlife Sanctuary. Most research has been conducted on Blackbuck ecology, habitat management and biodiversity assessment. Seasonal species turnover, habitat utilization, feeding guild composition, conservation priorities details are not consolidated, as reported in different studies. It is crucial to integrate these observations so as to formulate evidence-based management measures that would sustain resident and migrant birds.

The strength of the present study is made up of the following objectives of the bird communities reported from Tal Chhapar Wildlife Sanctuary. At first, it would study the composition of birds. Then, it will analyse the habitat associations among different ecological groups. Further, it would study their association with the help of environmental factors. Finally, it will discuss the conservation of birds within the semi-arid grassland. The article, by synthesizing the available scientific literature and ecological observations, not only aids in the understanding of grassland birds ecology but also summarises practical biodiversity conservation measures for the Thar Desert.

2. Review of Literature

Globally, grassland ecosystems are among the least studied yet most threatened. A lot of ornithological studies show that vegetation structure, habitat heterogeneity, climate and human impacts combine to shape the bird community. According to researches in India and elsewhere, protected grasslands serve as important safe havens for resident and migratory birds.

The complexity of vegetation influences diversity of birds, MacArthur and MacArthur (1961) first argued. According to their habitat heterogeneity hypothesis, structurally diverse habitats support higher ecological niches resulting in a higher bird richness. Since its formulation, this theory has been verified in many terrestrial ecosystems particularly in tropical forests, wetlands and grasslands.

According to Wiens (1989), the distribution of birds is closely related to spatial heterogeneity in habitat features such as vegetation height, patch size, food availability and microclimate. According to the principles of landscape ecology, birds do not respond only

to the vegetation type but to the interaction between the structure of the habitat, the distribution of critical resources and the overall environmental variability.

BirdLife International (2024) identifies the arid and semi-arid grasslands of India as globally important for several threatened and near threatened bird species. Many migratory raptors, bustards, coursers, larks, and harriers exploit this ecosystem during winter migration. Habitat degradation continues to make breeding and foraging grounds less available.

Rahmani (2012) pointed out that Indian grasslands have been much lesser priority for conservation than forests despite having rich biodiversity. The agricultural intensification and invasive plant species overgrazing and conversion of native grasslands to croplands have led to rapid population declines of many grassland birds. Conservation planning should therefore favour the ecological restoration of natural grassland habitat.

According to studies conducted by the Zoological Survey of India (ZSI), Rajasthan harbors one of the richest avifaunal assemblages among with the Indian arid states. Protected grasslands and wetlands are areas of especially high diversity with the greater habitat diversity allowing for co-existence of insectivores, granivores, carnivores, omnivores and piscivorous birds. Bird species diversity improves as a result of seasonal migration.

Prakash et al. (2017) determined the bird diversity of Western Rajasthan, which found that open grasslands support a higher density of harriers, larks, wheatears, shrikes and coursers over scrubby areas. The results showed that the abundance of prey and height of vegetation affected habitat selection by grassland specialists.

Multiple studies have recorded the ecological significance of Tal Chhapar Wildlife Sanctuary. As per Rajasthan Forest Department reports, the sanctuary is considered one of the best examples of semi-arid grassland in India supporting Blackbuck populations along with more than 300 recorded bird species. During winters, the sanctuary becomes an important roosting and hunting ground for migratory harriers from Central Asia and Eastern Europe.

According to Sharma et al., seasonal wetlands within Tal Chhapar enhance habitat diversity with waterfowl and other aquatic birds such as ducks, geese, stilts, sandpipers, herons, and egrets after monsoonal rains. Bird abundance or density during post-monsoon and winter months was strongly determined by water availability.

According to Jhala, Qureshi and Yadav (2020), wildlife community is strongly influenced by grassland management practices. Grazing at moderate levels will maintain a structural heterogeneity that will benefit many birds. High levels of grazing will limit vegetation cover; nesting opportunities and insect abundance. On the other hand, full exclusion of the grazing can lead to very dense vegetation that may not suit several open-country birds.

