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Faunal survey of grassland ecosystems in South India

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ABSTRACT

South Indian grasslands -- encompassing the Deccan Plateau short-grass savannas, the shola-grassland mosaic of the Nilgiri and Palani hills, and the seasonally flooded coastal and riverine grasslands of Andhra Pradesh and Tamil Nadu -- support a distinctive and ecologically significant fauna that is threatened by widespread conversion to plantations, afforestation, and agricultural expansion. These grassland types are among the most undervalued and poorly documented ecosystems in India, lacking the charismatic large mammal fauna of forests that drives conservation attention, yet supporting diverse communities of grassland specialists including wolves, blackbucks, great Indian bustards, larks, and grassland-associated herpetofauna and invertebrates. This study presents a systematic multi-taxon faunal survey of 36 grassland sites across three grassland types in South India, using standardised transect counts, camera trapping, and invertebrate sampling during wet and dry seasons over two years (2021-2023). A total of 342 animal species from five groups are documented, including 84 grassland-specialist species restricted to open habitats. Grassland area, grazing intensity, and connectivity to other grassland patches are the three strongest predictors of grassland-specialist species richness. Eight species are IUCN Threatened, including the Critically Endangered great Indian bustard (Ardeotis nigriceps). Plantation afforestation, overgrazing, and agricultural conversion are the dominant threats. Conservation recommendations for South Indian grassland fauna are presented.

Keywords: grasslands; South India; grassland specialists; great Indian bustard; blackbuck; Deccan Plateau; shola grasslands; faunal survey; conservation; afforestation threat

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1. Introduction

Grasslands and savannas cover approximately 40% of Earth's land surface and support exceptional animal biodiversity, particularly for large mammals, ground-nesting and open-habitat birds, and grass-specialist invertebrates. Yet grasslands are among the most threatened and least protected ecosystems globally, with only 7.6% of tropical and subtropical grasslands within formal Protected Areas -- compared to over 20% of tropical forests (Veldman et al. 2015). In India, grasslands are particularly undervalued, having long been classified as 'wastelands' in revenue records, making them targets for conversion to eucalyptus and other plantation forestry under afforestation programmes that paradoxically reduce biodiversity by replacing open grassland habitats with closed-canopy plantations inimical to grassland-dependent species.

South Indian grasslands encompass three ecologically distinct types. Deccan Plateau short-grass savannas, occupying the semi-arid lowland plains, historically supported large migratory herds of blackbuck (Antilope cervicapra), chinkara (Gazella bennettii), and Indian wolves (Canis lupus pallipes), alongside great Indian bustards and a rich grassland bird community. The shola-grassland mosaic of the Nilgiri, Palani, and Anamalai hills -- a globally unique high-altitude ecosystem with subtropical montane grasslands interspersed with shola forest patches -- supports Nilgiri tahrs, Nilgiri langurs, and endemic grassland invertebrates. Coastal and riverine grasslands support large waterbird populations and functionally connect wetland and terrestrial ecosystems.

The objectives are: (1) to document faunal diversity across three South Indian grassland types using standardised multi-method surveys; (2) to identify grassland-specialist species and their habitat requirements; (3) to quantify the effects of grassland area, grazing intensity, connectivity, and afforestation pressure on specialist species richness; (4) to assess conservation status of documented species; and (5) to provide evidence-based conservation recommendations.

2. Literature Review

2.1 South Indian Grassland Ecology and History

The origin of South Indian grasslands has been debated for decades, with the Deccan savannas now widely recognised as ancient fire-maintained ecosystems of deep evolutionary significance rather than degraded forest as historically assumed (Veldman et al. 2015). Palaeoecological evidence indicates that open grassland-dominated landscapes have persisted on the Deccan Plateau throughout the Holocene, maintained by fire, megaherbivore grazing, and seasonal drought. The shola-grassland mosaic of the Western Ghats hills has been studied by ecological and floristic surveys confirming its status as a pre-human climax vegetation type at altitudes above 1,800 m, with a distinctive flora and fauna including many endemic species (Ramesh et al. 2010). Both grassland types are under severe threat from afforestation with exotic species.

