

Research Article

Conservation Status of Crocodilian Species (*Osteolaemus tetraspis*) in Okomu National Park: A Study on the Impacts of Environmental Degradation on Biodiversity in Niger Delta, Nigeria

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Abstract

This study assessed the conservation status of crocodiles in Okomu National Park, Nigeria, and the impact of environmental degradation on biodiversity. A multi-faceted approach was used to gather data, including field surveys, bushmeat market surveys, oral interviews, and documentary analysis. The field survey yielded no results, while nearby bushmeat market surveys recorded 30 dwarf crocodiles at Ekiuwa Market and 17 at Oba Market. Demographic data from 35 park staff revealed that 74.3% were male and included various roles such as field researchers and park rangers. Results indicated the presence of dwarf crocodiles in the park, with Chi-square analysis showing no significant difference in responses regarding their safety and disturbance. The sale of dwarf crocodiles in nearby markets highlights potential poaching threats to conservation efforts. Factors threatening crocodile species included major issues like hunting, poaching, and habitat destruction, while water quality and food availability posed minor threats. Documentary evidence indicated that human activities, such as logging and agricultural clearance, significantly impact environmental degradation in the Niger Delta. The findings underscore the need for conservation strategies, including habitat protection, anti-poaching measures, pollution control, prohibition of agricultural activities and community engagement to safeguard the dwarf crocodile population and biodiversity in Okomu National Park.

Keywords

Okomu National Park, Crocodile Conservation, Biodiversity, Poaching, Sustainable Forest Management

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1. Introduction

Crocodiles are large, carnivorous reptiles that thrive in tropical regions worldwide, encompassing crocodiles, caimans, and gharials. These aquatic animals are well adapted to life in fresh water, with robust tails, short legs, and webbed feet [1]. Their scaly skin and sharp teeth enable them to thrive in aquatic ecosystems, where they are excellent swimmers, capable of staying submerged for extended periods without breathing [2-4]. In African ecosystems, crocodiles play a crucial role as apex predators, maintaining species balance and ecosystem health. However, many crocodile species face significant threats, including the slender-snouted crocodile, which is categorized as Critically Endangered by the International Union for Conservation of Nature (IUCN). The main threats to crocodile populations include overhunting for their meat and skin, habitat destruction and degradation due to deforestation and pollution, and other human activities that impact their habitats and ecosystems [5-7]. Crocodiles and their ecosystems are also vulnerable to the impacts of invasive species, human activities, and climate change, which can alter water levels, temperature, and humidity. Human activities such as agriculture, fishing, and development can cause habitat damage and pollution, negatively impacting crocodile populations [8, 9]. Additional threats to crocodiles include entanglement in fishing nets, fear-driven killing by fishermen, explosive fishing practices, poison usage, and illegal killing, particularly in the context of the bushmeat trade in West and Central Africa [10].

The degradation of the environment encompasses the destruction of natural resources, including air, water, and soil, as well as the elimination of wildlife [11-13]. This damage can manifest as soil, water, or air degradation, primarily caused by human activities such as overconsumption, over-exploitation, pollution, and deforestation [14-16]. Deforestation, climate change, overgrazing, and pollution are key drivers of environmental degradation, leading to decreased crop yields, water shortages, and poverty [13, 16-20].

The Okomu National Park, a 1,082 km² woodland reserve located 60 km northwest of Benin City, is experiencing significant environmental degradation [21]. Despite its importance for protecting endangered species, the park's size has been reduced due to encroachment from surrounding villages, resulting in the loss of approximately two-thirds of its original area [22]. The park's width spans 50-100 km along the Niger River [23]. Established in 1935, the Okomu woodland reserve is home to various endangered plant species, including Kapok trees, Celtis Zankeri, and Alstonia congoensis [21, 24]. The park's fauna is diverse, featuring species such as the African forest Elephant, 33 species of mammals, including the vulnerable white-throated guenon primates and chimpanzees [25-27]. Other wildlife species present in the park include dwarf crocodiles, red river hogs, warthogs, civet cats, grass cutters, mona monkeys, and tree pangolins [24]. The park is also home to approximately 150 species of birds and various

invertebrates [28].

