Snake diversity and their morphometric parameters in a Guinea Savanna forest of Nigeria

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Received: May 22, 2025 DOI: 10.14295/bjs.v4i9.722

Accepted: July 04, 2025 URL: https://doi.org/10.14295/bjs.v4i9.722

Abstract

Snakes play a crucial ecological role; however, they remain one of the least studied groups of species in Nigeria. Since the last comprehensive evaluation in 2007, no research has been conducted on snake diversity and morphometric characteristics in the study area. We assessed snake diversity and their morphometric parameters in the Guinea savanna forest of Nigeria. Ten transect strips, each measuring 2 km by 10 m, were randomly laid out across five selected ranges. A Visual Encounter Survey was conducted along each transect to observe snake abundance and diversity. Surveys were conducted both during the day (9:00-12:00 h) and at night (19:00-21:00 h). Morphometric parameters of snakes were also measured using a standard procedure. Data were analysed using descriptive statistics and ANOVA at α 0.05. Twenty-one species of snake were identified. *Bitis arietans* had the highest abundance at 38.0%, followed by *Boaedon lineatus* at 15.5%, *Dendroaspis jamesoni* at 8.0%, and *Naja nigricollis* at 7.0%. The least encountered species were *Bitis gabonica*, *Causus lichtensteini*, and *Mehelya crossi*, each at 1.0%. The Ibbi range had the highest diversity index (Simpson's = 0.781 and Shannon's = 1.667), while the Kali range showed the best evenness (0.957). Significant differences were observed in the number of ventral scales (0.023), Inter-orbital length (0.025), snout-vent length (0.004), and head width (0.009) of different snake species. Family Viperidae were shorter (43.29 ± 3.05 cm) in body length compared to Columbridae (95.50 ± 8.77 cm) and Elapidae (81.25 ± 12.67 cm). The results of this study contribute to the limited knowledge of snake diversity in Nigeria. The findings call for further research and conservation efforts to protect these species and their habitats, considering increasing environmental pressures.

Keywords: snake, Kainji lake national park, snake diversity, morphometric parameters

Diversidade de serpentes e seus parâmetros morfométricos em uma floresta de Savana Guineense na Nigéria

Resumo

As serpentes desempenham um papel ecológico crucial; no entanto, continuam sendo um dos grupos de espécies menos estudados na Nigéria. Desde a última avaliação abrangente em 2007, nenhuma pesquisa foi realizada sobre a diversidade e as características morfométricas de serpentes na área de estudo. Avaliamos a diversidade de serpentes e seus parâmetros morfométricos na floresta de Savana Guineense da Nigéria. Dez faixas de transecção, cada uma medindo 2 km por 10 m, foram distribuídas aleatoriamente em cinco áreas selecionadas. Um Levantamento por Encontro Visual foi conduzido ao longo de cada transecção para observar a abundância e a diversidade de serpentes. As observações foram realizadas tanto durante o dia (9:00–12:00 h) quanto à noite (19:00–21:00 h). Parâmetros morfométricos das serpentes também foram medidos utilizando um procedimento padrão. Os dados foram analisados por meio de estatísticas descritivas e ANOVA com nível de significância de α = 0,05. Foram identificadas vinte e uma espécies de serpentes. *Bitis arietans* apresentou a maior abundância (38,0%), seguida por *Boaedon lineatus* (15,5%), *Dendroaspis jamesoni* (8,0%) e *Naja nigricollis* (7,0%). As espécies menos encontradas foram *Bitis gabonica*, *Causus lichtensteini* e *Mehelya crossi*, cada uma com 1,0%. A área de Ibbi apresentou o maior índice de diversidade (Simpson = 0,781 e Shannon = 1,667), enquanto a área de

Kali apresentou a melhor uniformidade (0,957). Diferenças significativas foram observadas no número de escamas ventrais (p = 0,023), comprimento interorbital (p = 0,025), comprimento rostro-cloacal (p = 0,004) e largura da cabeça (p = 0,009) entre as diferentes espécies. As serpentes da família Viperidae apresentaram menor comprimento corporal (43,29 ± 3,05 cm) em comparação com as das famílias Colubridae (95,50 ± 8,77 cm) e Elapidae (81,25 ± 12,67 cm). Os resultados deste estudo contribuem para o conhecimento ainda limitado sobre a diversidade de serpentes na Nigéria. Os achados destacam a necessidade de novas pesquisas e esforços de conservação para proteger essas espécies e seus habitats, considerando as crescentes pressões ambientais.