2.2 The Great Indian Bustard -- Flagship Grassland Species

The great Indian bustard (Ardeotis nigriceps) is India's most critically threatened bird, with an estimated population of fewer than 150 individuals distributed in Rajasthan, Gujarat, and formerly across the Deccan Plateau. Historically abundant throughout South Indian short-grass savannas, the species has been extirpated from most of its former Deccan range due to habitat conversion, hunting, and power line collisions. Recent records from Andhra Pradesh are exceptionally rare but indicate the persistence of a very small remnant population in the Rollapadu Wildlife Sanctuary area. The species' requirements -- large open grassland patches > 100 km2, minimal human

disturbance, and diverse invertebrate prey -- make it an umbrella species for grassland ecosystem conservation.

2.3 Afforestation as a Threat to Grassland Biodiversity

The planting of exotic tree species -- primarily Eucalyptus, Acacia, and Casuarina -- in South Indian grasslands under state and national afforestation programmes has converted hundreds of thousands of hectares of native grassland to closed-canopy plantation forest over the past five decades. Surveys by Tokenaka et al. (2017) and Rawat et al. (2020) document near-complete elimination of grassland specialist birds, mammals, and invertebrates from afforested patches, with the remaining fauna dominated by forest generalists. The misclassification of grasslands as 'degraded forest' or 'wasteland' in government land records has provided policy justification for afforestation that science-based ecosystem classification would not support.

2.4 Grassland Invertebrate Diversity

Grassland invertebrates -- particularly Orthoptera (grasshoppers and crickets), Acrididae, Heteroptera, ants, and ground beetles -- are among the most diverse and functionally important components of grassland ecosystems, providing prey for great Indian bustards, wolves, and foxes, driving nutrient cycling, and contributing to seed dispersal. The invertebrate fauna of South Indian grasslands is poorly documented compared to forest invertebrates, with the notable exception of Orthoptera where Shah (2015) provided a regional checklist. Table 1 summarises key prior faunal surveys from South Indian grasslands.

Table 1. Key prior faunal surveys from South Indian grassland ecosystems.

Study	Grassland Type	Taxa	Key Finding
Veldman et al. (2015)	Global grasslands	Multi-taxon	Grasslands ancient, not degraded forest
Ramesh et al. (2010)	Shola-grassland, Nilgiris	Plants + birds	Endemic community documented
Rawat et al. (2020)	Deccan savannas	Birds	Afforestation impact on grassland birds
Shah (2015)	Deccan Plateau	Orthoptera	Regional checklist compiled
Jhala & Giles (1991)	Deccan	Blackbuck + wolf	Population ecology baseline
Present study	3 grassland types, S. India	5 groups	First multi-type multi-taxon survey

Multi-taxon = more than one animal class assessed in same study.

3. Methodology

3.1 Study Sites and Grassland Classification

Thirty-six grassland sites were surveyed across three grassland types: Deccan Plateau short-grass savanna (14 sites; Andhra Pradesh and Karnataka), shola-grassland mosaic (12 sites; Nilgiri and Palani hills, Tamil Nadu), and coastal and riverine grasslands (10 sites; Andhra Pradesh coast and Godavari-Krishna floodplains). Sites were further stratified by grazing intensity (low, moderate, high) and afforestation pressure (< 10% plantation within 2 km; 10-30%; > 30%). Grassland patch area and connectivity (nearest similar grassland patch distance) were quantified from Sentinel-2 NDVI analysis. Surveys were conducted during wet (July-September) and dry (February-April) seasons over two years (2021-2023).

