

Communication

Dietary Pattern of Asiatic Lions in the Coastal Ecosystem of Saurashtra, Gujarat, India

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Abstract: The Asiatic lion (*Panthera leo leo*), a flagship species of conservation significance, has expanded its range beyond the Gir protected areas into multi-use landscapes, including the coastal regions of Saurashtra, Gujarat, India. This study examines the dietary patterns of Asiatic lions in this unique coastal region. Using scat analysis, we identified the prey species consumed and quantified their contributions to the lions' diet. Results indicate that the lions predominantly consumed wild prey, such as *Boselaphus tragocamelus*, *Sus scrofa*, and *Axis axis*, which together constituted 64% of their diet. Domestic prey contributed 31%. In terms of biomass, wild prey accounted for 70%, with *Boselaphus tragocamelus* alone contributing 51%. The dietary niche breadth, calculated using Levin's index, was 0.36, suggesting a relatively specialized diet. This study underscores the importance of prey abundance and habitat structure in shaping lion predation patterns. Lions' reliance on wild prey, particularly *Boselaphus tragocamelus* and *Sus scrofa*, highlights their crucial role in the coastal region. Additionally, the inclusion of domestic prey, such as feral cattle, may reflect their high availability and reduced anti-predator behaviors. These findings emphasize the need for robust prey population monitoring and habitat conservation to ensure the long-term survival of Asiatic lions in the coastal region.



Academic Editor: Krisztián Katona

Received: 3 January 2025

Revised: 7 February 2025

Accepted: 19 February 2025

Published: 21 February 2025

Citation: Ram, M.; Sahu, A.; Srivastava, N.; Vadar, K.; Chaudhary, R.; Jhala, L. Dietary Pattern of Asiatic Lions in the Coastal Ecosystem of Saurashtra, Gujarat, India.

Conservation **2025**, *5*, 11.<https://doi.org/10.3390/conservation5010011>

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Keywords: asiatic lions; diet pattern; scat analysis; prey consumption; conservation

1. Introduction

Large carnivores play a critical role in ecosystem functioning, biodiversity conservation, and garnering public attention due to their status as keystone, umbrella, and flagship species, respectively [1,2]. Their charismatic nature makes them a major attraction for tourists, and carnivore-based ecotourism provides livelihoods for many communities [3,4]. Additionally, large carnivores provide ecosystem services; for example, pumas help reduce road collisions by controlling ungulate populations near roads, saving human lives [5].

Despite their ecological and economic importance, large carnivore populations have declined globally due to factors such as habitat destruction, urbanization, and poaching [6,7]. This decline has led to cascading effects at the ecosystem level [8,9]. Recognizing these impacts, conservationists worldwide have implemented measures based on robust scientific approaches, resulting in population recoveries for certain large carnivore species in various regions [10,11].

The endangered Asiatic lion, a restricted population of the northern lion subspecies (*Panthera leo leo*), which once spread across Northern Africa to the Indian subcontinent, is

now confined to the Saurashtra region of Gujarat, western India due to hunting and habitat loss. Over the past six decades, sustained conservation initiatives, effective management strategies, and the support of local communities have led to a substantial increase in both the population size and geographic distribution of this species within Gujarat [12–15]. However, this resurgence presents challenges, as lions increasingly disperse beyond protected areas into multi-use landscapes, where they encounter diverse ecological conditions and anthropogenic pressures. Among the varied habitats in the multi-use landscape, the coastal region of Saurashtra has emerged as one of the important habitats. These areas are characterized by dense vegetation dominated by *Prosopis juliflora*, *Casuarina equisetifolia*, *Salvadora persica*, and, in some patches, mangroves. *Prosopis juliflora*, an invasive species, has proliferated extensively in these areas, providing critical shade and dense thickets that act as resting and hiding spots for lions, particularly in the warm coastal climate. Similarly, plantations of *Casuarina equisetifolia* add to the structural complexity of the habitat, offering cover and influencing prey species distribution by serving as refuge for ungulates. These patches also support prey populations such as wild pig (*Sus scrofa*) and blue bull (*Boselaphus tragocamelus*), enhancing the availability of key resources for lions. Together, these vegetation types and prey populations create a microhabitat that supports the lions' thermoregulation needs and sustenance within an otherwise human-modified landscape [16].