The Okomu National Park faces significant threats from large-scale illegal logging, the expansion of rubber and oil palm plantations, and farming and hunting activities [21]. Deforestation has led to the degradation of the park's ecosystem, resulting in the loss of thick forests and the conversion of land into arable farmlands. The park's resources, including timber and wildlife, have been exploited by poachers and illegal loggers.

In response to these challenges, the Edo State Governor, Godwin Obaseki, launched a 10-year forest recovery plan and inaugurated the Edo Forestry Commission in June 2023 [29]. The Governor highlighted the importance of conservation and sustainability, noting that the Okomu reserve was once a thriving forest ecosystem but has been degraded due to lack of knowledge and attention [29]. The Edo Forestry Commission was mandated to create awareness about sustainability, develop an institution to manage forest and wildlife resources, create a recovery plan for degraded forests, and promulgate laws to conserve forest and game reserves [30, 31]. The commission's goal is to facilitate the proper utilization, preservation, protection, and management of forest and wildlife resources in Edo State [32].

The loss of biodiversity has severe consequences for ecosystems and species. As populations decline, the long-term survival of species is jeopardized, and the risk of extinction increases [33]. Biodiversity loss also disrupts ecosystem structure and function, eroding resilience and increasing vulnerability to collapse. The decline of ecosystem productivity and service quality can have far-reaching consequences, impacting essential functions such as soil maintenance, water purification, and food provision [33]. Furthermore, excessive species removal or decline can destabilize ecosystems, leading to rapid transformation and loss of ecosystem character and functions. Reduced biodiversity can also lead to ecosystem homogenization, where regional and global uniqueness is lost [33]. Specialist species are more susceptible to population declines and extinction, while generalist species and human-favored species may thrive in vacated ecosystems [33].

The consequences of environmental degradation are widespread, including the decline of water quality, which poses a significant threat to aquatic ecosystems [34-36]. This degradation can have a cascading effect on aquatic food webs, impacting various trophic levels in both freshwater and marine environments [37-39]. Although the effects of degradation often build up gradually, once critical thresholds are exceeded, other biological components can respond rapidly, leading to unexpected outcomes. Notably, apex predators like crocodiles can exhibit swift responses to these changes [40].

Crocodylians in the wild face numerous threats, primarily due to habitat loss, destruction, or degradation. Historically, unregulated hunting for their valuable skins posed a significant threat to their survival. Although regulated farming has

helped mitigate this issue, some species and populations remain vulnerable due to past hunting practices [10]. Recovery efforts are often hindered by fragmented populations, isolated and scattered across remaining habitats. Habitat loss results from various human activities, including deforestation and land conversion for agriculture, river siltation and drainage of

wetlands, coastal wetland dredging and sand-mining, dam construction and water diversion for agriculture, urban development, and pollution [10].

This study aimed to investigate the impact of environmental degradation on the biodiversity of dwarf crocodile species (*Osteolaemus tetraspis*) in Okomu National Park.