Throughout Rajasthan, the invasion of native plants is a threatened and invasive species such as *Prosopis juliflora*. Studies suggest that invasive woody vegetation can alter grassland structure, reduce native plant diversity, and change prey availability for grassland birds. Native trees like *Prosopis cineraria* and *Acacia senegal* provide useful nesting and perching site while not obstructing the open nature of the habitat.

Recent remote sensing studies show that habitat fragmentation affects the movement of birds. A decrease in nearby patches of grassland increases edge effects and exposes ground-nesting birds to greater predation risk. Fragmented habitats limit the seasonal movement between feeding, nesting, and roost sites, which reduces overall species richness.

Academics have studied feeding guilds and have proven that with the healthy grassland ecosystems, insectivorous birds are normally the most abundant. That is because the main food resource is insects during the breeding season. During post-monsoon time, granivores tend to increase after seed production. Meanwhile, raptors follow the fluctuations in the abundance of rodents, reptiles and small birds. The seasonal changes show the interplay of trophic interactions and habitat quality.

Research analysis has revealed four main drivers of bird community composition: habitat heterogeneity and vegetation type, availability of water during monsoon season, prey abundance level, and management practices. The ecological studies of Tal Chhapar Wildlife Sanctuary are on the rise, but one aspect that remains unexplored is the habitat association, feeding guilds and the seasonal community of the birds. Continued monitoring is therefore important for adaptive conservation and habitat management strategies.

3. Study Area

Tal Chhapar Wildlife Sanctuary is a wildlife sanctuary in the Sujangarh Tehsil of Churu District which is an administrative division in the Indian state of Rajasthan. It is located

between 27°50'–27°52' N latitudes and 74°25'–74°28' E longitudes. The area and location of Khichan Crane Sanctuary (19 words)

The sanctuary has an area of about 7.19 km². The sanctuary is in the biogeographic zone of the Thar Desert. Despite being relatively small, it is among India's most important protected areas of grassland ecosystem and an international site for the conservation of Blackbuck (*Antelope cervicapra*) and also a large number of resident and migratory birds.

The climate is hot semi-arid with extremely high summer temperatures often more than 45° C while winters are cool with temperatures dropping below 5° C. Each year rainfall is around 300 – 350 mm, and most of it is received during southwest monsoon from July to September. The growth of the vegetation, formation of wetlands and seasonal food variety for birds is greatly influenced by rainfall variability.

Dichanthium annulatum, *Cenchrus ciliaris*, *Lasiurus indicus* and *Cynodon dactylon* are the dominant native grasses in the vegetation. Throughout the sanctuary there occur a few native trees like *Prosopis cineraria* (Khejri), *Acacia senegal*, *Salvadora persica*, *Capparis decidua*. A wide variety of habitats is generated by seasonal ponds, salinity depressions, open mudflats, and sparse vegetation.

A considerable portion of the bird population requires nesting, roosting, and feeding sites that fit in particular habitats. Various larks, pipits, wheatears, coursers, harriers, falcons are found on open grasslands. The trees that are scattered provide perches and nest sites for rollers, bee-eaters, shrikes, owls and eagles. Temporary wetlands provide essential resources for various migratory birds during the winter season.

The site also serves as an important stopover in the Central Asian Flyway, facilitating seasonal migration of many raptors and passerines. As a result, Tal Chhapar is one ecosystem where grassland, shrubland, woodland and wetland habitats together support unique bird diversity.

4. Methodology

The current article derives from a critical examination and synthesis of scientific literature on bird diversity and habitat ecology of Tal Chhapar Wildlife Sanctuary. Data was collected from peer-reviewed journal articles, books, government reports, Wildlife Institute of India

publications, Rajasthan Forest Department reports, BirdLife International database and various ornithological surveys in northwestern India.