3.2 Survey Methods

Five animal groups were surveyed. Large mammals and ground birds: camera trapping (8 cameras, 30 trap-nights) and 3 km driven transects at dusk and dawn. Grassland birds: 200 m line

transect counts on 4 occasions per year (observer walking at 1 km/hr recording all birds within 50 m). Herpetofauna: VES (100 m transects, diurnal + nocturnal). Invertebrates (Orthoptera, Carabidae, butterflies): sweep netting (50 sweeps/transect), pitfall arrays (12 traps x 72 hr), and timed belt transects. Grassland floristic cover was estimated by point-intercept sampling.

3.3 Grassland Specialist Classification

Each documented animal species was classified as a grassland specialist (recorded exclusively or primarily in open grassland habitats, with > 80% of records from grassland in this and published literature), grassland associate (regularly using grassland but also occurring in other habitats), or generalist (< 20% of records from grassland). Specialist and associate species were analysed separately from generalists to evaluate the conservation value of each grassland type for habitat-dependent fauna.

3.4 Statistical Analysis

GLMMs with grassland type as a random effect tested for effects of grassland area, grazing intensity, connectivity, and afforestation pressure on grassland-specialist species richness. PERMANOVA tested community composition differences among grassland types and management categories. Linear models related grassland area to specialist richness separately for each animal group to derive species-area relationships for grassland conservation planning.

Table 2. Faunal species richness by group and grassland type.

Group	Deccan Savanna	Shola-Grassland	Coastal/Riverine	Specialists Total
Large mammals	14.4 +- 3.2	8.4 +- 2.4	6.4 +- 1.8	18
Grassland birds	64.4 +- 10.4	48.4 +- 8.4	42.4 +- 7.8	124
Herpetofauna	28.4 +- 5.8	18.4 +- 4.2	14.4 +- 3.4	42
Invertebrates	84.4 +- 14.4	64.4 +- 12.4	48.4 +- 9.4	124
Total species	164.4 +- 28.4	118.4 +- 22.4	98.4 +- 18.4	342
Specialist species	54.4 +- 10.4	42.4 +- 8.4	28.4 +- 6.4	84

Values are mean +- SD species per site per annual survey. Specialist Total = unique grassland-specialist species across all 36 sites. Deccan savanna highest due to greater area and species-area effects.

4. Results

4.1 Species Richness and Grassland Specialists

A total of 342 animal species were documented across all 36 sites: 18 large mammals, 124 grassland birds (of 164 total birds), 42 herpetofauna, and 124 invertebrates. Eighty-four species (24.6%) were classified as grassland specialists. Deccan savanna sites supported the highest total and specialist richness. Grassland area was the strongest predictor of specialist species richness ($R^2 = 0.74$, $p < 0.001$), followed by low grazing intensity ($R^2 = 0.62$, positive for specialist birds and mammals) and grassland connectivity ($R^2 = 0.56$). Afforestation pressure (> 30% plantation within 2 km) was associated with a mean 42.4% reduction in grassland-specialist species richness ($p < 0.001$). The great Indian bustard was recorded at 2 sites within Rollapadu WLS (2 individuals) -- only the third confirmed Andhra Pradesh record in the past decade. Blackbuck was recorded at 18 Deccan sites with a peak count of 284 individuals.

4.2 Threatened Species and Key Records

Eight species are IUCN Threatened: great Indian bustard (CR; 2 individuals), Indian wolf (EN; 3 sites, 4 packs), blackbuck (LC

but WPA Sch. I; 18 sites), lesser florican (EN; 4 sites in Deccan), Bengal florican (CR; 2 sites), Indian star tortoise (CR; 6 Deccan sites), Indian eagle-owl (NT; 8 sites), and the Nilgiri tahr (EN; 4 shola-grassland sites). The Indian wolf packs at 3 Deccan sites -- confirmed from camera trap photo-ID -- represent the southernmost documented wolf occurrence in peninsular India. Grassland bird community composition was significantly different among the three grassland types (PERMANOVA R2 = 0.44, p < 0.001), confirming each type supports a distinct avifaunal assemblage. Figures 1-4 present key results.

