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A Review on Conservation and Population Status of Lion Tailed Macaque

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The lion-tailed macaque is a critically endangered species. They are only found in the Western Ghats. Threats to these endangered species over time have included encroachments, road deaths, poaching, and climate change. The survival of this one-of-a-kind species is directly related to environmental degradation and destruction. An astonishing fact checks revealed by IUCN states that there are about 2400-2500 Lion Tailed Macaque in the world. According to recent reports in the daily "THE HINDU," Valparai in Tamil Nadu may be the last remaining home for Lion Tailed Macaques. Appropriate conservation techniques, demographic research, and educational campaigns on these species could aid in their survival. The review study was carried out to find out the conservation gap and population assessment of the species over the years. In order for the species to survive the natural habitats should be proposed as the conservation site.

Keywords: Lion tailed macaque; non- human primate; endangered species; conservation; western ghats; diurnal species; endemic; IUCN; Poaching.

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1. INTRODUCTION

Macaca silenus is a unique primate species which is endemic to Western Ghats, India. This charismatic species is characterized by its striking appearance, featuring a distinctive mane of fur surrounding its face, which resembles that of a lion. Being an arboreal species, the Lion Tailed Macaque spends most of its time in the upper canopy of the rainforests and montane evergreen forests. With its long limbs and strong grip, it navigates the treetops with agility and speed. As an herbivore it diet consists primarily of fruits, leaves, flowers and occasional insects (Kumara, A., & Singh M. 2018).

The social structure of the Lion-Tailed Macaque is fascinating. It lives in hierarchical groups led by a dominant male, multiple females, and their offspring. This species exhibits female philopatry, meaning females remain within their natal groups, while males disperse to other groups upon reaching sexual maturity. This behavior helps maintain genetic diversity within the population (Bhagwat, T., & Gadgil, M. 2008).

The Lion-Tailed macaque faces various threats to its survival. Habitat loss due to deforestation, driven by human activities like agriculture and logging, poses a significant challenge. The small population size and limited geographical range make the species vulnerable to natural disasters, disease outbreaks and poaching [1].

Conservation measures targeting the Lion-Tailed Macaque are crucial for maintaining biodiversity in the Western Ghats. These primates play a vital role as seed dispersers, contributing to the survival and regeneration of plant species[31]. Studies by Kumar et al. [2] have shown that their foraging behaviour significantly influences seed dispersal patterns, making them indispensable agents in maintaining ecosystem health.

Conservation efforts focused on the Lion-Tailed Macaque can also yield economic advantages. The charismatic nature of this species attracts eco-tourists, generating revenue for local communities. A study conducted by Mohanraj et al. [3] highlighted the potential of eco-tourism in providing sustainable livelihoods while safeguarding the species and its habitat.

Preserving Lion- Tailed macaque population ensures the continuity of vital ecosystem services in the Western Ghats. The habitat of these primates encompasses natural resources that regulate water availability, stabilizes soils, and sequester carbon. The study by Kumar et al. [4] underscored the importance of conserving these primates to maintain ecosystem balance and sustain the services they provide. Scientific research on primates contributes to our understanding of primate behaviour, evolution, and conservation strategies. Research by Singh et al. [5] highlighted the value of such studies in formulating conservation plans.

The purpose of this article is to highlight the importance of conservation efforts for lion-tailed macaque (*Macaca silenus*) and its habitat. The article aims to provide an overview of the significance of preserving this critically endangered primate species, focusing on various aspects such as biodiversity conservation, economic benefits, ecosystem services, cultural value and scientific contributions. By presenting a comprehensive analysis if the conservation efforts, the article aims to raise awareness about the urgent need for action and the potential strategies that can be employed to ensure the long-term survival of the lion-tailed macaque.

Taxonomy:

KINGDOM : Animalia
PHYLUM : Chordata
CLASS : Mammalia
ORDER : Primates
FAMILY : Cercopithecidae
GENUS :*Macaca*
SPECIES : *Macaca silenus*

Physical appearance of Lion tailed macaque: The lion tailed macaque is a medium-sized primate with a robust build. It has a black glossy fur covering most of its body, which contrasts sharply with its silver-grey mane that encircles its face. This characteristic gives the species its name, as the mane resembles that of a male lion. The mane extends from the cheeks to the chin and merges into a tuft of hair at the end of the tail.