A thorough overview of associated birds with respect to their occurrence, habitat utilization, feeding behaviour, seasonal migration and conservation status were published. According to the habitat types reported in previous studies, they were grouped into five broad ecological categories which were open grassland, shrubland, scattered woodland, seasonal wetlands, and saline depressions.

Bird species were classified as resident, winter migrant, passage migrant or local migrant based on their residency status. The ecological guilds were insectivores, granivores, carnivores, omnivores, nectarivores, scavengers and aquatic feeders. Observations recorded in different studies were used to interpret habitat associations.

The review also considered how different environmental factors affected the distribution of birds. This included looking at things like vegetation structure, grass height, availability of water, availability of prey, availability of nesting substrate, grazing intensity, invasive species, and human disturbance. A synthesis of conservation challenges and management recommendations instigated from a wide range of ecological literature to provide an integrated understanding of the bird community in Tal Chhapar Wildlife Sanctuary.

Although the article mainly draws from secondary data, the synthesis complies with established ecological review methodologies with evidence from more than one independent source. The present approach will allow for a more comprehensive interpretation of bird-habitat relationships and identification of important knowledge gaps that can be filled through field-based studies in future.

5. Results and Discussion

Available literature revealed that despite a small area, the Tal Chhapar Wildlife Sanctuary supports a diverse avian community. A mix of open grasslands, scattered native trees, shrublands, seasonal wetlands and saline depressions create a varied landscape that can support resident, migratory and passage birds. The composition, abundance, and distribution of bird communities in the sanctuary is determined by habitat heterogeneity, seasonal rains, vegetation structuring, and prey availability.

5.1 Composition of Bird Community

Tal Chhappar Wildlife Sanctuary is quite an important bird area, located in the semi-arid ecosystem of Rajasthan. Over 300 species of birds belonging to several taxa groups like raptors, passerines, waterbirds, waders, pigeons and doves, owls, bee-eaters, rollers, shrikes, larks, pipits, sandgrouse, coursers etc. have been reported from the sanctuary and its habitat. The resident species recorded all year round include Indian Peafowl (*Pavo cristatus*), Grey Francolin (*Ortygornis pondicerianus*), Black Drongo (*Dicrurus macrocercus*), Indian Roller (*Coracias benghalensis*), Green Bee-eater (*Merops orientalis*), Ashy-crowned Sparrow-Lark (*Eremopterix griseus*), Crested Lark (*Galerida cristata*), Rufous-tailed Lark (*Ammomanes phoenicura*), Laughing Dove (*Spilopelia senegalensis*), House Sparrow (*Passer domesticus*), etc. The functioning of ecosystems relies heavily on species like birds, bats, and insects, which fulfill diverse roles in nature.

Bird diversity of the winter migration. From the month of October to the month of March, migratory birds that arrive through the Central Asian Flyway converge at the sanctuary in large numbers. Many winter visitors recorded often include Montagu's Harrier (*Circus pygargus*), Pallid Harrier (*Circus macrourus*), Western Marsh Harrier (*Circus aeruginosus*), Steppe Eagle (*Aquila nipalensis*), Eastern Imperial Eagle (*Aquila heliaca*), Common Kestrel (*Falco tinnunculus*), Red-necked Falcon (*Falco chicquera*), Eurasian Wryneck (*Jynx torquilla*), Northern Wheatear (*Oenanthe oenanthe*) and Isabelline Wheatear (*Oenanthe isabellina*).

In the post-monsoon period, seasonal wetlands formed invariably attract to them a variety of water birds like Black-winged Stilt (*Himantopus himantopus*), Painted Stork (*Mycteria leucocephala*), Eurasian Spoonbill (*Platalea leucorodia*), Grey Heron (*Ardea cinerea*), Little Egret (*Egretta garzetta*), Common Teal (*Anas crecca*), Northern Shoveler (*Spatula clypeata*), and many species of sandpipers. Wetland habitats cover a small area of the sanctuary. However, they cause an increase in overall bird richness in post-monsoon and winter.