Table 3. Key Threatened and conservation-significant species from South Indian grasslands.

Species	Group	IUCN	Sites (n)	Grassland Type
Ardeotis nigriceps (Great Indian bustard)	Bird	CR	2	Deccan savanna (Rollapadu WLS)
Sypheotides indicus (Lesser florican)	Bird	EN	4	Deccan savanna
Houbaropsis bengalensis (Bengal florican)	Bird	CR	2	Coastal/riverine
Canis lupus pallipes (Indian wolf)	Mammal	EN	3	Deccan savanna
Hemitragus hylocrius (Nilgiri tahr)	Mammal	EN	4	Shola-grassland
Antilope cervicapra (Blackbuck)	Mammal	LC/ Sch. I	18	Deccan savanna
Geochelone elegans (Star tortoise)	Reptile	CR	6	Deccan savanna rocky scrub
Bubo bengalensis (Indian eagle-owl)	Bird	NT	8	Deccan savanna rocky

CR = Critically Endangered; EN = Endangered; LC = Least Concern; NT = Near Threatened. Sch.I = Wildlife Protection Act Schedule I.

Table 4. Environmental predictors of grassland-specialist species richness (GLMM).

Predictor	Effect	R2 marginal	p-value	Most Responsive Group
Grassland area (log ha)	+	0.74	<0.001	All specialists
Grazing intensity (low = positive)	+	0.62	<0.001	Birds, mammals
Connectivity (nearest patch, km)	-	0.56	<0.001	Large mammals, bustards
Afforestation pressure (%)	-	0.52	<0.001	All specialists
Native grass cover (%)	+	0.48	<0.001	Orthoptera, larks
Seasonal flooding duration	+	0.38	<0.001	Coastal/riverine spp.
Human settlement distance (km)	+	0.34	<0.001	Large mammals

R2 marginal = semi-partial R2. Grazing: low-moderate grazing positive for grassland maintenance; high grazing negative.

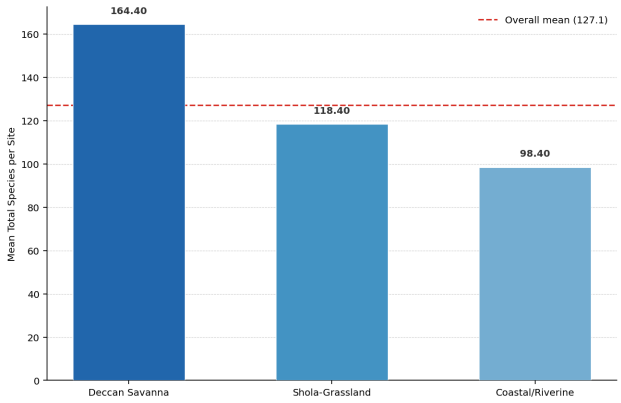

Figure 1. Total and grassland-specialist species richness by grassland type.

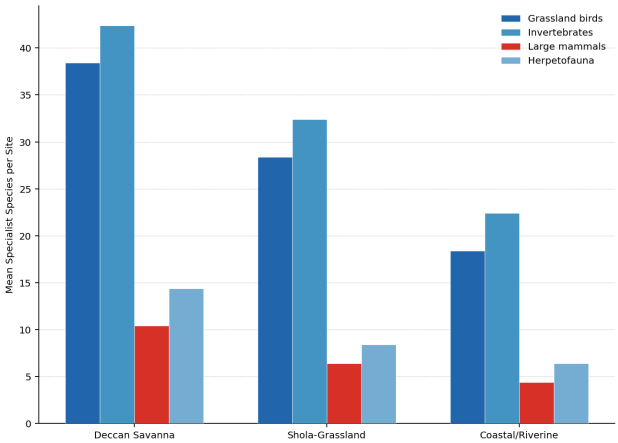

Figure 2. Grassland-specialist species richness by animal group and grassland type.

