



## **Comparative Behavioural, Morphological and Ecological Study of Leopards in the regions of Ranthambore National Park and Jhalana Reserve Forest**

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### **ABSTRACT**

Conservation of wildlife is essential to maintain the delicate ecological balance, without which both wildlife and humanity is at risk. Leopards are classified as Vulnerable on the IUCN Red List. India is home to more than 12,000 leopards with Madhya Pradesh having the highest population. The population of leopards in India is threatened by extensive poaching practices, habitat loss etc. Moreover, trained human resources, basic facilities and effective networks for control of poaching and trade in wildlife are lacking in India. In order to bolster our conservation efforts, it is essential that we gain a deeper understanding of animal behaviour. We aim to compare the leopards of Jhalana Reserve Forest, which is located in Jaipur, Rajasthan and has an area of 29 sq km, to leopards of and Ranthambore National Park, which is located in Ranthambore, Rajasthan and has an area of 1334 sq km. We aim to study the following four factors – population density, size, spatial distribution, diet and geo-spatial mapping. Population data can be calculated using camera-traps, using thermal remote sensors or M- stripe collars that give real-time data stored at monitoring stations. The estimation of difference in population density of leopards can aid in leopard conservation projects, and provide the opportunity to study behavioural change and adaptation abilities of leopards. To estimate the body size of leopards, we can use photographs and videos of leopards. The estimation of difference in the body size of leopards can aid conservation methods like translocation and reintroduction of animal species. Spatial distribution basically helps identify the geolocation and spatial coordinates or clusters where the concentration of leopards are residing in different regions of a forest. We can calculate the population density of specific regions of the forest to map out the spatial distribution and translocation simultaneously. We can also identify crucial areas which have the potential of being hotspots for human-animal conflict. Analysis of leopard faeces/scats can enable us to learn about the diet of a leopard. The estimation of the difference in diet of leopards from the two parks can enable us to calculate the nutritional differences of leopards of both reserves. The main objective of this project is to study the difference in behavioural, morphological and ecological features of leopards. Additionally, we have focused on methods that cause the least disturbance to animals, keeping up with government regulations and ethical considerations. Moreover, our methodology is economical and suitable with the current infrastructure in place. This study will not only give us greater insight into animal behaviour but

also aid greatly in conservation efforts. This research is not singular to leopards and can easily be applied to other species such as tigers

### **Keywords**

Jhalana, Ranthambore, Leopard, Conservation

## **INTRODUCTION**

India is recognized as one of the 12 countries in the world with exceptional biodiversity. Over the years, India has demonstrated a commitment to conservation and the sustainable use of its natural resources. A significant milestone in India's wildlife conservation journey occurred in 1972, following the Stockholm Conference on Human Environment. It was during this time that the Indian government passed the "Wildlife (Protection) Act," which granted legal protection to wildlife.

This extensive network of protected areas reflects India's commitment to safeguarding its diverse ecosystems and ensuring the continued existence of its rich biodiversity. Through these conservation measures, India aims to strike a balance between the preservation of its natural resources and the sustainable use of these resources for the benefit of present and future generations.

### *Leopards-*

The leopard, a solitary and elusive big cat species, holds the distinction of being the most widely distributed felid, spanning Africa and Asia from the Middle East to the Pacific Ocean. Leopards exhibit adaptability to various habitats, including tropical forests, grasslands, deserts, and alpine regions. Notably, they can even coexist near urban areas like Mumbai and Johannesburg (Odden et al., 2014; Kuhn, 2014), (Nowell & Jackson, 1996). Another remarkable aspect of leopards is their diverse diet.(Hayward et al., 2006) This flexibility allows them to survive in regions where other large cat species have faced extinction or isolation(Athreya et al., 2013; Athreya et al., 2014). However, despite their adaptability, leopards confront significant and ongoing threats to their existence.

Similar to other large carnivores, leopards are experiencing population declines across their range(Ripple et al., 2014). These threats include habitat loss, fragmentation, depletion of prey, human-wildlife conflicts, unsustainable trophy hunting, poaching for body parts, and indiscriminate killing. The International Union for the Conservation of Nature (IUCN) classifies leopards as Vulnerable and recognizes nine subspecies (Stein et al., in press).

