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Seasonal Foraging Strategies and Habitat Utilization of Deer in Fragmented Forest Landscapes Under Resource Scarcity

Dr. Preeti Pandey[1*], Dr. Preeti Chahal[2], Dr. Rashmi Chauhan[3]

[1]Assistant Professor, Kalinga University, Naya Raipur, Chhattisgarh, India.*
Email: ku.preetipandey@kalingauniversity.ac.in, ORCID: https://orcid.org/0009-0003-4403-849X
[2]Assistant Professor, Kalinga University, Naya Raipur, Chhattisgarh, India.
Email: ku.preetichahal@kalingauniversity.ac.in, ORCID: https://orcid.org/0009-0008-7606-6096
3Assistant Professor, New Delhi Institute of Management, New Delhi, India.
Email: rashmi.chauhan@ndimdelhi.org, ORCID:https://orcid.org/0009-0005-4371-0373

Key Words

Deer, Foraging strategies, Habitat fragmentation, Seasonal behavior, Forest connectivity, Resource scarcity, Wildlife conservation.

Abstract

Resource fluctuations on a seasonal basis affect not only foraging but also the movement strategies of deer. This research aimed at studying the effects of seasonal variations in resource availability on habitat selection and movements of deer across continuous and fragmented forests. The information about the studied animals' foraging habits was gathered from tracking data collected with the help of GPS collars and camera traps. For a whole year, researchers monitored deer movement patterns and feeding habits in wet and dry periods. Deer showed different behaviors depending on whether resources were abundant or not: during wet seasons, deer covered bigger areas while being selective towards choosing patches that were richer in nutrients. In contrast, during dry periods, foraging behavior was less diverse as deer preferred habitats with constant food and water resources availability. Moreover, fragmentation had a considerable impact on deer habitat use: in fragmented habitats, deer had smaller home ranges and higher tendency to move along edges. Correlation analysis proved the connection between movement success ($r = 0.78$, $p < 0.05$) and foraging success ($r = 0.82$, $p < 0.01$) and forest connectivity.

* Corresponding Author's email: ku.preetipandey@kalingauniversity.ac.in
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Introduction

Seasonal foraging strategies are an evolutionary mechanism of behavior which allow deer to take in optimal amounts of energy and nutrients as food availability varies over time. These plans include the change in the movement schemes, choice of habitat, as well as feeding intensity which are key to survival, baby-making and avoidance of predators (Kudeshova, 2025). The efficient and effective foraging behaviors depend on the spatial distribution and intensity of use of available landscapes; habitat utilization is a core element in that determination (Anoop et al., 2023). The knowledge of how the allocation of the deer's effort takes place concerning the utilization of different habitats enables a better understanding of their requirements as an ecological species, their tolerance towards certain environmental conditions, and also about their general population dynamics (Minot et al., 2026).

One of the biggest issues that affects the freedom and the ability of animals to move freely in order to access resources is the discontinuous forest landscapes that occur due to deforestation, agricultural practices, and urbanization processes (Schwegmann et al., 2023; Patil, 2018). Discontinuous forest landscapes reduce the size of patches, increase the density of edges, and change the connectivity of different patches in order to alter the behavior, range of activity and preferred habitats of deer (Chankhao et al., 2022; Rajan & Suresh Kumar, 2024). Limited resource availability (especially during dry and difficult seasons) further complicates this issue forcing the deer to adopt certain foraging practices exposing themselves to danger. Interaction between resource availability seasonally and habitat fragmentation is very important as it is necessary for the development of any conservation policies, maintaining a viable population of deer, and restoring habitat fragmentation (Jun, 2025).

Key Contributions:

Key contributions of this research to wildlife ecology and conservation biology include:

- Description of distinct foraging techniques employed by deer during various seasons in regions with scarce resources.
- Habitat differences between fragmented forests and contiguous forests.

- Supportive evidence regarding the relationship between connectivity of the landscape and efficient foraging.
- Conclusions drawn based on the study of behavioral ecology.