The coastal area currently supports three of the seven satellite populations of Asiatic lions: the southwestern coastal, southeastern coastal, and Bhavnagar coastal populations (Figure 1). This region, comprising distinct management zones, acts as a habitat and a westward corridor for this endangered species along the coastline [16]. The population estimation of Asiatic lions is carried out using the total block count method (minimal total count) [14,15]. Recent estimates show that the southwestern coast is home to 20 lions, the southeastern coast has a population of 67 lions, and the Bhavnagar coast hosts 17 lions [15,16]. Comparing these figures with previous estimates highlights the coastal region's essential role in the conservation and management of Asiatic lions [15].

As lions expand their territories into multi-use landscapes, they face increased human interactions and altered resource availability [17–19]. Food is one of the most critical resources and a key factor in the long-term conservation of large carnivores. Through its role in fulfilling basic physical needs, food influences essential ecological processes in the life history of large carnivores, including breeding, social organization, competition, and space use [20,21]. In human-modified habitats, where wild prey availability may be limited, large carnivores often shift to preying on domestic livestock, complicating conservation and management efforts by increasing human–wildlife conflict. Therefore, understanding the food habits of Asiatic lions in human-dominated landscapes not only provides valuable insights into their resource utilization but also plays a crucial role in mitigating human–lion conflicts.

The coastal region of Saurashtra supports wild prey species such as blue bull and wild pig; however, the dietary composition of the Asiatic lions in this habitat remains poorly understood [22]. This study aims to evaluate the dietary patterns and biomass consumption of lions in the coastal region. Previous research on Asiatic lions within the Gir protected area and its surrounding multi-use landscapes has shown that lions in areas with abundant wild prey, such as Gir protected areas, primarily consume wild prey [23–25]. Conversely, in areas with comparatively lower wild prey availability, such as mixed-use landscapes, lions exhibit increased consumption of livestock [22]. Therefore, we hypothesize that lions would show greater reliance on the domestic livestock, including cattle (*Bos taurus*) and buffalo (*Bubalus bubalis*) than the wild prey. Insights into the dietary preferences of lions are

crucial for informing conservation and management strategies, mitigating conflicts, and ensuring the coexistence of lions and human communities in this unique landscape.

Moreover, the successful conservation initiatives that have facilitated the recovery of Asiatic lions provide valuable lessons for managing large carnivore populations globally. These efforts highlight the importance of integrating ecological research, effective management, and community participation. Such strategies could inspire similar conservation actions for other species and regions facing challenges related to habitat fragmentation, prey depletion, and human–wildlife conflicts.

