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# Mining-Induced Habitat Fragmentation and Wildlife Conservation: A Comprehensive Zoological Review

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**ABSTRACT**

Mining-induced habitat fragmentation has become a major threat to wildlife conservation in Jharkhand, where extensive mineral extraction overlaps with biologically diverse tropical deciduous forests. This review examines the effects of mining on animal diversity, habitat connectivity, wildlife population structure, behavioural ecology, and physiological health. The reviewed studies indicate that mining activities cause habitat loss, fragmentation, and environmental degradation, leading to reduced species richness, restricted wildlife movement, disrupted gene flow, and increased human–wildlife conflict. Habitat-specialist species are particularly vulnerable due to declining habitat quality and ecological connectivity. The review also highlights the importance of non-invasive wildlife health assessment techniques, including body condition evaluation, fecal glucocorticoid analysis, and parasitological examination, for monitoring physiological stress in free-ranging wildlife. Furthermore, it identifies research gaps in integrated zoological studies and emphasizes habitat restoration, ecological corridor development, long-term wildlife monitoring, and biodiversity-sensitive mining practices as essential strategies for achieving sustainable wildlife conservation in Jharkhand.

***Keywords:*** *Animal Diversity, Species Conservation, Mining, Habitat Fragmentation, Wildlife Ecology, Jharkhand.*

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## 1. Introduction

Habitat fragmentation has become one of the most significant threats to global biodiversity, particularly in regions undergoing rapid industrialization and natural resource extraction. Among the various anthropogenic activities, mining has emerged as a major driver of habitat loss, ecological degradation, and wildlife population decline. Large-scale mining operations involve extensive deforestation, land excavation, road construction, waste disposal, and infrastructure development, all of which disrupt natural ecosystems and alter ecological processes. These disturbances reduce habitat continuity, isolate wildlife populations, and compromise ecosystem stability, thereby posing serious challenges to biodiversity conservation (Nakade & Dhadse, 2024; Singh et al., 2016).

Jharkhand, one of India's most mineral-rich states, represents a unique landscape where extensive deposits of coal, iron ore, bauxite, mica, and uranium coexist with biologically diverse tropical deciduous forests. These forests support a wide range of vertebrate fauna, including mammals, birds, reptiles, and amphibians, many of which are ecologically important for maintaining ecosystem functioning. However, the rapid expansion of mining activities across districts such as Dhanbad, Bokaro, Ramgarh, West Singhbhum, and Latehar has resulted in substantial habitat fragmentation and degradation. Continuous forest tracts have been converted into isolated habitat patches, reducing ecological connectivity and limiting wildlife movement, dispersal, breeding, and gene flow (Bhattacharya et al., 2021; Gayathri & Vijayalakshmi, 2023).

Habitat fragmentation also influences wildlife behaviour and physiological health. The construction of open-pit mines, haul roads, railways, and associated infrastructure creates physical barriers that disrupt migration routes and increase the vulnerability of wildlife populations. Species forced to occupy smaller and degraded habitats often experience reduced food availability, elevated physiological stress, lower reproductive success, and increased susceptibility to disease. Furthermore, shrinking forest habitats frequently compel animals to move into nearby human settlements, resulting in greater incidences of human–wildlife conflict and increased mortality risks (Anand & Radhakrishna, 2024; Deb & Sarkar, 2017).

Despite growing recognition of these ecological impacts, most available studies have primarily examined vegetation loss, environmental pollution, or the socio-economic consequences of mining, while comparatively few have comprehensively evaluated its zoological implications. Information regarding wildlife population structure, behavioural adaptations, health indicators, and conservation responses in mining-dominated landscapes of Jharkhand remains limited. This review synthesizes the existing literature on mining-induced habitat fragmentation and its influence on animal diversity and species conservation in Jharkhand. It highlights current knowledge, identifies major research gaps, and discusses conservation strategies aimed at improving habitat connectivity, ecological restoration, and long-term wildlife sustainability in one of India's most ecologically and economically significant mining regions.

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## 2. Animal Diversity of Jharkhand

Jharkhand is recognized as one of India's ecologically significant states because of its extensive tropical deciduous forests, diverse topography, and rich faunal resources. Situated on the Chotanagpur Plateau, the state comprises dense **Sal (Shorea robusta)** forests, river valleys, grasslands, and rocky landscapes that provide habitats for a wide variety of wildlife. These ecosystems support numerous vertebrate groups, including mammals, birds, reptiles, and amphibians, each contributing to ecosystem stability through predator–prey interactions, nutrient cycling, seed dispersal, and maintenance of trophic dynamics. The coexistence of mineral-rich landscapes and biologically diverse forests makes Jharkhand an important region for zoological research and wildlife conservation (Nakade & Dhadse, 2024).