2. Materials and Methods

2.1. Study Area

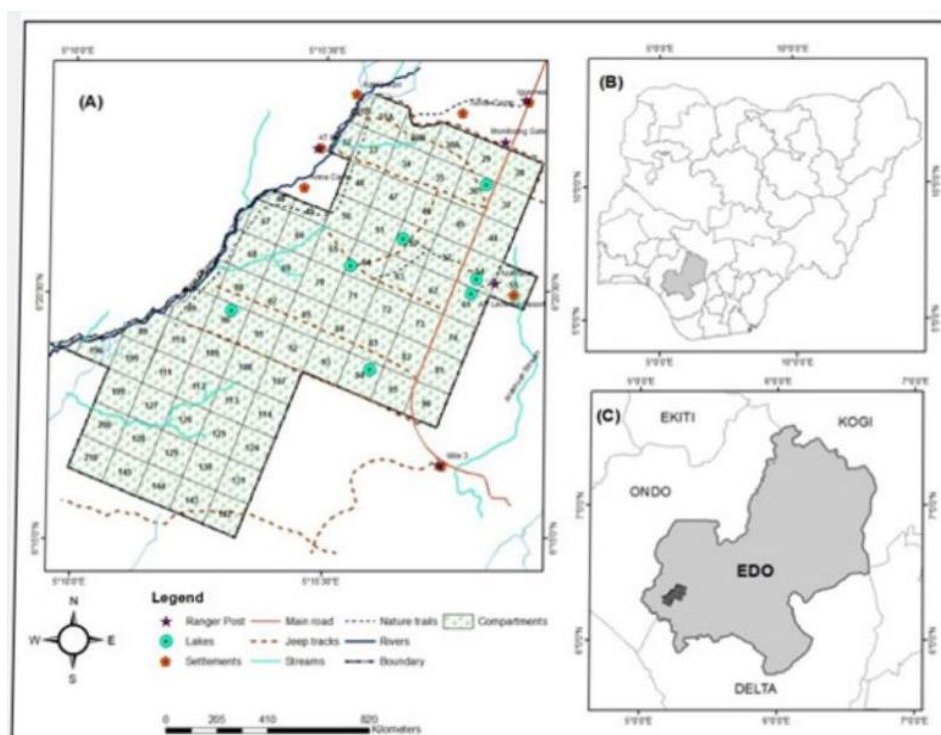


Figure 1. Map of Okomu National Park. Udo, Edo State, Nigeria [43].

The Okomu National Park, formerly known as Okomu Wildlife Sanctuary is a 1,082 square kilometer forest preserve. It is located in Udo, Olivia South West Local Government Area of Edo State, Nigeria. It is approximately 60 kilometers northwest of Benin City [41]. The park was established in 1935, covering an area of 200 km² at the coordinates of 6°20'0"N and 5°16'0"E (Figure 1). The state government declared the area protected in 1986 [42], but it was later taken over by the Nigerian Conservation Foundation (NCF), which took over in 1987 and expanded the protected area by adding a 1.6 km wide zone. 114 square kilometers [41]. There are 33 species of large animals in the park, including 150 species of birds such as gray parrots, and ruffed hornbills, as well as reptiles such as dwarf crocodiles and other small animals such as pangolins [41, 27], 46 mammal species and more than 700 butterfly species [41].

2.2. Methods of Data Collection

In order to gather data on the presence and nature of crocodiles in Okomu National Park, we employed a multi-faceted approach that included field surveys, oral interviews, and analysis of documentary evidence.

Field Survey: During our extensive field tour within the park, we conducted a thorough search for dwarf crocodiles. Unfortunately, despite our efforts, we did not sight any crocodiles within the park's boundaries. However, our survey of a nearby bushmeat market revealed that crocodiles were being sold as shown in figure 3, indicating their presence in the surrounding area.

Documentary Evidence: Given the absence of physical sightings within the park, we relied on documentary evidence stored in the park's archives to gather more information about

crocodiles. This approach provided valuable insights into the historical presence and dynamics of crocodiles in the park.

Staff Survey: We also collected demographic data from 35 staff members of Okomu National Park using a structured questionnaire administered orally. This helped us understand the perspectives and experiences of park staff regarding crocodile management and conservation.

2.3. Statistical Analysis

Chi-square (χ^2) statistical Analysis was used to analyze the responses to polar questions in the questionnaire.

3. Results

Table 1 shows the demographic status of Okomu National Park staff. 26 (74.3%) of the respondents were males, 9(25.7%) were females. Among these workers, 6(17.1%) of the respondents were field researchers, 17(48.6%) were park rangers, 5(14.3%) were drivers while 7(20%) of the respondents were security personnel. A cross section of the staff was depicted in **Figure 2**.

Table 1. Demographic Characteristics of Okomu National Park Workers, Udo, Edo State.

Features	Number of Respondents (35)	Percentage
Male	26	74.3
Female	9	25.7
Field researcher	6	17.1
Park Rangers	17	48.6
Drivers	5	14.3
Security	7	20

Table 2 show the results of survey of bushmeat markets near Okomu National Park and it revealed that dwarf crocodiles are being sold in these markets. Specifically, at Ekiuwa

Market, we made three visits and recorded a total of 30 dwarf crocodiles being sold. In contrast, Oba Market was visited twice, and we found 17 dwarf crocodiles for sale.

Table 2. Nearby Bushmeat Markets To Okomu National Park Visited in 2023 In Benin City, Edo State, Nigeria.