The Indian Leopard (*Panthera pardus fusca*) population faces an escalating threat from poaching for illegal wildlife trade (Datta et al., 2008). A study by Raza et al. (2012b) estimated that approximately four Leopards per week were poached for the illicit wildlife trade over the previous decade. In addition to poaching, certain regions report high levels of human-wildlife conflict, leading to the lethal control of Leopards considered problematic (Athreya et al., 2013). The decline in available wild prey species further exacerbates the situation, negatively impacting Leopard numbers in specific areas (Datta et al., 2008; Selvan et al., 2014). Consequently, the future of Leopard populations appears to be at risk of decline.

Interestingly, even in well-protected areas, the recovery of Tiger populations often results in a decrease in Leopard numbers (Harihar et al., 2011; Mondal et al., 2012). This is because Tigers have been observed to kill and displace Leopards, leading to their diminished presence (McDougal, 1988; Odden et al., 2010). In 2014, a significant milestone was achieved with the first-ever scientific national census of Leopards conducted in India, excluding the northeast region. The census estimated a population of 7,910 Leopards in Tiger habitats, with a speculated national total of 12,000-14,000 individuals (Bhattacharya, 2015). This survey provides valuable insights into the Leopard population in India, highlighting the urgent need for conservation efforts to mitigate the threats they face.

#### *Ranthambore National Park-*

Situated between the Banaras River in the north and the Chambal River in the south, Ranthambore National Parks a renowned tiger reserve characterised by dry deciduous forests, grasslands, and numerous water bodies. It is located at the junction of the Vindhya and Aravalli mountain ranges, spanning from 25° 30' to 26° 21' N and 75° 51' to 77° 12' E. This park experiences a dry, semi-arid climate and is prone to drought. The annual rainfall, averaging 800 mm, primarily occurs between July and September. The weather varies significantly throughout the year, with January recording minimum temperatures of 2°C and May reaching maximum temperatures of 47°C during peak summer. . Its rugged topography and diverse vegetation provide a rich habitat for a variety of wildlife, including leopards.(Singh et all, 2007)

The Ranthambhore Tiger habitat plays a crucial role in supporting not only tigers and their prey but also a wide range of biodiversity. Additionally, these habitats provide valuable ecosystem services that contribute to the well-being of both local communities and the global environment. These services include water harvesting, carbon sequestration, the preservation of plant genetic materials, food security, access to medicinal plants, and opportunities for community-based tourism. These benefits directly and indirectly enhance human well-being and contribute to the sustainable future of our planet.

With a population of over 60 tigers, the study area in Ranthambore supports the livelihoods of more than 1.5 million people who directly or indirectly rely on the ecosystem services provided by this tiger habitat. The ecosystem services derived from the tigers and their habitat serve as

vital sources of income and livelihood for the local communities. They create opportunities for sustainable livelihoods that are intertwined with the functioning of the tiger ecosystem services in Ranthambore.

#### *Jhalana Reserve Forest-*

Jhalana Reserve Forest, covering 29 square kilometres, consists mainly of scrubland and dry deciduous forests. Despite its smaller size, Jhalana is a critical habitat for leopards in an urban setting, as it is located on the outskirts of the city of Jaipur.

By conducting this comprehensive comparative study, we aim to contribute to the understanding of leopard populations in Ranthambore National Park and Jhalana Reserve Forest. The insights gained from this research can inform evidence-based conservation strategies tailored to the specific needs of leopards in these habitats. Through the effective management of these iconic big cats, we can ensure their continued existence and foster harmonious coexistence between humans and wildlife in these ecologically significant regions.

### **Parameters**

#### *1. Population density -*

Population is a crucial parameter that must be taken into account because it is inversely related to the species' average territory. When the population density of a species is high, the territory is compressed, which also increases competition for food and mates (Visser et al, 2003). Leopards are territorial, and females are more tolerant of other female leopards than male leopards are. When comparing leopards, population density must be taken into account because it correlates with territorial sizes and reveals information about an organism's adaptations. Larger territories are associated with lower population densities, and smaller average territories are associated with higher densities. This affects behaviour because animals travel less when they are constrained to limited areas, which also implies that resources are abundantly available. Due to the need for frequent visits to the acquired territory, the organism must constantly keep their cognition updated by their territory's map (Nams et al, 2023). The total number of leopards in the limited reserves was divided by the total amount of restricted areas in order to determine the population density of the leopards in Jhalana Reserve Forest and Ranthambore National Park.