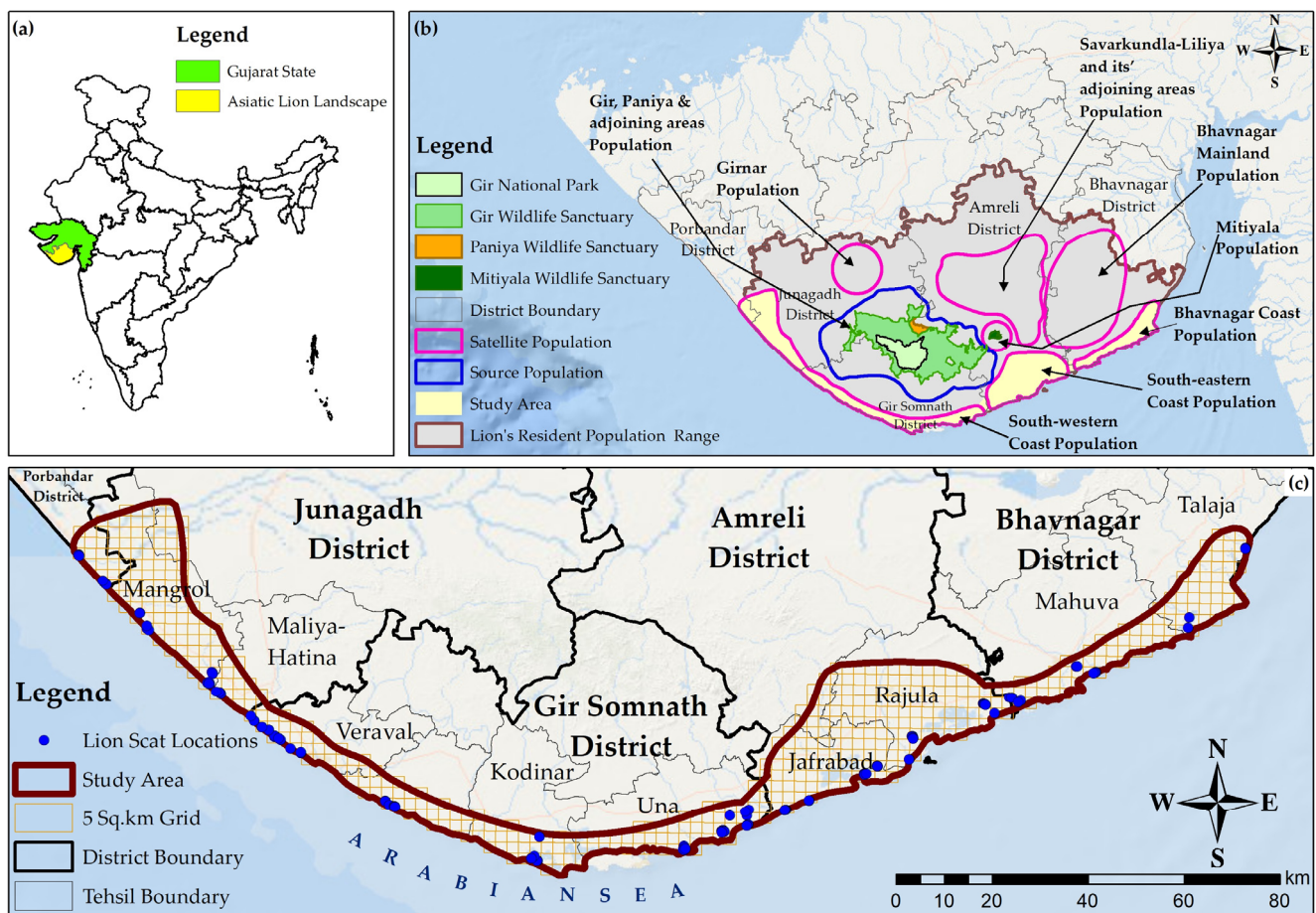


Figure 1. Study area map depicting the locations of scats collected from the coastal region of Saurashtra, Gujarat. Map insets indicate the location of Gujarat in India and the Asiatic lion landscape in Gujarat (a), the source and satellite population of Asiatic lions in their resident range (b), and location of scat sample collected along the coastal area (c).

2. Materials and Methods

2.1. Study Area

The Saurashtra region of Gujarat, located in western India, lies within the semi-arid biogeographic zone and the Gujarat-Rajputana province [26]. Gujarat is home to India's longest coastline, stretching approximately 1600 km, and is known for its rich coastal biodiversity [27]. The coastal region supporting Asiatic lions span across the districts of Bhavnagar, Amreli, Gir-Somnath, Junagadh, and Porbandar (Figure 1).

Within these districts, key tehsils (sub-districts) contributing to the lion's southwestern range include Mangrol, Maliya, Patan-Veraval, Sutrapada, Kodinar, and Una [16]. The southeastern coast encompasses the tehsils of Jafrabad and Rajula, while Mahuva and

Talaja tehsils represent the Bhavnagar coast. These areas collectively cover distinct lion range units (Figure 1).

The study area, along Saurashtra's coast (Figure 1), hosts a range of large carnivores, including the striped hyena (*Hyaena hyaena*) and leopard (*Panthera pardus fusca*). Key prey species in the region include blue bull, spotted deer (*Axis axis*), and wild pigs alongside other wild and domestic prey.

2.2. Methodology

Studying the dietary patterns of large carnivores poses challenges due to their elusive behavior. Scat analysis, a widely used and cost-effective method, is particularly suited to study large carnivores [28]. In this study, we used scat analysis to assess the diet of Asiatic lions in the coastal region of Saurashtra.