Nearby Bushmeat Market To Okomu National Park	Number of Times	Number of Dwarf Crocodile shaded for sale
Ekiuwa Market	3	30
Oba Market	2	17

Table 3. Presence of Crocodiles in Okomu National Park.

S/N	Descriptions	YES	NO
1	Have you seen a crocodile in this park? (n = 30)	19	11
2	Are crocodiles in this area safe from danger? (n=32)	26	6
3	Do you have any disturbances from the presence of Crocodiles around? (n= 23)	15	8

Table 3. contains polar questions showing the presence of crocodile in Okomu National Park. Out of 30 respondents,

19 affirmed the presence of dwarf crocodile as against 11 whose answers were on the contrary from questions 1. From

the 32 respondents for questions on safety of crocodiles in the area (question 2), 26 respondents answered YES while 6 of them answered NO. From question 3, 23 respondents, 15 answered YES on the disturbance of crocodiles in the area while 8 emphatically said NO.

Table 3 was analyzed using the Chi square (YES: $X^2 = 0.000$, Df = 2, P-value = 1.000, NO: $X^2 = 0.000$, Df = 2, P-value = 1.000). Since the F value is lower than the P value, there is no significant difference between the answers given on the Table 2. This implies that crocodiles are evidently available in Okomu National park.



Figure 2. Okomu National Park Staff.



Figure 3. Ekiuwa Bushmeat Market Nearby Okomu National Park.

Table 4: show the factors threatening crocodile species in Okomu National Park Udo Edo State. Water quality, climate change and food availability have minor threatening rate on the species in the park while pollution, competition and Predation have moderate threatening rate. However, hunting, poaching habitat destruction/degradation, logging, clearance for agricultural activities and Soil erosion have a major threatening impact on the crocodile species in the park.

Table 4. Impact Rate of Threatening Factors on Crocodile Species In Okomu National Park, Udo, Edo State.

S/N	Threatening Factors on Crocodile Species in the Park	RATES OF IMPACT		
		MINOR	MODERATE	MAJOR
1	Water Quality	✓		
2	Climate change	✓		
3.	Hunting and Poaching			✓
4.	Habitat Destruction/Degradation			✓
5.	Pollution		✓	
6.	Food Availability	✓		
7.	Logging and Poaching			✓
8.	Clearance for Agricultural activities			✓
9.	Soil erosion and Degradation			✓
10.	Competition and Predation		✓	

The findings suggest that habitat availability, water quality, climate, hunting and poaching, habitat destruction and degradation, pollution, food availability, predation, and competition are potential factors affecting crocodilian species.

The documentary evidence and images provided further evidence of the impact of human activities on environmental degradation and crocodile abundance in the Niger Delta. Respondents identified logging, poaching, clearance for ag-

gricultural activities, soil erosion, and degradation as major environmental concerns. Figures 4, 5 and 6 corroborate these claims.

These findings and documentary evidence collectively suggest that anthropogenic factors, particularly logging, poaching, and agricultural activities, are significant threats to the environment and crocodilian species in the Niger Delta.



Figure 4. Logs of Timbers seized from Poachers in National Park.



Figure 5. Truck Loaded with timbers seized from Okomu Poachers in Okomu National Park.



Figure 6. Seized Tractor Used for Agricultural Activities at the Outskirt of the park.

4. Discussion

The demographic data presented in Table 1 highlights the gender composition and job roles of the Okomu National Park staff. The predominance of male staff compared to females suggests a significant gender disparity, which is not uncommon in many conservation areas globally [44-46]. This disparity may stem from various factors, including cultural norms, hiring practices, and the challenges women face in pursuing careers in environmental science and park management.

The distribution of roles among respondents indicates that park rangers form the largest group, reflecting the critical nature of field conservation work in protecting biodiversity, following by field researchers and security personnel. The relatively smaller number of drivers may indicate a logistical support aspect rather than direct involvement in conservation efforts. This aligns with findings from other studies emphasizing the importance of well-defined roles within conservation organizations to enhance efficacy and morale [47, 48].