$$\text{Population density} = \frac{\text{Total number of leopards recorded inside the restricted area}}{\text{Total restricted area of the reserve}}$$

Although Jhalana Leopard Reserve only contains 25 distinct leopards, Ranthambore National Park has recorded the activity of 105 leopards in its reserve area. Nevertheless, Jhalana is only 29 square km and Ranthambore is 1394.5 square km. This demonstrates that despite the fact that Ranthambore contains substantially more leopards, its leopard density is predicted to be lower due to the significant size disparity between the two reserves (Singh, Sen , 2022). As

different territories suggest different levels of resource abundance, overlapping territories, the likelihood of interactions with other leopards, differences in the cognitive map, and the availability of food, differences in population density will show disparities in the behaviours of the leopards.

Leopard densities in Ranthambore National Park and Jhalana Leopard Reserve are respectively  $7.5 \times 10^{-2}$  leopards/ $km^2$  and  $8.6 \times 10^{-1}$  leopards/ $km^2$ . There is a noticeable distinction  $7.9 \times 10^{-1}$  leopards/ $km^2$  indicates that the leopards of Ranthambore cover a much larger territory than the leopards of jhalana, as there is an availability of 13.28 square kilometre of area for each leopard, whereas the leopards of jhalana are crowded and fit in as only 1.16 square kilometre of area is available for each leopard if the territories get distributed uniformly. This leads to significant disparities in the cognition and behaviours of the leopards as different territories suggest different levels of resource abundance, overlapping territories, the likelihood of interactions with other leopards, difference in cognitive map and the availability of food.

## **2. Density-**

Diet is an important factor that has to be investigated as future initiatives like interstate translocation would need to take into account the availability and preferred prey of the leopards in the separate parks. It is expected that the diets of leopards in the Jhalana Leopard Reserve and the Ranthambore National Park will differ because of the differences in geography and prey availability between the two locations. While Ranthambore is in a rural area of Sawai Madhopur and provides the leopards with plenty of wild prey as well as domestic preys on the buffer regions of the reserve where there is an abundance of livestock due to agricultural practices (Karanth et al, 2013), Jhalana is located in the urban centre of the city of Jaipur and provides easy access to domestic prey like dogs, pigs, livestock, etc (Kumbhojkar et al, 2020). Similarly, as Jhalana is only a 29 square kilometre forest, most of its leopards can interact with domestic animals, and all of the leopards in Jhalana are expected to have a similar diet with little variation. Ranthambore is a 1394.5 square kilometre forest, which illustrates the likelihood of a significant variation in the availability of prey to leopards as those living in the core of the forest have access to a lot of wild animals in contrast to those living in the park's buffer zone and borders. We conducted a literature study that included several studies to determine the difference in the diet of leopards of both the reserves. We evaluated the differences in tiger and leopard food preferences to generate an idea of the leopard diet based on a study on the faecal samples of tigers in Ranthambore because there hasn't been sufficient study on leopards in that area. In order to assess the diet of leopards, we also obtained data from a research on leopard faeces in Jhalana, which determined the diet of leopards.

Due to the widespread accessibility of domestic prey, leopards in Jhalana primarily prey on domesticated animals. Given that the reserve's surroundings are urbanised and have been occupied by considerable human populations, domestic animals are easily accessible to these