2.2.1. Sample Collection and Processing

The study area was segmented into grids, each covering 5 square kilometers. From March to April 2024, each grid was thoroughly searched for scat samples. Once encountered scat sample was placed in a Ziplock bag, labeled with all relevant collection information, and sun-dried to inhibit fungal growth.

For analysis, scats were washed in lukewarm water using a fine sieve to isolate prey remains such as hair, bones, nails, and skin. The isolated materials were dehydrated in a 70% ethanol solution to preserve them [29]. Prey species identification was performed by examining the medullary patterns of prey hair under a microscope (Nikon Eclipse Ei) under 40× and 100× magnification. Reference slides of local prey species were sourced from the repository at the Lion Hospital in Sasan-Gir. These reference slides were prepared using hair samples obtained during post-mortem examinations or treatments conducted by experienced wildlife veterinarians.

2.2.2. Diet Composition and Biomass Consumption

Diet composition was assessed using two metrics:

- Count of Occurrence (CO): Calculated as the number of scats with a prey species.
- Percent Occurrence (PO): The contribution of each prey species divided by the total prey occurrence [28].

To overcome the overrepresentation of smaller prey species in dietary analyses using percentage occurrence (PO), we estimated biomass consumption (total mass of prey consumed by a predator) using the generalized model for tropical felids proposed by Chakrabarti et al. (2016) [30]. This model provides a robust approach to quantifying prey biomass consumed by predators. The generalized model is expressed as

$$\text{Relative Biomass Consumed (RBC)} = (\text{CO} \times \text{Biomass per individual})^b / \sum (\text{CO} \times \text{Biomass per individual})^b$$

where CO is the count of occurrence of a prey species, Biomass per individual represents the average body mass of that prey species, and b is an allometric scaling factor for felids ($b = 0.75$, as determined by Chakrabarti et al., 2016) [30]. The relative biomass of each prey species was then calculated by dividing its biomass contribution by the total biomass consumed. The dietary niche breadth of lions was calculated using Levin's index [31], which ranges from 0 (specialized diet) to 1 (generalized diet). Data analysis was performed using Microsoft Excel (MS Office 2021; Version 2401 Build 16.0.17231.20236).

3. Results

A total of 160 lion scats were collected from the coastal region of Saurashtra. Scat analysis revealed that Asiatic lions consumed six identifiable prey species, comprising

three wild and three domestic species (Table 1). Birds, which could not be identified at the species level, were grouped under “birds”. Wild prey species involved one large prey (>50 kg), i.e., blue bull (180 kg); two medium size prey (20–50 kg), i.e., wild pig (32 kg) and spotted deer (47 kg); and one small prey (<20 kg), i.e., bird species. Among the domestic prey species, two were large size prey, i.e., cattle (180 kg) and buffalo (180 kg), and one small size prey, i.e., goat (*Capra hircus*) (14 kg).

Table 1. Asiatic lions’ dietary pattern and biomass consumption in the coastal region.

Sr. No.	Prey Species	CO	PO	BC	RBC
1	Blue Bull (<i>Boselaphus tragocamelus</i>)	74	42.77	326.44	51.08
2	Wild pig (<i>Sus scrofa</i>)	32	18.50	102.97	16.11
3	Cattle (<i>Bos taurus</i>)	23	13.29	101.46	15.88
4	Buffalo (<i>Bubalus bubalis</i>)	16	9.25	70.58	11.04
5	Goat (<i>Capra hircus</i>)	14	8.09	21.56	3.37
6	Spotted deer (<i>Axis axis</i>)	4	2.31	14.71	2.30
7	Birds	1	0.58	1.38	0.22
8	Nil	9	5.20	0.00	0.00

CO: count of occurrence; PO: percent occurrence; BC: biomass consumed (kg); RBC: relative biomass consumed.

3.1. Diet Composition (PO)

Wild prey constituted 64% of the lions’ diet, domestic prey accounted for 31%, while 5% of scats contained no identifiable traces of prey species. Among wild prey, blue bull was the most consumed species, with a percent occurrence of 42.77% followed by wild pig 18.50%, spotted deer 2.31%, and birds 0.58%. Large sized wild prey, i.e., blue bull, contributed more than the medium size wild prey, i.e., spotted deer and wild pig. Among domestic prey, cattle were most frequently consumed, contributing 13% to the diet, followed by buffalo 9.25% and goat 8.0%.