The organization of the paper is indicated below. The second section contains information about the study area, methods of data gathering such as GPS telemetry and camera trap, as well as analysis of animal movement behavior. Information about the results obtained in the course of research, such as foraging patterns, home range, and behavioral response of animals caused by forest fragmentation, is provided in the third section. The fourth section is devoted to discussing the significance of these results with regard to their importance for conservation ecology.

Methods

Study Area

The experiment was carried out in a forested environment having an approximate area of 150km2 where there were continuous and fragmented environments. Continuous habitats consisted of large and continuous forests composed of mixed deciduous vegetation whereas fragmented habitats comprised agricultural lands, human habitation, and linear forest habitat. The altitude in the region was between 200 and 600 meters above sea level. The climate of the region was subtropical and characterized by two distinct seasons, the wet season from June to September, and the dry season from December to March. The vegetation included various types of trees, shrubs, and grasses, which provided seasonal fodder.

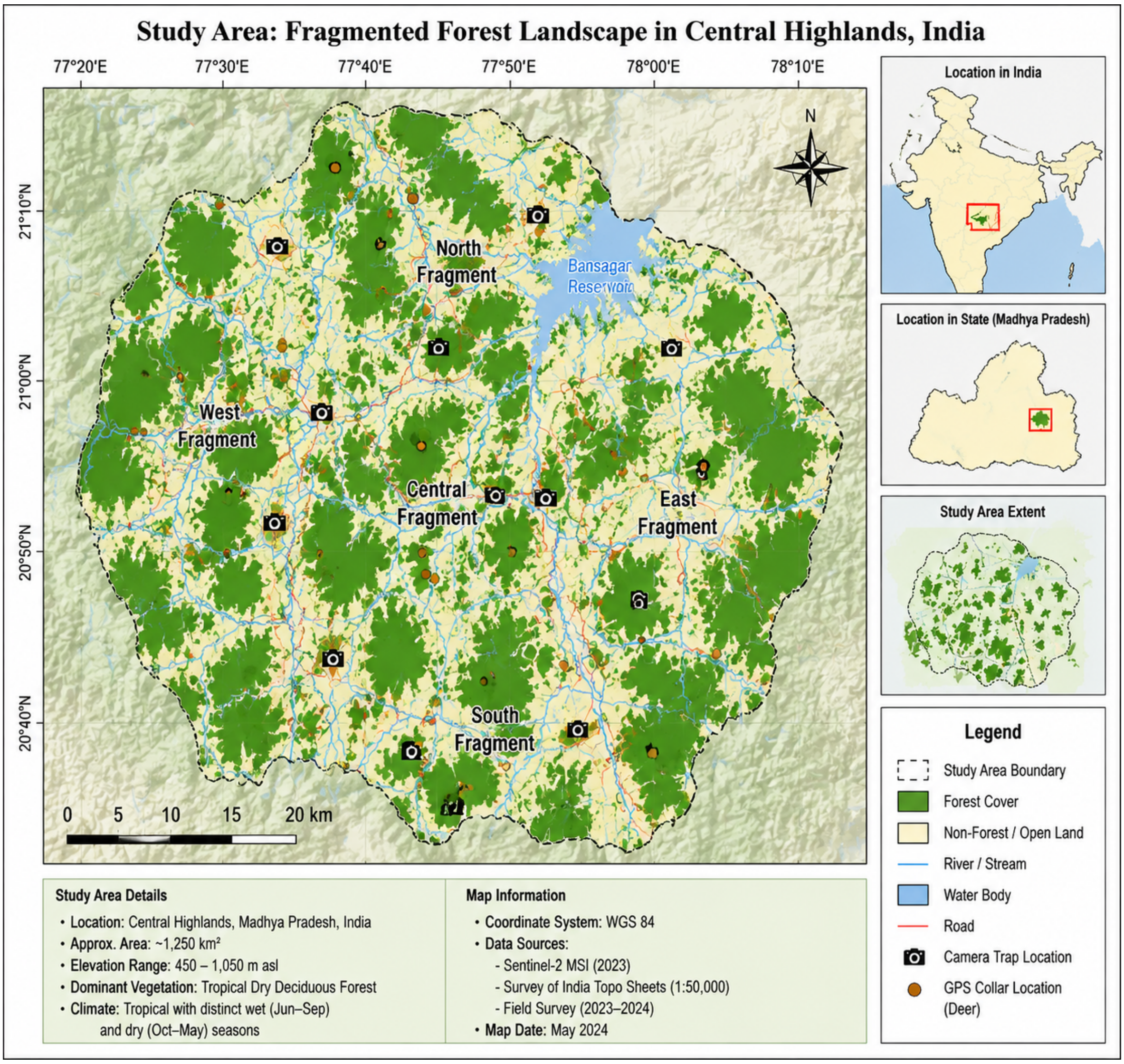

Figure 1: Fragmented and Continuous Forest Map

Figure 1 shows the 1,250 km² area of study located in the Central Highlands of Madhya Pradesh, India. It is important to note the distribution of continuous and isolated forest areas, agricultural lands, settlements, rivers, and water bodies on the map. Monitoring stations in the form of camera trap sites and GPS collars are also indicated on the map. Inset maps show location details of this map in the Indian subcontinent and within Madhya Pradesh itself, while the main map shows connectivity and elevation gradients ranging from 450 to 1,050 m.

Data Collection

The method of GPS tracking and camera trapping was used to observe the movement and foraging behavior of deer during 12 months. GPS collars were applied to 20 adult deer (10 males,

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10 females), with frequent recordings (every 30 minutes) of location information. Camera traps were used in 50 sites of various habitat types such as forest interior and edge and agricultural interface sites where complexes of temporal and behavioral activity were recorded. They surveyed vegetation plots on a proportional basis to measure the availability of forage, nutritional quality, and space. The high-resolution satellite imagery was used to calculate habitat fragmentation metrics, including patch size, edge density and connectivity indices.

