



Original Research Paper

Seasonal Resource Variability and Habitat Fragmentation Influencing Adaptive Foraging Strategies and Social Behaviour of Ungulates

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Key Words

Ungulates;
Seasonal resource
variability;
Habitat
fragmentation;
Adaptive
foraging; Social
behavior; Habitat
connectivity;
Wildlife
conservation.

Abstract

This research paper will assess the effects of seasonality and resource variability on the foraging behaviors and sociality of ungulates. Ungulates require resources such as food, water, shelters, and corridors; however, the transition from wet to dry seasons causes changes in foraging, water, feeding time, and the movement distance. It is found that during the wet season, there is greater grazing behavior, large foraging group sizes, and low movement, while browsing, visiting water points, larger movement, and increased aggression occur in the dry season. Fragmentation of habitats due to agricultural expansion, roads, fences, human settlement, and infrastructural developments makes it difficult for ungulates to find foraging and watering grounds. This places an additional ecological stress on the animals, who are forced to utilize fragmented habitats and other alternate feeding areas. This paper also mentions some examples of adaptive behavior, such as switching to a different diet, changing habitats, adjusting to different times of feeding, dividing into small groups, and choosing specific corridors. All of these adaptations will help with survival, but could increase energy consumption, stress, chances of conflict, and difficulties in reproduction. The paper further suggests that the conservation strategy should involve protecting the seasonal grazing grounds, access to water, migration paths, and ecological corridors. The long-term monitoring can be done using field surveys, GPS telemetry, and cameras, and vegetation assessment is recommended for better ungulate habitat management.

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Received: 07 January 2026; Reviewed: 10 February 2026; Revised: 28 February 2026; Accepted: 29 April 2026

(DOI): [10.70102/AEJ.2026.18.1.44](https://doi.org/10.70102/AEJ.2026.18.1.44)

Introduction

The ungulates, including deer, antelope, wild cattle, goats, sheep, and many others, rely on food, water, shelter, and safe migration paths that are available seasonally (Almudhafar et al., 2024). In natural ecosystems, there is a variation in the resources during dry and wet periods. When there are abundant resources in the environment, ungulates benefit from good foraging conditions and efficient utilization of energy while maintaining stable herds (Berry et al., 2025). In contrast, when there are lean seasons with scarce resources, poor grazing conditions, and a lack of water, ungulates are forced to migrate longer distances for adequate habitats.

The research problem of this study is that resource shortages and fragmentation of habitats have an ecological impact on the ungulates (Patil, 2018). Agricultural development, road networks, settlements, fences, mining activities, and many more have contributed to fragmentation and broken down the continuous habitats into smaller fragments. Habitat fragmentation leads to reduced mobility, decreased availability of feeding areas and water, increased chances of predation attacks, increased competition, and disturbances from humans. Therefore, ungulates might have dietary changes, increased browsing habits, altered behavior, ranging activities, disbandment of social groups, and utilization of edges of fragmented habitats (Owen-Smith, 2008).

This research is significant owing to the importance of ungulates in performing ecological

functions such as grazing, browsing, seed dispersal, and predation (Khyade et al., 2018; Marino & Baldi, 2014). Any variation in their foraging behavior, movement, or social life may affect their population, reproductive processes, offspring survival, and ecosystem balance. In light of this, this paper attempts to explore the effect of seasonal variability of resources and habitat fragmentation on the foraging strategy and social behavior of ungulates (Bhattacharjee et al., 2026; Ramya & Geetha, 2025). This paper will address issues pertaining to food choices, movements, grouping, and other survival-based behaviors that may be of value in planning corridors, habitat restoration, and water management (Stone et al., 2017).

Key Contribution

1. The paper explains how wet and dry seasonal changes affect ungulate feeding patterns, movement distance, water use, and group behavior.
2. It highlights how habitat fragmentation restricts movement, increases competition, and forces ungulates to use disturbed or marginal habitats.
3. It identifies key adaptive strategies such as diet switching, browsing, altered feeding time, group splitting, and corridor use for survival.