From Table 2, the survey of bushmeat markets near Okomu National Park revealed that dwarf crocodiles are being sold in these markets. It obviously shows the widespread trade of wildlife species including crocodiles, in bushmeat markets across Africa [49, 50]. The sale of dwarf crocodiles in these markets suggests that hunting or poaching activities may be occurring within or around the park, which is a concern for conservation efforts [51]. [52] was of the view that bushmeat trade can have significant impact on wildlife populations, particularly for species with limited ranges or populations, such as the dwarf crocodile. Furthermore, the variation in the number of dwarf crocodiles sold between the two markets may indicate differences in demand or supply chains. According to [53], understanding the dynamics of bushmeat markets is crucial for developing effective conservation strategies. Our findings highlight the need for further research and conservation efforts to protect dwarf crocodile populations and understand the impact of the bushmeat trade on their numbers. This could involve collaborating with local communities, conservation organizations, and government agencies to develop sustainable livelihoods and conservation strategies that balance human needs with wildlife conservation [54].

Table 3, which focuses on the presence of crocodiles in Okomu National Park, reveals a consensus among the surveyed staff about the existence of dwarf crocodiles, affirming their presence. This aligns with current knowledge regarding the habitat of the dwarf crocodile (*Osteolaemus tetraspis*), which is known to inhabit forested areas in West and Central Africa. Studies suggest that proper habitat management is crucial for sustaining such populations [49, 55, 33]. The documentary evidence of crocodiles in Okomu National Park have shown that only dwarf crocodile species are available in the park [56, 57, 24]. The best estimate for the population of dwarf crocodiles in Okomu National Park

comes from [58] study, which estimated the population to be around 1,500 individuals. This estimate was based on a survey of crocodile nests in the park. It is important to note that this estimate is only a rough approximation, and the actual number of dwarf crocodiles in the park could be higher or lower. Regarding the safety of crocodiles, a significant of respondents believe it is safe to encounter them in the park. This might reflect an effective awareness and training program for the staff about the species' behavior and the safety measures necessary when interacting with wild reptiles. However, it is essential to consider that safety perceptions can also be influenced by successful conservation education practices, as referenced in recent literature [58]. The responses to the disturbance of crocodiles indicate an ongoing concern about human activities within the park. With 50% affirming disturbances, it suggests potential issues with human-wildlife conflict that may arise from activities such as poaching or excessive recreational uses. This insight aligns with research in similar ecosystems, which found that disturbances can significantly affect wildlife behavior and population dynamics [59]. Several factors threaten crocodiles in Okomu National Park. One of the biggest threats is habitat loss, as the park is surrounded by farmland and the human population in the area is growing rapidly. This has led to encroachment on the park's boundaries and loss of habitat for the crocodiles. Other threats include poaching and hunting, as well as pollution from nearby industries and farms [60, 61].

The results presented in Table 4 highlight the various factors threatening the crocodile species in Okomu National Park, Udo, Edo State. Water quality, climate change, and food availability have a minor threatening impact on the crocodile species. Recent literature suggests that water quality is a crucial factor in determining the health and well-being of crocodiles [62]. However, in this study, water quality is reported to have a minor impact, indicating that the park's water quality may not be a significant concern for the crocodile population. Climate change is also reported to have a minor impact, which is consistent with other studies that suggest that crocodiles are relatively resilient to climate change [63]. Food availability is also categorized as a minor threat, which may indicate that the park's ecosystem is providing sufficient food resources for the crocodile population. Pollution, competition, and predation have a moderate threatening impact on the crocodile species. Pollution is a significant concern for crocodile populations, as it can affect their health and well-being [64]. Competition and predation are also important factors to consider, as they can impact the crocodile population's dynamics and survival [65]. Hunting, poaching, habitat destruction/degradation, logging, clearance for agricultural activities, and soil erosion have a major threatening impact on the crocodile species. These factors are consistent with other studies that highlight the importance of addressing human-crocodile conflict and habitat preservation [66, 67]. The high impact rate of these factors

suggests that urgent conservation efforts are needed to protect the crocodile population in Okomu National Park.

Furthermore, the documentary evidence indicating timber seizures and the involvement of agricultural machinery on the fringes of the park portrays a concerning reality of poaching and illegal land use that threatens the integrity of Okomu National Park. This is consistent with broader concerns regarding illegal activity in protected areas, which has been extensively documented [68]. The presence of vehicles and equipment tied to poaching emphasizes the urgent need for intensified surveillance and law enforcement efforts. Reports suggest integrated conservation strategies combining local communities in management efforts could mitigate such illegal activities [69, 70].