leopards. Cattle (*Bos taurus*), goats (*Capra aegagrus hircus*), cats (*Felis catus*), and dogs (*Canis lupus familiaris*) are the main prey species for leopards in Jhalana, with feral dogs accounting for 44% of their diet. With wild animals making up only 10.5% of the diet, domesticated animals made up about 89.5% of it (Kumbhojkar et al, 2020). This data not only demonstrates the scarcity of prey in Jhalana, but it also suggests a potential explanation for the region's high population density, as leopards in Jhalana eat primarily at the reserve's edges, eliminating the need to traverse extensive areas in search of food and other resources. In the areas close to the Jhalana reserve forest, this has increased the likelihood of human-animal conflict, which has an influence on a leopard's cognition as it forces it to adapt to the urbanised surroundings. Sambar (*Rusa unicolor*) and chital (*Axis axis*) were the primary prey of tigers in the Ranthambore national park, with an frequency of occurrences of 47.6 and 30.9% in tiger scats, respectively (De et al, 2018). Similar studies conducted in other forested locations have revealed that tigers and leopards have similar diets, however they prefer different sizes of prey. Studies have shown that leopards prefer prey which weigh in the range of 10-40kg and avoid any prey larger than that (Hayward et al, 2006). With the abundance of chital (*Axis axis*) in the restricted reserve, we can predict that the leopards' main diet in the core area of the park is focused on chital as it falls within the preferred weight range. Although experimental information on the diets of the leopards in Ranthambore is not yet available, deer made up 78.5 percent of the tiger's prey, which is a sign of an ample availability of food in the park. This demonstrates that the park's leopards have access to sufficient wild prey.

### **3. Climatic Conditions and Diversity of Tree Species**

Considering climatic conditions before translocating a species is vital to ensure its survival and ecological balance. Incompatible climates can hinder acclimatisation to a new environment. Assessing temperature, precipitation, and habitat suitability helps minimise risks and aids in establishing a sustainable and thriving population. Similarly, the vegetation in these areas is essential to maintain the diverse wildlife species that are present. The vegetation serves as the main source of food for herbivores, which in turn supports populations of carnivores like tigers and leopards. These ecosystems' overall ecological balance is improved by the presence of this type of vegetation, which also encourages habitat diversity and fills niches for a variety of animal species. Therefore, flora diversity is an important aspect to be taken into consideration.

Jhalana forest area experiences a semi-arid climate characteristic of Rajasthan. The region endures hot and dry summers with temperatures frequently surpassing 40°C. Winters are relatively mild, with nighttime temperatures dropping to around 5°C. The annual rainfall in Jhalana is relatively low, with the majority of precipitation occurring during the monsoon season, typically from July to September. This semi-arid climate significantly influences the vegetation of Jhalana. The diversity of tree species in Jhalana is limited due to the arid climatic conditions. The vegetation predominantly comprises hardy and drought-resistant species, such as Acacia, Prosopis, Neem, and Babool. The sparse tree cover and prevalence of thorny bushes are characteristic of desert ecosystems found in arid regions.

- (1. Rajasthan Forest Department. (n.d.). Jhalana Panther Safari. Retrieved from <https://www.rajasthanwildlife.rajasthan.gov.in/jhalana-panther-conservation-reserve-jaipur>
2. Pandey, M., & Dharaiya, N. (2019). Leopard Monitoring Manual: Jhalana Leopard Conservation Reserve, Jaipur. Wildlife Institute of India.)

In contrast, Ranthambore National Park, situated in southeastern Rajasthan, experiences a more diverse climate compared to Jhalana. The summers in Ranthambore can be intensely hot, with temperatures soaring over 45°C, while winters are cooler, with nighttime temperatures dropping to approximately 2°C. The region receives a moderate amount of rainfall during the monsoon season, contributing to a richer ecosystem. The climate in Ranthambore supports a higher diversity of tree species compared to Jhalana. The park falls under the tropical dry deciduous forest biome and hosts various tree species such as Dhok (*Anogeissus pendula*), Banyan (*Ficus benghalensis*), Tendu (*Diospyros melanoxylon*), and Sal (*Shorea robusta*). These forests provide a more suitable habitat for numerous wildlife species.

- (1. Ranthambore Tiger Reserve. (n.d.). Official Website. Retrieved from <https://rtr.rajasthan.gov.in/>
2. Dharmendra, K., & Sharma, K. K. (2013). Floristic Diversity in Ranthambore Tiger Reserve: A North Indian Dry Deciduous Forest. *International Journal of Biodiversity*, 2013, 1-13. doi:10.1155/2013/509198 )