The paper is divided into five parts. Part I begins with an introduction to the seasonality of resources, habitat fragmentation, and the objective of the paper. Part II deals with the seasonality of resources. Part III highlights the effects of habitat fragmentation. Part IV covers

adaptive responses and social organization. Lastly, Part V focuses on recommendations for conservation.

Seasonal Resource Variability

Seasonal Changes in Resource Availability

Food availability varies with seasons, influencing both the amount and quality of food available for ungulates (Seri et al., 2018). With the onset of wet seasons, there is abundant vegetation, improved protein content in grass, and an abundance of water sources. Ungulates can thus afford to spend more time grazing within the grassland habitats without making long travels. During the dry season, however, the biomass of grass is low, water sources are few, and grasses are fibrous and hence poor in nutritional value. This compels ungulates to adopt new strategies of accessing other sources of food. Some ungulates may move from grazing to browsing during the dry periods. Deer and antelopes may opt to feed on shrubs, tree leaves, dry pods, and roots of plants during periods of no grass. While larger ungulates will travel further in search of water sources, smaller ones will resort to using shadowed areas and dense vegetation to reduce energy loss and heat stress.

Adaptation of Different Ungulate Species

However, different ungulate species have various reactions to the changing seasons. Since grazers feed largely on grass, become very sensitive when the grassland becomes dry. Browsers are adaptable since feed on leaves, branches, fruits, and shrubs. The mixed feeders demonstrate the greatest adaptability since can

alternate grazing and browsing based on seasonality. This means that deer species may tend to browse more when the seasons become dry; wild cattle may migrate to grasslands by rivers. In addition, antelopes may decrease their daytime activities and feed in the mornings and evenings to escape the scorching sun rays, while mountain ungulates tend to migrate along vertical gradients to get fresh vegetation. These examples show that behavioral flexibility is essential for survival under seasonal resource stress (Couriot et al., 2018).

Impact on Foraging Behavior

Seasonal resource availability affects feeding group size, travel distance, feeding habits, and choice of habitats (Boone, 2019). In seasons when resources are plentiful, ungulates may form larger feeding groups as there is enough food supply without much competition. During drought seasons, competition increases around water sources and surviving vegetation patches. This results in increased aggression, decreased feeding group sizes, increased mobility, and selective feeding. Selective feeding involves picking vegetation with more nutritional content while avoiding patches with less vegetation content. In instances where resources are scarce, ungulates will eat lower-quality feed to fulfill basic energy requirements. Such changes can affect body condition, reproductive success, juvenile survival, and long-term population stability.

This is evident from Table 1 below, which depicts seasonal variations in resources and how it affect ungulate grazing behaviors and group organization. In the wet season, increased

vegetation availability encourages increased grazing duration, lower movement distances, and bigger foraging groups. In the dry season, limited availability of food and water favors browsing, increased movement distances, more visits to

water sources, and aggressive behavior. This supports the paper's argument that ungulates adjust feeding and social behaviour according to seasonal resource conditions.

Table 1: Seasonal Variation in Foraging Behavior and Social Response of Ungulates

Behavioural Parameter	Wet Season	Dry Season	Ecological Interpretation
Average grazing time	5.8 hours/day	3.4 hours/day	Grass availability declines during dry periods, reducing grazing time.
Average browsing time	1.6 hours/day	4.2 hours/day	Ungulates depend more on shrubs, leaves, and dry plant parts during resource scarcity.
Movement distance	3.2 km/day	6.5 km/day	Longer movement is required to locate food and water sources.
Feeding group size	18 individuals	9 individuals	Smaller groups reduce competition when resources are limited.
Water-point visits	2 visits/day	5 visits/day	Dry-season water scarcity increases dependence on permanent water sources.
Aggressive interactions	Low	High	Competition increases around limited forage and water patches.

Habitat Fragmentation

Meaning and Causes of Habitat Fragmentation

Habitat fragmentation means the division of continuous wild habitats into small and disconnected patches. The main causes of habitat fragmentation include agricultural development, road construction, urbanization, fencing, deforestation, industry, and infrastructure construction. Fragmentation of the landscape affects the natural migration process of ungulates and separates their feeding areas, breeding areas, resting areas, and watering areas. Habitat fragmentation also leads to edge habitats, whereby there are high chances of ungulates being disturbed, involved in traffic accidents,

competition from cattle, and predation by other species. In most cases, ungulates need to cross agricultural fields, roads, and towns to access feeding areas. This increases stress and reduces safe access to resources.