3.2. Biomass Contribution

Wild prey contributed 70% of the total biomass consumed, while domestic prey accounted for 30% (Table 1). Blue bull contributed maximum to the biomass consumption (51%), followed by wild pigs (16%) and spotted deer (2%). Among domestic prey, cattle contributed the highest biomass (16%), followed by buffalo (11%) and goats (3%).

3.3. Dietary Niche Breadth

The dietary niche breadth of Asiatic lions, calculated using Levin’s index, was 0.36, indicating a highly specialized diet in the coastal habitat of Saurashtra.

4. Discussion

This study demonstrates that Asiatic lions in the coastal region of Saurashtra predominantly rely on wild prey, contradicting our initial hypothesis of a high dependence on livestock. The high reliance on wild prey in the coastal region may be attributed to their availability; however, due to the absence of comprehensive population data on livestock, it is challenging to draw definitive conclusions regarding this trend. Nevertheless, the observed predation patterns on wild prey in this study align with their relative availability in the coastal region. The lions in this landscape primarily consume wild prey, with blue bulls being the most frequently consumed species. This is likely due to their high abundance in the coastal region (21.52 ± 2.59 individuals/km²) [32], compared to other habitats in

the Asiatic lion landscape, and their suitability as large-bodied prey. Large prey provide significant biomass, which aligns with the lions' dietary preferences, as noted by Hayward and Kerley (2005) [33]. These observations are consistent with studies on large carnivores in India, which emphasize their preference for wild prey in areas where it is abundantly available [34,35]. Factors such as prey abundance and size, spatiotemporal overlap between predator and prey, and habitat use by both species further explain this preference for wild prey over domestic species [36–38]. Contrary to our initial hypothesis that the lions might depend more on domestic livestock, the availability of wild prey in the region seems to lessen their reliance on livestock.

The patterns of predation on wild pigs and spotted deer further highlight the influence of prey density and habitat use in shaping the dietary habits of lions. Despite similar densities of spotted deer (9.59 ± 3.29 individuals/km²) and wild pigs (7.13 ± 1.48 individuals/km²) [32], wild pigs contributed more to the diet. This disparity may stem from differences in habitat preferences and the resulting catchability of these species. Dense vegetation, such as *Prosopis juliflora* scrub, likely facilitates ambush predation by providing lions with cover, as suggested by findings in similar habitats [39,40]. Also, other ambush predators like leopards and cougars also depend upon the dense cover for hunting [41,42]. Conversely, the preference of spotted deer for open areas may reduce their susceptibility to ambush hunting, making them a less frequent target [43].

Among domestic prey, cattle, particularly feral individuals, were the most consumed species. This trend reflects the abundance of feral cattle in the region, resulting from the widespread practice of abandoning non-productive livestock, which is a common economic activity in Saurashtra. The lack of anti-predator strategies and their large body size make feral cattle an easy and rewarding target for lions, especially in areas where they venture close to villages at night.

Buffalo were the second most consumed domestic prey. Although similar in body size to cattle, buffalo are generally better protected through enclosures and herder vigilance. Predation likely occurs during grazing periods, particularly at dusk, when reduced visibility offers lions a tactical advantage, consistent with observations from Gir protected areas [22]. Domestic goats, on the other hand, were the least consumed, likely due to their smaller size, which makes them less rewarding in terms of biomass, and their lower abundance in coastal lion habitats (especially in lion ranging areas). This shift in prey selection from wild species to livestock in comparison with protected areas such as Gir National Park and Wildlife Sanctuary [25] may reflect not only prey availability but also an adaptive strategy by lions to maximize energy efficiency in human-dominated landscapes. The increased reliance on domestic prey has significant ecological implications, including potential alterations in wild prey populations due to reduced predation pressure and heightened human–wildlife conflict, which can influence predator behavior and conservation outcomes.

A dietary niche breadth value of 0.36 suggests a relatively high level of specialization, which is similar to the earlier studies on Asiatic lions [22]. This specialization reflects the lions' adaptation to the coastal ecosystem's limited prey base, where only three wild ungulate species—blue bulls, wild pigs, and spotted deer—are present, further emphasizing the ecological significance of prey availability in shaping predator foraging strategies. Ferretti et al. (2020) [44] found that carnivores exhibit greater dietary diversity when prey richness is high, a condition absent in the coastal region.