Despite having different climates, Ranthambore and Jhalana both have weather patterns that are typical of the Indian subcontinent. Hot, dry summers with high temperatures are common in these areas. It is more common to see animals around water sources and in shady locations throughout the summer because the hot temperature makes it difficult for wildlife to survive. Animals also become more concentrated around water sources during the dry season, which is crucial for their survival. Both Jhalana and Ranthambore receive rainfall throughout the monsoon season, which revitalises the environment and restocks water sources. The monsoons provide respite from the oppressive heat, and the revitalised vegetation benefits the environment as a whole. Animals' behaviour is influenced by seasonal changes as they adjust to variations in food and water availability. The thorny plants and bushes found in these areas are typical of desert and dry deciduous habitats. Both regions are home to several species, including Acacia, Prosopis, and Babool, which provide a vital source of food and shelter for numerous wildlife species. Although they have certain similar plant species that are adapted to the semi-arid environment in common, Jhalana and Ranthambore have a number of different tree species which can pose a challenge in translocation. However, this data is not focused on buffer regions of Ranthambore which are expected to host a limited number of tree species. Understanding these climatic, meteorological, and vegetational parallels offers important insights into the shared biological dynamics of Ranthambore and Jhalana. Both regions offer unique prospects for animal conservation and research despite having different environmental characteristics, making them important sites for researching before any conservation activities.

## CONCLUSION

The population density of leopards in an area is inversely proportional to their territory size. On the other hand, lower population densities allow leopards to have larger territories with abundant resources and less competition. When comparing two reserves, Jhalana Leopard Reserve and Ranthambore National Park, we find significant differences in leopard behaviour due to variations in population density and territory sizes. Despite Ranthambore National Park having a higher number of leopards, its larger area leads to lower population density compared to Jhalana Leopard Reserve. Consequently, leopards in Ranthambore have larger territories, while those in Jhalana are crowded into smaller areas. This difference in territory size results in distinct cognitive maps, resource availability, and likelihood of interactions with other leopards, all of which can significantly impact their behaviours. For translocation projects, understanding these differences is crucial. When moving leopards from high-density areas to larger reserves, they may have difficulty adapting to the vast territories and locating resources. Conversely, translocating leopards from low-density areas to smaller reserves may increase competition and territorial conflicts. Therefore, it is essential to consider population density, territory sizes, and their corresponding effects on leopard behaviour before undertaking any translocation projects. By carefully assessing these factors, conservationists can make informed decisions to ensure successful and sustainable outcomes for both the leopards and their ecosystems.

The primary factor influencing the leopard's behaviour is their diet, which is shaped by the availability of prey in their respective habitats. The difference in prey availability between the two locations can pose challenges to translocation projects. In Jhalana, leopards heavily rely on domestic animals due to urban surroundings, leading to human-animal conflicts. In Ranthambore, they have access to wild prey like sambar and chital, which reduces dependence on domestic animals. Diet variations within Ranthambore due to its large size can impact leopard behaviour in different areas of the reserve. When moving leopards from an area with abundant wild prey to one with limited options, they may face difficulties in adapting to a new diet, potentially leading to conflict with humans as they resort to preying on domestic animals. Conversely, leopards translocated from areas with high reliance on domestic animals may struggle to compete with resident predators in locations where wild prey is more abundant. To ensure the success of translocation projects, it is crucial to carefully consider the dietary preferences and availability of prey in both the source and target habitats. Conducting thorough research and assessing the potential impact on leopard behaviour are vital steps in planning and executing such initiatives.

The influence on behaviour by climatic and vegetational conditions can have significant implications for translocation projects. The semi-arid climate of Jhalana limits the diversity of



tree species and vegetation available, affecting the habitat and food sources for leopards and other wildlife. On the other hand, Ranthambore's more diverse climate supports a richer ecosystem with a higher variety of tree species, providing a more suitable habitat for wildlife. Both regions experience hot and dry summers, leading to increased animal activity around water sources and shady areas. The monsoon season plays a critical role in revitalising the environment and replenishing water sources, influencing animal behaviour as they adapt to changes in food and water availability. When considering translocation projects, it is crucial to assess these climate and vegetation differences between the source and destination areas. Incompatible climates can hinder successful acclimatisation, posing risks to the survival of translocated leopards and disrupting ecological balance in the target region. Proper research and understanding of these parallels and disparities can help conservationists make informed decisions and ensure the success of translocation projects. Ultimately, considering the climatic and vegetational factors before undertaking translocation efforts is vital to protect leopards and maintain ecological harmony in both the source and destination habitats. By taking into account these aspects, conservationists can maximise the chances of creating sustainable and thriving leopard populations, contributing to broader biodiversity conservation efforts

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