Effects on Ungulate Populations

Fragmentation of habitat can have negative effects on the size of the population, gene flow, and survival rate of the species. Isolation of the population in small fragments will lead to food scarcity, risk of inbreeding, and competition. Habitat fragmentation may lack space for movement of the species, particularly those that require extensive areas for ranging, such as the ungulates. Fragmentation can also have an effect on reproductive behaviour of the species (Becker et al., 2021). Scarcity of resources and inability

to move may result in poor body condition, reducing reproduction potential. The juvenile population is at greater risk because fragmentation exposes them to predators and limits their hiding spaces. Over time, these pressures can reduce population stability.

Link Between Fragmentation and Foraging Strategies

The impact of habitat fragmentation on foraging behavior occurs by restricting their ability to reach optimal food sources. Ungulates might be obliged to use poor-quality patches for feeding or even agricultural lands. Become more nocturnal in order to escape people, or modify migration routes according to current conditions. Ungulates living in fragmented habitats have to spend additional effort in order to travel from one patch to another. As a result, less time will be left for eating and resting. The size of ungulate groups will vary under different fragmentation conditions. Large groups can be safer in open fragmented zones, whereas small ones would be better for dense or disturbed patches may reduce detection by humans and predators.

Adaptive Foraging Strategies

Types of Adaptive Foraging Strategies

Adaptive foraging techniques are behavioral adaptations that aid in the survival of animals as environmental conditions change. Adaptive foraging techniques include diet switch, seasonal

migration, habitat shift, selective foraging, feeding time alteration, increased activity, and coordination at the population level. Enable animals to manage the energy supply, water supply, predator threats, and disturbances. Diet switching happens when there is a lack of availability of their favorite foods. Grass eaters will incorporate shrubs and leaves into their diet, and browsers will incorporate fruits, bark, and crop plants. Habitat shifting involves the movement of animals from dry grassland to areas such as swamps, riverside, small woods, or shaded zones.

Foraging Responses to Seasonal Resource Variability

For periods when conditions are favorable, ungulates tend to display consistent feeding behaviors, less movement, and enhanced body conditions. On the other hand, for dry or unfavorable seasons, ungulates intensify their search efforts and utilize a larger variety of plants. Some ungulate species migrate to perennial water sources, whereas others feed on plants containing moisture. Seasonal scarcity can also impact the social behavior of ungulates. For example, large ungulate herds can fragment into small sub-units to minimize food and water competition. The dominant ungulates could have greater access to food and water compared to the weaker ones. These social differences can influence survival and reproductive outcomes.