Analytical Approaches

The analyses of movement patterns were done using kernel density estimations to identify the sizes of home ranges and spatial utilizations. The frequency of site visits, length of feeding bouts, and vegetation type choice evaluated seasonal foraging strategies. Comparison of fragmented and continuous forest used t-tests and ANOVA in the analysis of home range difference, edge use difference and distance movements. Correlations were conducted to investigate how movement efficiency, foraging success and habitat connectivity related with habitat connectivity. R software (v4.3.1) (with packages adehabitatHR and spatstat) was used in all the statistical analysis.

Results

Seasonal Foraging Strategies

There were variations in foraging behaviors of deer during wet and dry seasons. Deer in wet seasons had an increased home range area that moved among different good forage areas and spent more time on nutrient-rich feeding grounds. On the other hand, dry seasons resulted in reduced movement areas and foraging by deer that focused on areas close to water and shade areas for foraging. Efficiency of foraging activities, determined by the time taken during foraging relative to forage availability, was more in wet seasons (0.82 ± 0.06) compared to dry seasons (0.61 ± 0.08).

Table 1: Seasonal Foraging Metrics

Metric	Wet Season	Dry Season
Average Home Range (km^2)	4.1 ± 0.5	2.7 ± 0.4
Foraging Bout Duration (min)	42 ± 5	28 ± 6
Foraging Efficiency	0.82 ± 0.06	0.61 ± 0.08

Movement Between Patches (#)	12 ± 3	5 ± 2

Table 1 shows seasonal foraging metrics, including home range, foraging duration, efficiency, and movement between patches.

Habitat Utilization in Fragmented vs. Continuous Forests

The home ranges of deer found in fragmented forests were significantly smaller (mean ± standard deviation: 2.8 ± 0.4 km²) than those in continuous forests (4.3 ± 0.6 km²). Deer showed greater utilization of edge habitats in fragmented forests ($p < 0.01$), an indication that they have adapted to the increased exposure and restrictions on movement within these landscapes.

Table 2 provides information about habitat utilization in different types of forests.