One of the most remarkable features of the lion tailed macaque is its prominent silver-grey mane, which distinguishes it from other macaque species. The tail, apart from the mane is relatively short and measures about 20-25 centimetres in length [6]. The tail ends in a tuft of a hair, further enhancing its unique appearance.

Another notable feature of the lion-tailed macaque is its prominent facial features. It

possesses a dark face with long, expressive whiskers extending from the sides of its muzzle. The muzzle itself is short and broad, with a prominent ridge on the top of the nose. The eyes are small and surrounded by a patch of pale skin, giving the species an intense and captivating gaze.

Additionally, the lion tailed macaque has a well-defined, elongated face and a prominent brow ridge. The species is sexually dimorphic with males being larger in size compared to females. Adult males can weigh between 10 and 15 kilograms, while females typically weigh around 6 to 10 kilograms [6].

Social structure of Lion tailed macaque: The lion-tailed macaque (*Macaca silenus*) exhibits a complex social structure characterized by a hierarchical organization and intricate social relationships. Understanding the social structure of this critically endangered primate species is crucial for effective conservation efforts.

Lion-tailed macaques live in multi-level social groups known as troops, typically consisting of several adult males, females and their offspring. These troops usually range in size from 10 to 20 individuals, although larger groups have been observed. Within the troop, a dominant alpha male holds the highest rank and has exclusive mating rights with the females. Other adult males are subordinate to the alpha male and may form alliances to challenge his position.

Females in lion-tailed macaque troops exhibit a matrilineal dominance hierarchy, where the oldest and highest-ranking female assumes a leadership role. This female hierarchy is maintained through aggressive displays and ritualized behaviours. Females typically remain in their natal troop for life, while males disperse to other troops to avoid inbreeding [7].

The social interactions within lion-tailed macaque troops involve a range of behaviours that contribute to group cohesion and dynamics. These behaviours include social grooming, Allogrooming, vocalizations and synchronized movements. Social grooming plays a significant role in strengthening social bonds, reducing tension and maintaining group harmony. Vocalizations such as grunts, screams and barks serve as signals for communication, including alarm calls, territorial defense and co-ordination within the troop.

Understanding the social structure of lion-tailed macaques provides insights into their breeding patterns, dispersal behavior and overall population dynamics. It helps conservationists develop strategies to protect and manage their populations effectively [8].

Distribution of the Lion Tailed Macaque: The lion tailed macaque is a critically endangered primate species endemic to Western Ghats Mountain range of southwestern India. Its distribution is limited to specific regions within this area, predominantly in the states of Karnataka, Kerala, and Tamil Nadu.

Within the Western Ghats, the Lion-Tailed macaque inhabits various forest types, including tropical rainforests, evergreen forests, mixed deciduous forests and shola forests found at higher elevations. Protected areas such as Silent Valley National Park, Annamalai Tiger Reserve, Periyar Tiger Reserve and Bhadra Wildlife Sanctuary are among the regions where the lion-tailed macaque populations can be found.

The distribution of the lion-tailed macaque is characterized by fragmentation and habitat loss resulting from human activities such as deforestation, agriculture and infrastructure development. The remaining populations are often isolated in small forest fragments, raising concerns about genetic diversity and long- term viability [9].

Conservation efforts are crucial for safeguarding the lion-tailed macaque and its habitat. These efforts include habitat protection, restoration and the establishment of corridors to connect fragmented populations. It is essential to implement effective conservation strategies to preserve the remaining populations and ensure the survival of this iconic primate species [1].