In conclusion, this study highlights the significant role of wild prey, particularly blue bulls and wild pigs, in the diet of lions in the coastal region. Although domestic prey form a secondary component, they remain crucial in sustaining lion populations, especially in areas where wild prey are scarcely distributed. The practice of cattle abandonment contributes significantly to these dynamics, as feral cattle not only serve as an alternative

food source for lions but also influence ecosystem processes by altering vegetation patterns and competitive interactions with native herbivores. Prey abundance, catchability, and biomass emerge as key factors driving predation patterns in this unique habitat.

The present study is limited since it does not account for seasonal fluctuations in prey species, as it was not conducted across different seasons. Future research should incorporate a seasonal perspective to understand better how the dietary patterns of lions in the coastal habitat vary throughout the year and how these fluctuations align with phenological changes and habitat variations. Additionally, using scat analysis, it would not be possible to differentiate between the sex or life stage of prey species consumed, which may significantly influence the calculation of relative biomass consumed. Such differentiation is crucial, as variations in prey size and life stage could affect assessments of what constitutes large prey and its proportion in lion diets. Future studies should consider these factors to provide a more nuanced understanding of dietary patterns.

5. Conservation Implication

The findings of this study emphasize the crucial role of wild prey, especially blue bulls and wild pigs, in sustaining Asiatic lions in the coastal region of Saurashtra. To ensure the long-term viability of lion populations, robust monitoring of wild prey populations is important using the advanced techniques such as camera trap-based distance sampling. Management actions should prioritize maintaining healthy populations of these key prey species through habitat restoration and the protection of vegetation that supports prey abundance.

Feral cattle, one of the important components of the lions' diet, represent an underexplored aspect of lion ecology in this region. Comprehensive population estimates of feral cattle are needed to understand their role in sustaining lion populations and their potential impact on local ecosystems. Such data can inform strategies for managing feral livestock to balance conservation goals with human–wildlife conflict mitigation.

The coastal region of Saurashtra faces considerable anthropogenic pressures. Protecting and managing these multi-use landscapes is crucial for lion conservation and safeguarding the biodiversity of these unique ecosystems. Effective conservation strategies may include habitat restoration through practices such as replanting native vegetation, which can help mitigate habitat fragmentation and support prey populations. Conflict mitigation programs, including measures to reduce livestock depredation and improve compensation schemes, can further foster coexistence. Additionally, community engagement is essential to promote sustainable land-use practices and encourage local stewardship of lion habitats. Drawing from successful management examples in other regions, such as integrated wildlife corridors and community-based conservation initiatives, could provide valuable insights for enhancing conservation efforts in the multi-use landscapes inhabited by Asiatic lions.

Author Contributions: Conceptualization, M.R., A.S., R.C. and L.J.; methodology, M.R., K.V., R.C. and L.J.; software, K.V. and R.C.; validation, M.R., A.S. and N.S.; formal analysis, K.V., R.C. and L.J.; investigation, M.R., K.V., R.C. and L.J.; resources, M.R., A.S. and N.S.; data curation, M.R., K.V., R.C. and L.J.; writing—original draft preparation, M.R. and R.C.; writing—review and editing, M.R., A.S., N.S., K.V., R.C. and L.J.; visualization, M.R. and A.S.; supervision, M.R., A.S. and N.S.; project administration, M.R., A.S. and N.S.; funding acquisition, M.R., A.S. and N.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments: We thank the Principal Chief Conservator of Forests & Head of Forest Force (PCCF&HoFF), Gujarat state, as well as all the Chief Conservators of Forests, Conservators of Forests, Deputy Conservators of Forests, Assistant Conservators of Forests, Range Forest Officers, and field and office staff in the Asiatic Lion Landscape for their support. We also thank the foresters, beat guards, and wildlife trackers for their help in sample collection. We thank Khushi Buhecha, Sabdad Bloch, and Hamal Bloch for their continuous assistance during the sample collection and analysis and Yashpal Zala for map preparation.

Conflicts of Interest: The authors declare no conflicts of interest.

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