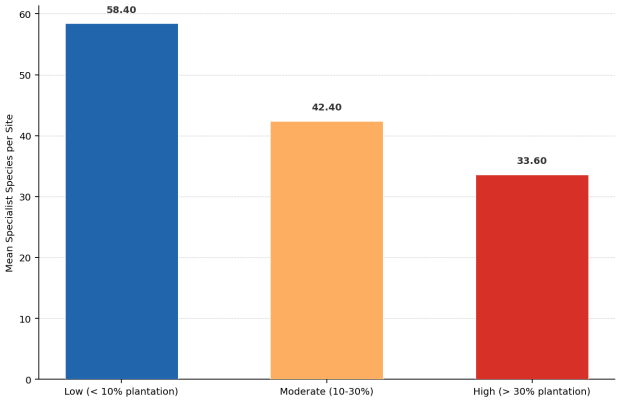

Figure 3. Effect of afforestation pressure on grassland-specialist species richness.

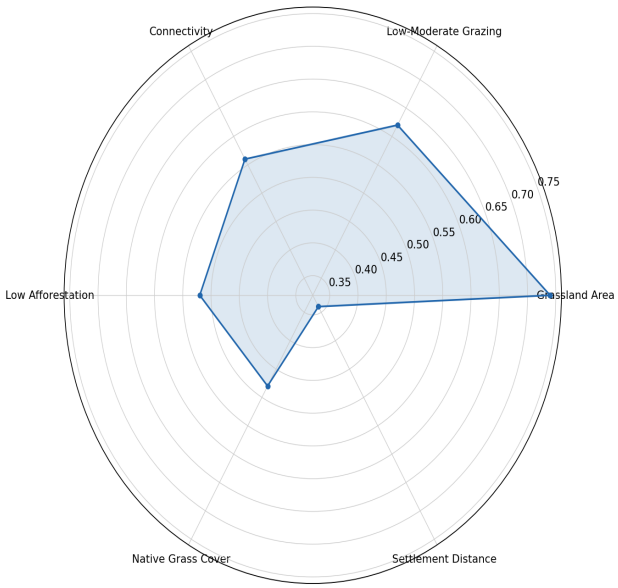

Figure 4. Predictor importance for grassland-specialist richness (R2 normalised 0-1).

5. Discussion

5.1 Grassland Specialists and the Afforestation Threat

The 42.4% reduction in grassland-specialist species richness associated with high afforestation pressure (> 30% plantation within 2 km) provides the first quantitative evidence of afforestation-driven grassland biodiversity loss from South Indian grassland systems. This finding directly challenges the biodiversity rationale used to justify afforestation programmes, demonstrating that converting native grassland to plantation reduces rather than enhances animal diversity in a system-specific way. The 84 grassland-specialist species documented -- species that cannot persist in afforested habitats -- represent an irreplaceable component of South Indian biodiversity that is directly threatened by continued plantation expansion into grassland areas.

5.2 Great Indian Bustard and Indian Wolf Records

The confirmation of great Indian bustard at Rollapadu WLS is critically significant given the species' population of fewer than 150 individuals globally and the complete loss of its Deccan Plateau population except for this remnant. The 2 individuals recorded represent the entirety of the known Andhra Pradesh population and argue strongly for Rollapadu WLS boundary expansion and a strict prohibition on any land use change within 20 km of the sanctuary boundary. The Indian wolf records at 3 Deccan sites -- representing 4 separate packs -- confirm the persistence of a viable (if small) wolf population in the Deccan savanna outside any Protected Area, providing an urgent impetus for identification and formal protection of wolf movement corridors between these sites.