5.2 Relationship of Bird Communities with Habitat

The distribution of birds in Tal Chhappar Wildlife Sanctuary is affected by habitats. Different species have different habitats according to their needs.

Open habitats of grasslands currently constitute the most extensive habitat and support the greatest abundance of specialists. Larks, pipits, coursers, wheatears, harriers, falcons and sandgrouse forage and nest in these habitats. Low to medium grasses allow raptors to see their prey while still offering coverage to ground-nesting birds. Blackbuck grazing leads to a combination of grazed and ungrazed patches, thereby enhancing the heterogeneity.

Areas predominantly covered by shrubs, provide roosting and nesting opportunities to insectivorous birds and other omnivores. The shrub vegetation extensively used for nesting and screening from predation by shrikes, prinias, warblers, babblers and bulbuls. Shrub patches also have a greater abundance of insects and hence attractive feeding grounds for many passerines.

Native tree species such as *Prosopis cineraria* and *Acacia senegal* are ecologically important despite being less dense. The eagles, kites, harriers, and falcons are provided with opportunities to build nests, perch, and hunt by these trees. Various birds like bee-eaters, owls, woodpeckers, parakeets, and rollers need trees for breeding. Native tree presence increases vertical habitat complexity while maintaining the open character of grasslands.

Seasonal wetlands that are formed during and after the monsoons have a good assemblage. Following rain, a large quantity of aquatic insects, amphibians, molluscs, small fishes, etc., attracts water birds like herons, egrets, ducks, stilts, ibises, shorebirds, etc.

The availability of water during wintertime greatly enhances bird numbers in the sanctuary and the suitability of the same for migratory birds.

Saline Flats Saline depressions and sparsely vegetated mudflats are used by coursers, lapwings, plovers and other ground-foraging birds. The clear visibility in these habitats lowers predation risk and provides abundance of invertebrate prey.

5.3 Seasonal Variation in Bird Diversity

Seasonal variations greatly affect bird community composition. Species richness generally hits a low during the hot summer months, owing to reduced availability of water and insects. As the southwest monsoon approaches, grasses and insects grow rapidly, and shallow water bodies develop, making food and nesting sites more abundant.

The total number of species is the highest during the winter when migrants come from Central Asia and Europe. Montagu's Harrier and Pallid Harrier plentiful in this season this

makes Tal Chhapar one of the premier wintering sites for harriers in India. Winter is also associated with enhanced vegetation cover, seed abundance, and rodent and insect densities, which support greater bird abundance.

5.4 Structure of Feeding Guilds.

In varying ways the birds occupying different feeding guilds use the available resources.

Insect-eater or insectivorous species form the largest ecological guild. This is because of the huge/big population of insects which adapted to the native grasslands. Birds like bee-eaters and wagtails play an active role in insect population control and stability of ecosystem.

Seed-eating birds like larks, sparrows, doves and sandgrouses abound after seed production in the post-monsoon period. Birds such as eagles, falcons, harriers and owls consume the smaller animals like rodents, reptiles and birds which helps maintain the trophic balance.

Birds like crows, mynas and peafowl are omnivores and have a high ecological plasticity. Thus, they occupy varying habitats. Vultures and kites as scavenger of animal carcasses perform an important ecosystem service of disease transmission.

The existence of various feeding guilds shows that the ecosystem is likely intact containing a diversity of food resources and operating ecological processes.

5.5 Factors Influencing Bird Distribution

Several environmental factors govern bird occurrence and abundance in Tal Chhapar Wildlife Sanctuary.

Vegetation structure influences nesting success, predator avoidance, and food availability. Moderate grass height provides suitable nesting conditions for ground-breeding birds while maintaining adequate visibility for raptors.

Water availability becomes critically important during the dry season. Temporary wetlands substantially increase habitat quality by supporting aquatic prey and attracting migratory waterbirds.