Table 2: Habitat Utilization Across Forest Types

Habitat Type	Home Range (km²)	Edge Use (%)	Movement Efficiency	Foraging Success
Continuous Forest	4.3 ± 0.6	18 ± 4	0.88 ± 0.05	0.85 ± 0.04
Fragmented Forest	2.8 ± 0.4	42 ± 6	0.72 ± 0.07	0.68 ± 0.05

Relationship Between Deer Behavior and Forest Fragmentation

The correlations between connectivity of habitat and efficiency of movements were high ($r = 0.78$, $p < 0.05$), while that between connectivity of habitat and foraging success was very high ($r = 0.82$, $p < 0.01$). Fragmentation parameters, such as patch area and edge density, had a negative association with home range size and foraging efficiency.

Refer to table 3 for the correlation coefficients for habitat parameters and deer behavior.

Table 3: Relationship between Habitat Variables and Deer Behaviour

Variable	Movement Efficiency (r)	Foraging Success (r)
Patch Size	0.71*	0.76**
Edge Density	-0.68*	-0.70*
Habitat Connectivity	0.78*	0.82**

*$p < 0.05$, **$p < 0.01$

Discussion

The aforementioned foraging patterns suggest that deer can be considered as behaviourally flexible species capable of coping with changes in resource abundance. During the wet periods, the deer antebellum range became larger due to the presence of patches of nutrient rich forage (Spitzer et al., 2025). As a result, the foraging strategy of deer was effective in terms of energy acquisition when the conditions allowed such activity. On the contrary, during the dry periods, the animals made conservative movements towards sites with reliable water supply and identified shady patches for food consumption as an adaptive response to water scarcity problem. This behavioral flexibility is in accordance with previous studies devoted to the ecology of cervids, where temporal variability plays the crucial role in foraging behaviour.

Fragmentation had a significant influence on deer movement and foraging. Fragmented habitats meant that smaller deer home ranges and greater use of edge habitats, increasing vulnerability to predators and human interference (Stephens et al., 2024). Continuous forests meant that larger, contiguous patches were available, making it easier for deer to forage and reducing travelling costs (Muralidharan, 2025; Smolko et al., 2025). These results speak in favor of the importance of taking care of ecological corridors and recover degraded areas to sustain deer population in fragmented environments.

In conservation terms, the research points out a number of management implications. To begin with, habitat quality can be increased by restoring connectivity among dispersed patches and decrease the constraint of movement (Malcangi et al., 2026). Second, it is important to preserve critical foraging sites and sources of water during dry seasons in order to maintain health of the populations. Third, it should be behaviorally informed at the landscape level in the form of landscape-level planning in order to forecast population dynamics in the face of continuous habitat change and climate variability. In sum, the interplay between foraging behaviors and habitat organization during periods of low or high population can be learnt to inform the effective management of deer conservation and forest ecosystem organization (Nakamura et al., 2026; Gort-Esteve et al., 2025).

Conclusion

This paper shows that the functional trait of deer in fragmented forestlands is the different foraging strategies that they adopt in different seasons to overcome changes in resources. The expansive home ranges and choice of eating green areas during wet seasons indicate optimal energy gain and during the dry seasons, foraging is more thrifty, with attention paid to watering and toned vegetation. The fragmented forests have negative effects, such as limiting movement, augmentation of use of edges habitats and lowering the efficiency of foraging in relation to continuous forests. The findings from the correlation study reveal that habitat connectivity plays an exceptionally critical role in the movement and foraging activity of the deer population. This research shows that behavioral ecology should be considered in conservation initiatives. Habitat corridor protection, preservation of water and foraging areas, and restoration of fragmented habitat patches can enhance the ability of the population to withstand the effects of scarce resources and habitat fragmentation. Additionally, this research provides empirical evidence in the correlation between habitat structure and deer movements, and this information can inform wildlife management interventions that will foster viable population sizes. More research is required on the multiyear patterns of foraging in different seasons, the impact of climatic variations, and interspecies relationships in fragmented habitats. Integrating remote sensing technology and GPS tracking in larger geographical areas would improve the prediction of habitat use and the conservation measures that need to be put in place. In essence, incorporating habitat and seasonal foraging behavior is imperative in evidence-based deer population management.

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