Population Status of Lion Tailed Macaque: The lion-tailed macaque is classified as a critically endangered species by the International Union for Conservation of Nature (IUCN). The population has experienced a significant decline due to habitat loss, fragmentation and human activities such as deforestation and encroachment. The remaining populations are often isolated in small forest fragments, posing challenges for their long-term survival. The current population status of the lion tailed macaque is estimated to be less than 4,000 individuals. However, population assessments and monitoring are essential to determine

accurate population numbers and trends. Conservation efforts are underway to protect and conserve the remaining lion-tailed macaque populations. These initiatives include habitat restoration, connectivity and community-based conservation programs aimed at mitigating threats and promoting sustainable coexistence with local communities [1].

Threats to Lion Tailed Macaque: Lion tailed macaque (*Macaca silenus*) faces a numerous threat that have led to its critically endangered status. Habitat loss and fragmentation due to deforestation, agriculture and infrastructure development are major threats to this species. These activities result in the loss of suitable habitat and isolation of populations, leading to reduced genetic diversity and increased vulnerability to further disturbances. Additionally human-wildlife conflicts, poaching and hunting pose additional risks to the survival of the lion tailed macaque. Urgent conservation efforts are required to mitigate these threats and ensure the long-term survival of this iconic primate species [1]. Various factors affect lion tailed macaque.

A. Habitat Loss and Fragmentation: Habitat loss and fragmentation have severe consequences for the survival and well-being of the lion-tailed macaque (*Macaca silenus*), a critically endangered primate species. Habitat loss occurs primarily due to deforestation for agriculture, logging and human settlements resulting in the destruction of the macaque's natural habitat. This loss directly reduces the availability of food resources, suitable nesting sites and secure shelter [10].

Fragmentation further compounds the issue by dividing the remaining habitat into smaller, isolated patches. The isolation hampers the movement of lion tailed macaques between these fragmented areas, restricting gene flow and increasing the risk of inbreeding [11].

The loss and fragmentation of their habitat disrupt the social dynamics of the species as well as their ability to establish and maintain stable social groups. This can result in increased competition for resources and heightened stress levels among fragmented populations [9].

Additionally, habitat loss and fragmentation contribute to human-wildlife conflicts as the macaques are forced to venture into human settlements of food and resources [12].

Mitigating habitat loss and fragmentation is crucial for the conservation of the lion-tailed macaque. This includes protecting and restoring their remaining habitats, implementing effective land- use planning and establishing wildlife corridors to reconnect fragmented populations [10].

B. Human Wildlife Conflict: Competition for resources exacerbates human-wildlife conflict. As their natural habitat diminishes, lion-tailed macaques may raid crops in search of sustenance, leading to conflicts with farmers. This often results in retaliatory actions, including injury or killing of primates. Moreover, human-induced mortality poses a significant threat. Lion-tailed macaques are hunted for their fur and captured for illegal trade. Increased vehicular traffic in forested areas also raises the risk of road accidents, causing fatalities among macaques. Human wildlife conflict induces stress and behavioral changes in lion-tailed macaques. Disruptions caused by human activities can lead to increased aggression, altered foraging and social behaviours and heightened levels of anxiety and fear [13].

C. Climate change: Climate change poses a significant threat to the survival and well-being of the lion tailed macaque (*Macaca silenus*), an endangered primate species native to the Western Ghats of South India. The impacts of climate change, such as rising temperatures, altered rainfall patterns, and habitat degradation, have severe consequences for these primates [14].

As temperatures increase, lion-tailed macaques face challenges in thermoregulation and finding suitable microhabitats within their already limited ranges. Changes in rainfall patterns disrupt their food availability, as they heavily rely on specific fruits, leaves and flowers. Moreover, habitat degradation due to climate change-induced factors like deforestation and increased frequency of extreme weather events further reduces their already fragmented habitats [15].

Conservation efforts for lion-tailed macaques need to consider the long-term implications of climate change. Protecting and restoring their habitats promoting sustainable land-use practices and implementing climate adaptation strategies are crucial to ensure their survival in the face of changing climatic conditions [16].

2. CONSERVATION MEASURES OF LION TAILED MACAQUE

Protected Areas and National Parks For Lion-Tailed Macaque: Protected areas and national parks are crucial for the conservation and protection of endangered species such as the lion-tailed macaque (*Macaca silenus*). As a critically endangered primate endemic to the Western Ghats in India, the lion tailed macaque heavily relies on these protected areas for its survival.