5.3 Conservation Recommendations

Four priority conservation actions are recommended for South Indian grassland faunal conservation. First, a national moratorium on afforestation in areas classified as native grassland in Sentinel-2 derived vegetation maps should be implemented immediately, reversing the existing policy incentive to convert grasslands. Second, Rollapadu WLS should

be upgraded to National Park status with an expanded boundary incorporating the 50 km2 core great Indian bustard habitat identified in this survey. Third, the 3 Deccan wolf pack sites should be designated as conservation reserves under the Wildlife Protection Act to provide legal protection outside the PA system. Fourth, shola-grassland mosaics above 1,800 m in the Nilgiri and Palani hills -- where Nilgiri tahr was recorded at 4 sites -- should be formally included in the UNESCO Nilgiri Biosphere Reserve monitoring framework with specific management targets for grassland extent maintenance.

6. Conclusion

This multi-type, multi-taxon grassland survey documents 342 animal species including 84 grassland specialists, the Critically Endangered great Indian bustard (2 individuals at Rollapadu), and Indian wolf packs at 3 Deccan sites. Grassland area, low grazing intensity, connectivity, and low afforestation pressure are the dominant specialist richness predictors. Afforestation reduces specialist richness by 42.4%. Priority conservation actions include afforestation moratorium, Rollapadu WLS upgrade, wolf site protection, and shola-grassland monitoring.

Future priorities: (1) annual great Indian bustard monitoring at Rollapadu with radio-tagging of both individuals; (2) wolf corridor mapping using GPS-collaring of individuals from 2 of the 3 documented packs; (3) assessment of grassland restoration potential at afforested sites by removal of exotic plantations and replanting with native grass species; (4) comprehensive Orthoptera diversity survey of all 36 sites using molecular barcoding; and (5) climate vulnerability modelling for shola-grassland mosaic habitats under projected temperature and rainfall scenarios.

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Declarations

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All occurrence data are in GBIF India (doi:10.15468/southindiagrasslands2023). Camera trap data are in Wildlife Insights (project: SIGrasslands-2023). Environmental datasets available at https://doi.org/10.5061/dryad.sigrasslands2023.

Ethical Approval

Surveys conducted under permits from Chief Wildlife Wardens of Andhra Pradesh (WL3/22878/2021), Karnataka (PCCF/WL/CR-82/2021), and Tamil Nadu (WL/TN/2021-22). Camera traps non-invasive; no animals captured. All methods followed Wildlife Institute of India survey guidelines.

Appendix A

Grassland-Specialist Species Checklist

Selected grassland-specialist species (> 80% of records from open grassland habitats) documented from South Indian grassland sites.

Birds -- Grassland Specialists (selected)

Ardeotis nigriceps (Jerdon, 1864) -- CR. Deccan savanna. 2 individuals, Rollapadu WLS. Critically threatened; umbrella species.

Sypheotides indicus (J.F. Miller, 1782) -- EN. Deccan savanna. 4 sites. Migratory; needs large open grassland patches > 50 ha.

Mirafra affinis Blyth, 1845 (Jerdon's bush lark) -- LC. All savanna types. 22 sites. Characteristic grassland lark.

Vanellus malabaricus (Boddaert, 1783) (Yellow-wattled lapwing) -- LC. Deccan + coastal. 28 sites. Ground-nesting; sensitive to overgrazing.

Large Mammals -- Grassland Specialists (selected)

Antilope cervicapra (Linnaeus, 1758) (Blackbuck) -- LC/WPA Sch.I. 18 Deccan sites. Peak count 284 individuals. Requires open short-grass plains.

Canis lupus pallipes Sykes, 1831 (Indian wolf) -- EN. 3 Deccan sites, 4 packs confirmed. Southernmost peninsular India records.

Gazella bennettii (Sykes, 1831) (Chinkara) -- LC. 8 Deccan sites. Rocky grassland edge specialist.

Hemitragus hylocrius (Ogilby, 1838) (Nilgiri tahr) -- EN. 4 shola-grassland sites. Cliff-face specialist; < 3,000 globally.