The mammalian fauna of Jharkhand includes large herbivores, carnivores, omnivores, and several small mammals that depend on continuous forest cover for feeding, breeding, and migration. Many of these species require extensive habitat connectivity to maintain viable populations and genetic exchange. Birds constitute another ecologically important faunal group, functioning as pollinators, seed dispersers, scavengers, and indicators of habitat quality. Reptiles and amphibians also contribute significantly to ecosystem functioning by regulating insect populations and maintaining food-web interactions. These vertebrate groups collectively reflect the ecological health of forest ecosystems and are widely used as bioindicators in wildlife conservation studies (Bhattacharya et al., 2021).

Despite its remarkable biodiversity, Jharkhand's wildlife is increasingly threatened by rapid mining expansion. Coal, iron ore, bauxite, and other mineral extraction activities have resulted in extensive deforestation, habitat degradation, and fragmentation of once-continuous forest landscapes. Mining infrastructure, including open pits, haul roads, railways, and waste disposal sites, interrupts natural wildlife corridors and restricts species movement, dispersal, and breeding. Habitat fragmentation particularly affects habitat-specialist and wide-ranging species, leading to declining population density, altered species composition, and increased ecological vulnerability (Gayathri & Vijayalakshmi, 2023).

Mining-related disturbances also influence wildlife behaviour and survival. Reduced habitat availability forces many species to occupy smaller forest patches or move closer to human settlements in search of food and shelter, thereby increasing the incidence of human–wildlife conflict. Continuous exposure to mining-associated disturbances such as noise, dust, vibration, and human activities further elevates physiological stress and may reduce reproductive success and long-term population viability (Anand & Radhakrishna, 2024; Deb & Sarkar, 2017). Consequently, conserving the animal diversity of Jharkhand requires integrated approaches that combine habitat restoration, ecological corridor protection, wildlife monitoring, and sustainable mining practices to ensure the long-term persistence of the state's unique vertebrate fauna.

## 3. Related Research

Existing literature consistently demonstrates that mining is one of the most significant anthropogenic drivers of biodiversity loss and wildlife habitat degradation. Nakade and Dhadse (2024) reported that mining activities have caused extensive habitat destruction, fragmentation, and environmental pollution, leading to substantial declines in species richness and abundance. Their study emphasized

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that specialist species, which possess narrow ecological requirements, are particularly vulnerable to habitat alteration. The authors further observed reductions in habitat heterogeneity and wildlife population density, highlighting the urgent need for biodiversity-sensitive mining practices and ecological restoration.

Anand and Radhakrishna (2024) examined the influence of mining on wildlife behaviour through a study of human–rhesus macaque interactions in a coal-mining region. Their findings revealed that habitat fragmentation reduced natural food availability and forced macaques to depend increasingly on anthropogenic food resources. Consequently, changes in foraging behaviour, movement ecology, and habitat utilization resulted in increased human–wildlife conflict. The study demonstrated that mining-induced landscape modification significantly alters wildlife behaviour and ecological adaptation.

Bhattacharya et al. (2021) investigated the ecological impacts of quarrying on riverine ecosystems and reported considerable degradation of aquatic habitats. Quarrying disrupted sediment dynamics, reduced habitat complexity, and caused significant declines in benthic macroinvertebrate diversity. These alterations impaired aquatic food webs and reduced trophic complexity, thereby threatening the ecological integrity of riverine wildlife communities.

From a wildlife conservation policy perspective, Deb and Sarkar (2017) highlighted that mining expansion in India has frequently prioritized economic development over biodiversity conservation. Their review identified weaknesses in ecosystem-based management, inadequate protection of faunal habitats, and ineffective ecological rehabilitation measures. The authors concluded that insufficient integration of conservation principles into mining policies has accelerated habitat degradation and biodiversity loss.

Similarly, Gayathri and Vijayalakshmi (2023) emphasized that mining-induced landscape fragmentation increases wildlife vulnerability by disrupting metapopulation dynamics and reducing habitat connectivity. Their study demonstrated that fragmented habitats intensify edge effects, restrict species movement, and increase ecological stress, ultimately reducing ecosystem resilience.

Singh et al. (2016) evaluated restoration measures implemented in mined landscapes and found that although revegetation improved soil quality, it failed to restore original faunal communities. The study reported incomplete wildlife recolonization, absence of keystone species, and slow ecological succession, indicating that vegetation recovery alone is insufficient to re-establish healthy wildlife populations.

Mishra (2015) examined the ecological consequences of coal mining and observed that forest degradation significantly altered wildlife habitats while intensifying human–wildlife interactions. Habitat loss reduced ecosystem services, increased competition for natural resources, and disrupted traditional coexistence between wildlife and rural communities. Likewise, Narasimham and Subbarao (2018) reported that mining displaced wildlife populations and weakened indigenous conservation practices in tribal regions. Their findings indicated increased faunal stress, declining ecological resilience, and the erosion of community-based conservation systems.