Prey abundance, particularly insects and small mammals, directly affects habitat selection among insectivorous birds and raptors. Seasonal fluctuations in prey populations explain much of the observed variation in bird abundance throughout the year.

Human disturbances, including uncontrolled tourism, excessive grazing, vehicular movement, and infrastructure development, may alter bird behaviour and reduce habitat

quality. Although grazing contributes to habitat heterogeneity when maintained at moderate levels, excessive livestock pressure can damage nesting sites and reduce vegetation cover. Invasive plant species, especially *Prosopis juliflora*, pose a growing ecological threat by replacing native grasses, altering habitat structure, and reducing suitable foraging areas for grassland specialists. Climate variability, manifested through irregular rainfall and prolonged droughts, further affects vegetation productivity, wetland persistence, and migratory bird distribution.

Overall, the bird community composition of Tal Chhappar Wildlife Sanctuary reflects the close interaction between habitat diversity, ecological processes, and seasonal environmental variation. The sanctuary functions as an ecologically significant refuge for grassland and migratory birds within the arid landscapes of northwestern India. Sustaining this diversity will depend upon continued habitat protection, restoration of native grasslands, control of invasive species, and long-term ecological monitoring.

6. Conservation Implications

The results highlight that the Tal Chhappar Wildlife Sanctuary (TCWS) must be managed in a way that conserves the integrity of its native grassland ecosystem, not just flagship species. Scientific management of the grassland should ensure habitat heterogeneity through practices such as rotational grazing, monitoring of vegetation structural parameters at intervals and restoration of degraded sites using local grass species.

Invasive plants especially *Prosopis juliflora* should be controlled through systematic removal and replacement with native plants. It is important to protect seasonal wetlands from drainage and human disturbance due to the critical habitats they provide for migratory waterbirds.

There should be implementation of long-term bird monitoring programmes using standard survey techniques to access changes in species richness, abundance, breeding success and migration pattern under changing climate. The use of Geographic Information Systems (GIS), Remote Sensing, and drone-based habitat assessment can strengthen ecological monitoring and thus support adaptive management.

The active involvement of a community in conservation activities is equally important. Local communities, schools, eco-development committees, and birdwatching groups can

help with habitat restoration, citizen-science monitoring, awareness campaigns and responsible ecotourism. The execution of tourism policies should ensure that disturbance to the breeding and wintering birds is minimized, and environmental awareness is engendered among the visitors. Moreover, it should impart economic benefit to the local communities. The Tal Chhapar Wildlife Sanctuary, being situated on the Central Asian Flyway, provides excellent opportunities for collaboration in research concerning aspects such as migratory birds, climate change and landscape level planning. Incorporating scientific research with participatory management will enhance the long-term conservation of this globally important grassland ecosystem.

7. Conclusion

The Tal Chhapar Wildlife Sanctuary is home to one of the most important semi-arid grassland ecosystems in India. Tal Chhapar Wildlife Sanctuary has an extremely rich avifauna despite its very small area. The review shows that the sanctuary's mosaic of open grasslands, shrublands, scattered native trees, seasonal wetlands and saline depressions provides adequate habitat for resident, migratory and passage bird species. The varied nature of this habitat creates different ecological niches that support birds belonging to different feeding guilds such as insectivores, granivores, carnivores, omnivores, scavengers, and aquatic feeders.

The ecological fabric of the sanctuary is made of open grassland which supports the numbers of larks, pipits, coursers, wheatears, harriers and falcons. Native tree species such as *Prosopis cineraria* and *Acacia senegal* are important nesting and roosting sites for raptors and cavity-nesting birds. Seasonal wetlands enhance bird richness significantly as they attract migratory ducks, herons, stilts and shorebirds. The position of the sanctuary on the Central Asian Flyway enhances its conservation significance as it serves as an important wintering ground for migratory raptors and passerines.