From the documentary evidence and images of plates obtained from the park, logging and poaching activities in Okomu National Park have severe effects on the biodiversity of organisms in the park. Some of these effects include Habitat loss and fragmentation: Logging and poaching lead to habitat destruction, leaving isolated patches of habitat, making it difficult for species to survive and interact [71]. Population decline: Over-exploitation of species for timber, bushmeat, and other resources reduces population sizes, making them vulnerable to extinction. Disruption of food chains: Removal of key species affects predator-prey relationships, leading to cascading effects throughout the ecosystem [72].

Okomu National Park is home to unique and endemic species found nowhere else, which are threatened by logging and poaching. Soil erosion and degradation: Logging leads to soil exposure, increasing erosion and nutrient loss, affecting plant growth and regeneration. Forest clearance alters water cycles, affecting aquatic life and water quality [57]. Deforestation contributes to climate change, impacting species adapted to specific conditions [73]. Reduced ecosystem resilience: Loss of biodiversity reduces the park's ability to withstand natural disturbances and recover from them. Loss of biodiversity affects livelihoods dependent on forest resources and ecotourism [74]. Logging and poaching have irreversible effects on the park's biodiversity, leading to permanent loss of species and ecosystem functions [75].

5. Conclusion

The demographic profile of the staff and their understanding of crocodile presence highlight essential facets of conservation management within Okomu National Park. On one hand, there appears to be a robust acknowledgment of crocodiles as integral species; on the other, the evidence of poaching poses significant risks to the park's biodiversity. Addressing these challenges requires further emphasis on community involvement in conservation, targeted training for park staff, and enhanced protection measures against illegal activities. Future studies should explore the socio-economic dynamics influencing poaching and the roles of local communities in conservation

success. The research provides evidence of the abundance of dwarf crocodile species in Okomu National Park, Edo State, Nigeria. However, the population is threatened by habitat loss, poaching, hunting, and pollution. Logging and poaching activities have severe effects on the park's biodiversity, including habitat loss and fragmentation, population decline, disruption of food chains, loss of endemic species, soil erosion, water cycle disruption, climate change, reduced ecosystem resilience, and negative impacts on local communities. The long-term consequences of these activities are irreversible, leading to permanent loss of species and ecosystem functions. Therefore, conservation efforts are necessary to protect the dwarf crocodile population and preserve the biodiversity of Okomu National Park. Habitat protection and restoration, anti-poaching and anti-hunting measures, pollution control and mitigation, community engagement and education, sustainable forest management practices continuous monitoring, and research are highly recommended.

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Author Contributions

Israel Omoghene Ogorode: Conceptualization, Field Work, Methodology, Writing - original draft, Data Analysis
Osikemekha Anthony Anani: Writing - review & editing
Ijeoma Favour Vincent-Akpu: Supervision
Bolaji Benard Babatunde: Supervision
Francis David Sikoki: Editing

Ethics Approval and Consent to Participate

Permissions were required from the National Park authorities to study the animals. The permission was approved to carry out the study within a specific time. We accept to participate in the publication of this work.

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Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

STRUCTURED QUESTIONNAIRES ON CROCODILE SPECIES AT OKOMU NATIONAL PARK, UDO EDO STATE, NIGERIA

1. Have you seen a crocodile in this park? Yes/ No
2. Do you think crocodiles in this area are safe from danger? Yes / No
3. Have you experienced any disturbances from the presence of crocodiles around? Yes / No
4. Do you think water quality is a threat to crocodiles in this park?
Minor/ Moderate / Major
5. Do you believe climate change affects crocodiles in this area?
Minor/ Moderate / Major
6. Have you witnessed hunting or poaching of crocodiles in this park?
Minor/ Moderate / Major
7. Do you think habitat destruction or degradation is a threat to crocodiles?
Minor/ Moderate / Major
8. Is pollution a concern for crocodiles in this area?
Minor/ Moderate / Major
9. Do you think food availability is a challenge for crocodiles in this park?
Minor/ Moderate / Major
10. Have you seen logging or poaching activities near crocodile habitats?
Minor/ Moderate / Major

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