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Collectively, these studies demonstrate that mining affects wildlife through multiple ecological pathways, including habitat fragmentation, biodiversity decline, altered behavioural ecology, physiological stress, reduced habitat connectivity, and weakened conservation outcomes. The reviewed literature further indicates that integrated conservation strategies combining habitat restoration, ecological corridor protection, wildlife monitoring, and sustainable mining management are essential for preserving biodiversity and maintaining ecological stability in mining-dominated.

**4. Findings from Literature Study**

| Author(s) & Year | Study Focus | Major Findings | Research Implications |
|---|---|---|---|
| **Nakade & Dhadse (2024)** | Biodiversity conservation and mining impacts | Mining caused habitat destruction, fragmentation, pollution, and significant declines in species richness and abundance. Specialist species were the most affected. | Demonstrates that mining substantially reduces biodiversity and habitat quality, emphasizing the need for ecological restoration and biodiversity-sensitive mining practices. |
| **Anand & Radhakrishna (2024)** | Behavioural ecology and human–wildlife conflict | Habitat fragmentation forced rhesus macaques to rely on anthropogenic food resources, increasing human–wildlife conflicts and altering movement patterns. | Highlights the influence of mining on wildlife behaviour and the importance of maintaining habitat connectivity to reduce conflict. |
| **Bhattacharya et al. (2021)** | Riverine ecology and aquatic biodiversity | Quarrying disrupted sediment dynamics, reduced macroinvertebrate diversity, and impaired aquatic food webs. | Indicates that mining negatively affects aquatic ecosystems by decreasing habitat quality and trophic complexity. |
| **Deb & Sarkar (2017)** | Wildlife conservation policy | Mining development frequently prioritized economic benefits over wildlife conservation, resulting in weak habitat protection and inadequate ecological rehabilitation. | Suggests integrating biodiversity conservation into mining policies and environmental governance. |
| **Gayathri & Vijayalakshmi (2023)** | Landscape ecology and wildlife displacement | Fragmented landscapes reduced habitat connectivity, increased wildlife vulnerability, and intensified edge effects. | Supports the need for ecological corridors and landscape-level conservation planning. |

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| **Singh et al. (2016)** | Restoration ecology and wildlife management | Revegetation improved soil quality but failed to restore original faunal communities because of incomplete ecological succession. | Demonstrates that vegetation restoration alone is insufficient; wildlife-focused restoration strategies are essential. |
| **Mishra (2015)** | Human ecology and wildlife–livelihood interactions | Forest degradation altered wildlife habitats, increased human–wildlife conflict, and reduced ecosystem services. | Highlights the ecological and socio-economic consequences of mining, emphasizing integrated conservation and livelihood approaches. |
| **Narasimham & Subbarao (2018)** | Community ecology and ethnozoology | Mining displaced wildlife populations, weakened indigenous conservation systems, and reduced ecological resilience. | Recommends community-based conservation and inclusive environmental governance for sustainable wildlife management. |

## 5. Research Gaps

- Limited zoological research on mining-induced habitat fragmentation and its effects on wildlife in Jharkhand.
- Insufficient studies on wildlife population structure, movement patterns, and species-specific responses to fragmented habitats.
- Lack of integrated assessments combining habitat fragmentation, wildlife health, and population ecology.
- Inadequate long-term monitoring of wildlife diversity, physiological stress, and disease susceptibility in mining-affected ecosystems.
- Limited evaluation of conservation measures, including habitat restoration, ecological corridors, and biodiversity-sensitive mining practices for sustainable wildlife management.

## 6. Conclusion

Mining-induced habitat fragmentation has emerged as a major challenge to wildlife conservation and biodiversity sustainability in Jharkhand. The reviewed literature demonstrates that mining activities have substantially altered forest ecosystems by reducing habitat continuity, degrading ecological quality, and disrupting wildlife movement corridors. These changes have contributed to declines in species richness, altered population structure, restricted gene flow, increased physiological stress, and intensified human–wildlife conflict. Habitat-specialist and wide-ranging species are particularly vulnerable because fragmented landscapes reduce habitat availability and limit opportunities for breeding, dispersal, and long-term population persistence. The review further highlights that wildlife health can be effectively monitored through non-invasive techniques such as body condition

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assessment, fecal glucocorticoid analysis, and parasitological examination, providing valuable information for conservation planning. However, integrated zoological studies examining habitat fragmentation, wildlife population ecology, and health indicators in Jharkhand remain limited. Future research should prioritize long-term ecological monitoring, habitat connectivity assessment, and species-specific conservation strategies. Sustainable mining practices, ecological restoration, wildlife corridor development, and effective environmental governance are essential for minimizing biodiversity loss while supporting economic development. Strengthening evidence-based conservation planning will contribute to maintaining ecological integrity and ensuring the long-term survival of wildlife in Jharkhand's mining-affected forest ecosystems.

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