Protected areas serve as sanctuaries that preserve the natural habitat of the lion-tailed macaque, providing crucial breeding and foraging opportunities. They play a vital role in maintaining the population and ensuring the long-term survival of this remarkable primate. Additionally, protected areas act as biodiversity hotspots, protecting a wide range of flora and fauna, including endemic and endangered species.

Silent valley National Park in Kerala, India and Annamalai Tiger Reserve in Tamil Nadu, India are notable examples of protected areas where significant conservation efforts for the lion-tailed macaque have taken place [17,18]. These areas have contributed to enhancing our understanding of the primate's behavior, population dynamics and habitat requirements.

Challenges such as habitat fragmentation, human-wildlife conflict and poaching continue to threaten the lion-tailed macaque. Strategies to address these challenges include landscape-level planning, corridor establishment, community-based conservation programs, and increased law enforcement [19-21).

To ensure the long-term survival of the lion-tailed macaque, it is essential to strengthen existing protected areas and establish new ones. Integration of scientific research, community participation and policy support are key factors in effectively managing and conserving this endangered primate and its habitat [20].

Conservation organizations and research initiatives of Lion tailed macaques: Conservation organizations and research initiatives play a vital role in the conservation and protection of the critically endangered lion-tailed macaque (*Macaca silenus*). These organizations and initiatives focus on studying the species, monitoring populations, implementing conservation strategies, and raising awareness about the importance of protecting this unique primate.

One notable organization actively involved in lion-tailed macaque conservation is the Wildlife Conservation Society (WCS). The WCS conducts research on the species, collaborates with local communities, and work towards protecting key habitats for the macaques. Their efforts have contributed to enhancing our understanding of the species ecology and behavior, as well as implementing conservation actions [22].

Another prominent organization is the Nature Conservation Foundation (NCF), which has been involved in long-term research and conservation efforts for the lion-tailed macaque. The NCF conducts scientific studies, supports community-based conservation programs, and advocates for the protection of the macaques and their habitats [23].

Additionally, research initiatives such as the Indian Primate Conservation Project (IPCP) have been instrumental in studying and conserving the lion-tailed macaque. The IPCP focuses on population monitoring, habitat assessment and capacity building among local stakeholders to ensure the ensure the long-term survival of the species [24].

These conservation organizations and research initiatives play a crucial role in raising awareness about the conservation needs of the lion-tailed macaque, implementing conservation measures and fostering community participation. Their efforts contribute to the protection of this critically endangered primate and its unique habitat in the Western Ghats.

Legislative Measures and Policies for Species Protection: Legislative measures and policies play a crucial role in ensuring the protection and conservation of endangered species. In the case of the lion-tailed macaque (*Macaca silenus*), a critically endangered primate endemic to the Western Ghats in India, various legislative measures and policies have been implemented to safeguard its habitat and promote its conservation.

One important legislative measure is the Wildlife Protection Act of 1972 in India. This act provides legal protection to wildlife, including the lion-tailed macaque, by prohibiting hunting, capturing

or trading the species or its parts. It also designates protected areas and national parks where the macaque's habitat is preserved and managed [25].

The Indian government has also developed policies and initiatives specifically targeting the conservation of the lion-tailed macaque. For instance, the National Wildlife Action Plan (2006-2016) outlines strategies and action plans for the protection and management of wildlife, including the macaque. It emphasizes the need for habitat conservation, research and community participation in conservation efforts [26].

Additionally, the Western Ghats Ecology Expert Panel (WGEEP) report, popularly known as the Gadgil report, has made significant recommendations for the conservation of the Western Ghats region, which is a critical habitat for the lion-tailed macaque. The report suggests the implementation of strict environmental regulations, sustainable development practices and the establishment of ecologically sensitive zones to protect the regions biodiversity [27].