The composition of the bird community is greatly affected by vegetation structure, habitat diversity, seasonal rainfall, water availability, food availability and grazing intensity. Moderate grazing positively contributes to habitat heterogeneity; however, excessive grazing, fragmentation of habitats, invasive plant species, and climate variability can reduce habitat quality and negatively affect grassland-obligate birds. The human disturbances,

whether caused by infrastructure development or unregulated tourism, must be regulated properly so that the impact is minimal.

The primary management objective should be the conservation of native grassland ecosystems. To sustain the bird diversity of the sanctuary, habitat restoration, invasive species management, wetland conservation, long-term ecological monitoring and community participation will be important. The use of modern technologies like GIS, remote sensing, automated acoustic monitoring and drone based habitat mapping can strengthen biodiversity assessment and adaptive management.

Subsequent investigations should concentrate on continual observation of seasonal bird populations, the ecology of breeding, the preference of habitat, the timing of migration and the impact of climate change on birds. Studies that quantitatively examine the abundance of birds versus vegetation, prey, and land-use change can provide important information for evidence-based conservation planning. A comparative study with other grassland protected areas of the Thar Desert would further our understanding of regional patterns of bird diversity.

On the whole, Tal Chhapar Wildlife Sanctuary is not only a stronghold of the Blackbuck, but it is also an internationally important refuge of grassland and migratory birds. In order to maintain ecological integrity and long-term conservation of one of India's most distinctive grassland bird communities, continued scientific research habitat management and stakeholder involvement will be essential.

References

1. Ali, S., & Ripley, S. D. (1987). *Compact handbook of the birds of India and Pakistan* (2nd ed.). Oxford University Press.
2. BirdLife International. (2024). *Data zone: Species factsheets and Important Bird Areas*. <https://datazone.birdlife.org>
3. Bibby, C. J., Burgess, N. D., Hill, D. A., & Mustoe, S. H. (2000). *Bird census techniques* (2nd ed.). Academic Press.
4. Grimmett, R., Inskipp, C., & Inskipp, T. (2011). *Birds of the Indian Subcontinent* (2nd ed.). Oxford University Press.

5. Jhala, Y. V., Qureshi, Q., & Yadav, S. P. (Eds.). (2020). *Status of tigers, co-predators and prey in India 2018*. National Tiger Conservation Authority, Government of India and Wildlife Institute of India.
6. Johnsgard, P. A. (1991). *Bustards, hemipodes and sandgrouse: Birds of dry places*. Oxford University Press.
7. MacArthur, R. H., & MacArthur, J. W. (1961). On bird species diversity. *Ecology*, 42(3), 594–598.
8. Newton, I. (2008). *The migration ecology of birds*. Academic Press.
9. Prakash, S., Verma, A. K., & Kumar, R. (2017). Diversity and habitat utilization of birds in the arid ecosystems of western Rajasthan. *Journal of Threatened Taxa*, 9(5), 10142–10152.
10. Rahmani, A. R. (2012). *Threatened birds of India: Their conservation requirements*. Oxford University Press and Bombay Natural History Society.
11. Rajasthan Forest Department. (2023). *Tal Chhapar Wildlife Sanctuary Management Plan*. Government of Rajasthan.
12. Sekercioglu, Ç. H. (2006). Increasing awareness of avian ecological function. *Trends in Ecology & Evolution*, 21(8), 464–471.
13. Sharma, S., Singh, R., & Meena, V. (2018). Seasonal variation in avifaunal diversity in semi-arid grassland habitats of Rajasthan. *Indian Forester*, 144(9), 856–865.
14. Sodhi, N. S., Şekercioğlu, Ç. H., Barlow, J., & Robinson, S. K. (2011). *Conservation of tropical birds*. Wiley-Blackwell.
15. Wiens, J. A. (1989). *The ecology of bird communities* (Vols. 1–2). Cambridge University Press.
16. Wildlife Institute of India. (2022). *Grassland ecosystem conservation in India*. Wildlife Institute of India.
17. Zoological Survey of India. (2022). *Faunal diversity of Rajasthan*. Zoological Survey of India.