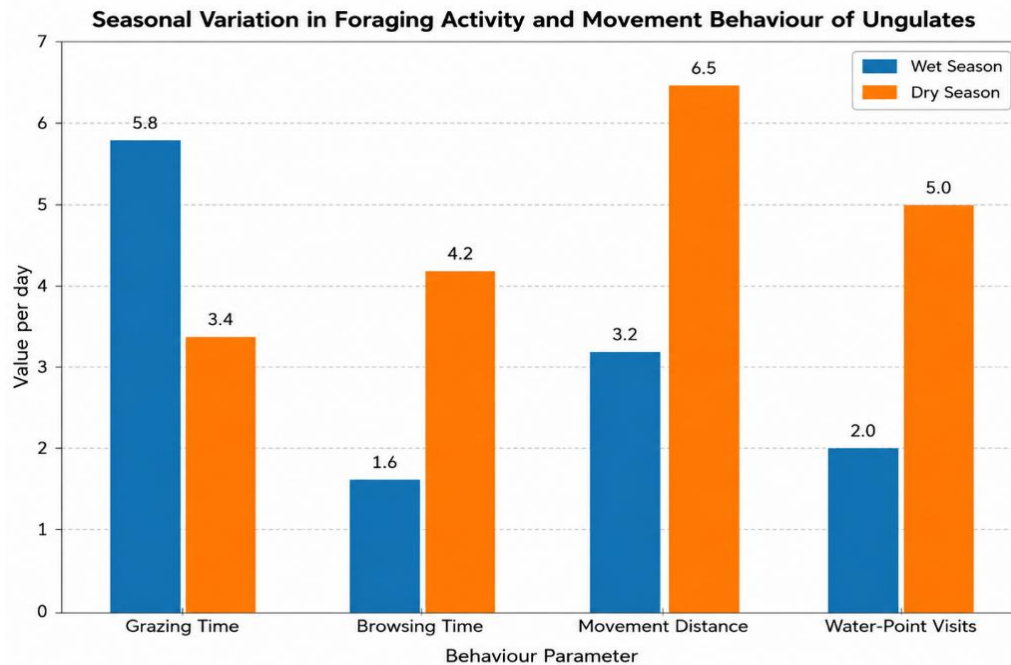


Figure 1: Seasonal Variation in Foraging Activity and Movement Behaviour of Ungulates

Figure 1 depicts the difference in behavior changes of the ungulates between the wet and dry seasons. From the graph, it can be noted that the time spent grazing is high during the wet season, whereas browsing time, distance covered, and frequency of visits to the water point are high during the dry season. This pattern indicates that ungulates shift from easy grazing to more flexible and energy-demanding foraging strategies when seasonal resources become limited.

Influence of Habitat Fragmentation on Adaptive Behaviour

The complexity in adaptive foraging due to fragmented habitats is that animals are not free to move and utilize all the resources available in other patches. Road barriers, fencing, human settlements, or human intervention in general can obstruct movement even when resources are available. Consequently, ungulates have to adapt their foraging behavior as well as movement behavior. Ungulates adapt by using crop fields,

borders of plantations, and secondary vegetation as an alternative to their foraging grounds. But this leads to human-animal conflicts as well. Another method of adaptation is to use narrow corridors and edges of forests, as well as water courses, to travel from one patch to another. In highly fragmented landscapes, behavioural flexibility becomes a key survival mechanism, but long-term survival still depends on habitat connectivity and resource protection.

Changes in Social Behaviour

Seasonal scarcity and fragmentation have effects on social behavior. The number of individuals within a group, group hierarchy, dominance, mating strategies, and parental care depend on resource availability. Large groups might be formed when food is plentiful, while smaller groups are favored when food sources become sparse. Fragmentation causes increased stress levels and aggression since there is not enough space for all individuals to roam around

freely. It also interferes with usual migration paths and causes limited interaction between subpopulations. Thus, social behavior is associated with environmental quality and the availability of natural resources.

Conclusion

Seasonal resource variations and habitat fragmentation have an impact on the behavior and foraging methods of ungulates. Seasonal factors such as food quantity, water availability, movement distances, and habitat choice play a role. While in seasons of abundant resources, the ungulates are able to continue with the same feeding methods as well as the social groups. In drought seasons or seasons of scarce resources, there is diet variation, increased movements, variation in feeding times, and habitat choices. Ungulates adapt to changing environmental conditions using these various survival techniques. Additionally, habitat fragmentation adds to the challenges faced by these animals in the way they move around, feed, and hydrate themselves. Ungulates have no option but to use fragmented landscapes, disturbed edges, agricultural lands, and restricted passages. The effects include increased stress levels, competition, wildlife-human conflict, increased energy use, and social behavior changes.

The results of this study point out that the conservation of ungulates involves not just protection during seasonally stressed conditions but also habitat connectivity. Habitat protection for ungulates includes their grazing areas, water, migration trails, forest edges, and ecological corridors for their sustenance. The conservation strategies for these animals should take into

account their seasonal movements rather than just protecting them through habitat fragments. Further studies should be conducted on how species react to fragmented habitats through various seasons. This may include the use of field observation, GPS tracking, camera trap data, and vegetation surveys. Climate change, land-use change, domestication of livestock, and other disturbances should also be studied as it affects the behavior of ungulates.

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