These legislatives measures and policies provide a legal framework and guidelines for the protection of the lion-tailed macaque and its habitat. However, challenges remain in their effective implementation and enforcement, particularly addressing habitat fragmentation, human-wildlife conflicts and illegal wildlife trade. Continued commitment from governments, collaboration with local communities and scientific research are essential to ensure the long-term survival of this endangered primate.

Successes and challenges in conserving Lion-Tailed Macaque: The conservation of the critically endangered lion tailed macaque (*Macaca silenus*) has been both successes and challenges. Efforts to protect this unique primate have been achieved significant milestones, but ongoing conservation challenges continue to pose threats to its survival.

The establishment of protected areas and national parks has been a key success in conserving lion-tailed macaque [17,18]. Scientific research and long-term monitoring programmes have provided valuable insights into the ecology, behavior and population dynamics of the lion-tailed macaque. These studies have contributed to targeted conservation interventions and adaptive management strategies [22,17].

The lion tailed macaque faces substantial habitat loss and fragmentation due to human activities, including deforestation and land conversion. This loss of suitable habitat restricts their distribution and increases the risk of population isolation [19]. Conflict between humans and lion-tailed macaques over resources such as agricultural crops, presents a significant challenge. Human-wildlife conflict mitigation measures, such as the use of deterrents and implementing crop compensation programs, are essential to reducing conflicts and promoting coexistence [20].

Research Gaps and Areas Requiring Further Study of Lion Tailed Macaque: The lion-tailed macaque, a critically endangered primate species endemic to Western Ghats of India, has been the focus of extensive research and conservation efforts. While significant advancements have been made, several research gaps and areas requiring further study remain.

A comprehensive understanding of the lion-tailed macaque population dynamics including factors influencing birth rates, mortality rates and dispersal patterns is lacking. Long – term demographic studies are essential to assess population viability and identify key factors affecting population growth [17].

Research on the species habitat requirements, particularly in fragmented landscapes, is crucial for effective conservation planning. Studying the macaque's response to habitat fragmentation, connectivity between fragmented populations and the impact of their habitat quality on their behavior and ecology will aid in targeted conservation efforts [22].

Investigating the prevalence, transmission and impact of diseases on the lion-tailed macaque population is an emerging research area. Understanding the macaque's susceptibility to diseases on population dynamics will contribute to comprehensive conservation strategies [24].

Further research is needed to understand the nature and consequences of human-wildlife interactions, particularly in the context of human settlements near macaques' habitats. Assessing the impacts of human disturbance, human-wildlife conflict and the effectiveness of mitigation measures will inform sustainable coexistence strategies [23,20].

Studies investigating the genetic diversity, population structure and gene flow of the lion-tailed macaque are limited. Genetic research can help identify genetically distinct populations, assess genetic viability and guide translocation efforts for population management [24].

Collaborations and National/International Efforts in Conservation of Lion Tailed Macaque: Conservation of the critically endangered lion-tailed macaque requires collaboration efforts at both National and International levels. Numerous organizations, institutions and governments have come together to address the challenges faced by this unique primate.

a. **Collaborations among research institutions:**Research institutions and organizations play a vital role in studying the lion-tailed macaque and implementing conservation measures. Collaborative research initiatives such as those involving the National centre for biological sciences (NCBS), Wildlife Institute of India (WII) and local universities have contributed to a better understanding of the macaque's ecology, behavior and population dynamics [17,22].
b. **Conservation organizations:**Various conservation organizations have been actively involved in lion-tailed macaque conservation. The Nature Conservation Foundation (NCF) and the Wildlife Conservation Society (WCS) are examples of organizations that have implemented conservation programs focused on habitat protection, community engagement and research.
c. **Government Initiatives:**National Governments particularly the Government of India, have taken significant steps to conserve the Lion Tailed Macaque. The wildlife protection act of 1972 provides legal protection to the species and its habitat while the National Wildlife Action plan outlines strategies for Wildlife conservation including the macaque [25,26].
d. **International collaborations:**International collaborations have played a crucial role in the conservation of the lion tailed macaque. The International Union for Conservation of Nature (IUCN) provides a platform for global cooperation and knowledge sharing while the Convention on International Trade in Endangered species of Wild Fauna and Flora (CITES) regulates the international trade of the species.

Breeding programs for conservation measures of the Lion-Tailed Macaque: Breeding program play a crucial role in the conservation of endangered species, including the lion-tailed macaque (*Macaca silenus*). These programs aim to maintain genetically diverse captive populations and provide individuals for reintroduction into the wild.

A. **Captive Breeding for Genetic Management:** Captive breeding programs serve as an insurance policy against the potential extinction of the lion-tailed macaque in the wild. These programs ensure the maintenance of a genetically diverse population, which can act as a source for reintroduction efforts. Managed breeding, using techniques such as mate selection based on genetic compatibility, helps preserve genetic diversity [28].
B. **Reintroduction and Population Augmentation:** Breeding programs provide individuals for reintroduction initiatives, aiming to establish or augment wild populations of lion tailed macaques. Successful reintroduction efforts such as those conducted in Parambikulam wildlife sanctuary, India, have demonstrated the potential for breeding programs to contribute to population recovery [29].
C. **Collaborations among zoos and Institutions:**Zoos and Conservation institutions collaborate in breeding programs to ensure the sustainability and success of captive populations. Such collaborations facilitate the exchange of individuals, genetic information and expertise, strengthening the genetic management of captive populations and enhancing conservation efforts [28].
D. **Challenges and Considerations**:Breeding programs face challenges including limited genetic diversity, inbreeding depression and the need for effective reintroduction strategies. Maintaining genetic diversity within captive populations is essential to preserve the adaptive potential of the species. Implementing careful breeding plans, considering both genetic and behavioral factors is crucial to overcome these challenges [29].

E. **Long term monitoring and Evaluation:**Continuous monitoring and evaluation of captive breeding programs are necessary to assess their effectiveness and adapt strategies accordingly. Regular genetic monitoring, behavioral observations and health assessments help ensure the well-being and genetic integrity of captive populations [28,30,31].

Breeding programs for the lion-tailed macaque have proven effective in preserving genetic diversity, providing individuals for reintroduction and enhancing conservation efforts. Collaborations among zoos and institutions play a vital role in facilitating genetic management and knowledge sharing. However, ongoing monitoring, evaluation, and adaptive management are essential to address challenges and maximize the success of breeding programs for the long-term conservation of the lion-tailed macaque.

3. CONCLUSION

The conservation of the critically endangered lion-tailed macaque (*Macaca silenus*) requires concerted efforts and collaboration from various stakeholders. This review has highlighted key aspects of conservation including protected areas, community engagement, breeding programs and the identification of threats. To ensure the long-term survival of the lion-tailed macaque, it is crucial to address the challenges posed by habitat loss and fragmentation, human-wildlife conflict, illegal wildlife trade, climate change and disease outbreaks.

Protected areas and national parks play a vital role in safeguarding the lion-tailed macaques' habitat and providing critical breeding and foraging opportunities. Collaborative efforts among research institutions, conservation organizations, and governments have contributed to our understanding of the species ecology, behavior and population dynamics. Additionally, community participation and sustainable livelihood initiatives have fostered local support for macaque conservation.

Breeding programs have been instrumental in maintaining genetic diversity and providing individuals for reintroduction efforts, helping to establish or augment wild populations. However, ongoing monitoring and evaluation are necessary to address challenges such as inbreeding depression and the development of effective reintroduction strategies.

Addressing the latest threats to the lion-tailed macaque such as habitat loss, human-wildlife conflict, illegal wildlife trade, climate change and disease outbreaks requires integrated and adaptive conservation approaches. Strengthening law enforcement, promoting sustainable land-use practices, and increasing public awareness are crucial components of these strategies.

Continued research, monitoring and collaboration among stakeholders both at the national and international levels are essential for the sustained conservation of the lion-tailed macaque. By implementing comprehensive conservation measures and addressing the identified threats, we can strive towards securing a future for this critically endangered primate and its unique habitat in the Western Ghats.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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