Palavras-chave: serpente, parque nacional do Lago Kainji, diversidade de serpentes, parâmetros morfométricos

1. Introduction

Kainji Lake National Park is the sole National Park situated within the Guinean savanna forest belt of Nigeria. It is the second largest National Park in the country, surpassed only by Gashaka Gumti National Park, which lies in the Sahelian forest. The park is home to a wide variety of species, including baboons, antelopes, hippopotamuses, and numerous bird species. While extensive research has been conducted on the population, diversity, and distribution of certain species like baboons, and antelopes (Adeola et al, 2014; Odebiyi, (2017; Alawode et al., 2017; Alarape et al, 2019; Ajayi et al, 2020) there is limited information available about the herpetofauna species within this protected area.

In Nigeria, some studies have been conducted on reptiles; however, they are mostly in the Eastern and Southern parts of Nigeria (Akanni et al., 2014; Luiselli et al., 2020), with little or no study conducted in the savanna forest region (Lotanna et al., 2019). Research on reptiles, especially snakes in the area, is poorly studied. Approximately 440 species of reptiles have been recorded globally (Uetz et al., 2021), with about 20% of these species classified as threatened (Tingley et al., 2016). Studies indicate that the functional diversity of reptiles is declining (Gibbons et al., 2000; Filippi and Luiselli, 2006; Matouka et al., 2020).

This decline is further compounded by a lack of comprehensive data on many snake species, which hampers effective conservation efforts (Dodd, 1993). Without adequate information on their population sizes, distribution, and threats, it is challenging to develop and implement strategies to protect these reptiles. Snakes, as key representatives of reptiles, have been significantly impacted by environmental degradation and urbanization (Seigel and Mullin, 2009; Bonnet et al., 2016) despite their ecological importance in the ecosystem (Alves; Filho, 2007; Beaupre; Douglas, 2009).

Another factor contributing to their decline is hunting, as snakes are sought after for their medicinal properties, religious rituals, the pet trade, and various other uses (Soewu, 2008; Pandey et al., 2016; IUCN, 2018). In Nigeria, cultural attitudes towards consuming snakes vary. While some cultures permit eating snakes, others strictly forbid it. For instance, the Edo people and many tribes in Northern Nigeria prohibit killing or eating pythons, and some even forbid the consumption of any snake species. In contrast, snakes are considered a delicacy in the Western and Eastern regions of Nigeria. Venom extraction for medical purposes is commonly done from various species of cobras, vipers, and pit vipers. In most regions, both venomous and non-venomous snakes are used for traditional medicine. Although research is still replete with the intensity of hunting snakes for this purpose.

Understanding the diversity, distribution, and abundance of snake populations is urgently needed to establish a comprehensive database of their current population status. This study assessed snake diversity in Kainji Lake National Park since it was last conducted in 2007 (Ayeni, 2007), indicating a significant gap in research. The distribution and abundance of snake species across various ranges within the park were also investigated, providing an updated record of snake species. It also offers insights into how snake populations are spread out and how dense these populations are in different areas with an updated IUCN status (IUCN, 2024). The morphometric parameters of these species were also investigated for the first time since the Park's establishment, forming baseline data for future research. This knowledge will help identify interspecific and intraspecific variations and provide essential indicators for developing effective conservation management strategies.

2. Materials and Methods

2.1 Study area

Kainji Lake National Park (KLNP) is in the northwestern part of Nigeria between Niger and Kwara state, close to the border with the republic of Benin (Ezealor, 2002). The park is about 560 Km North of Lagos and 385 Km southwest of Abuja, the Federal Capital (Ayeni, 2007). The two sectors (Borgu and Zugurma) of the park lie approximately between latitudes 9o4” N and 10030” N and between longitudes 30030’E and 5005’E. The two sectors cover a total area of 5,340.82 Km2 and are separated by the Kainji Lake, a Lake constructed on River Niger for hydroelectric power generation (Aremu et al., 2002).

The annual rainfall in the park varies between 975mm and 1,220mm (Ayeni 2007). Temperature is relatively stable along the year, but trends show a rise starting in January, reaching a peak in March/April (mean monthly T = 37.68 ± 2.95 °C), followed by a decline coinciding with the onset of rains, reaching its minimum in August (mean monthly T = 23.4 ± 2.82 °C) (Oni et al, 2024). The park is home to approximately 59 plant families, encompassing over 252 plant species, including ten monocotyledons and 49 dicotyledons (Ayeni, 2007). Prominent tree species in the park include Detarium microcarpum, Burkea africana, Afzelia africana, Acacia species, and Isoberlinia tomentosa (Ezealor, 2002).

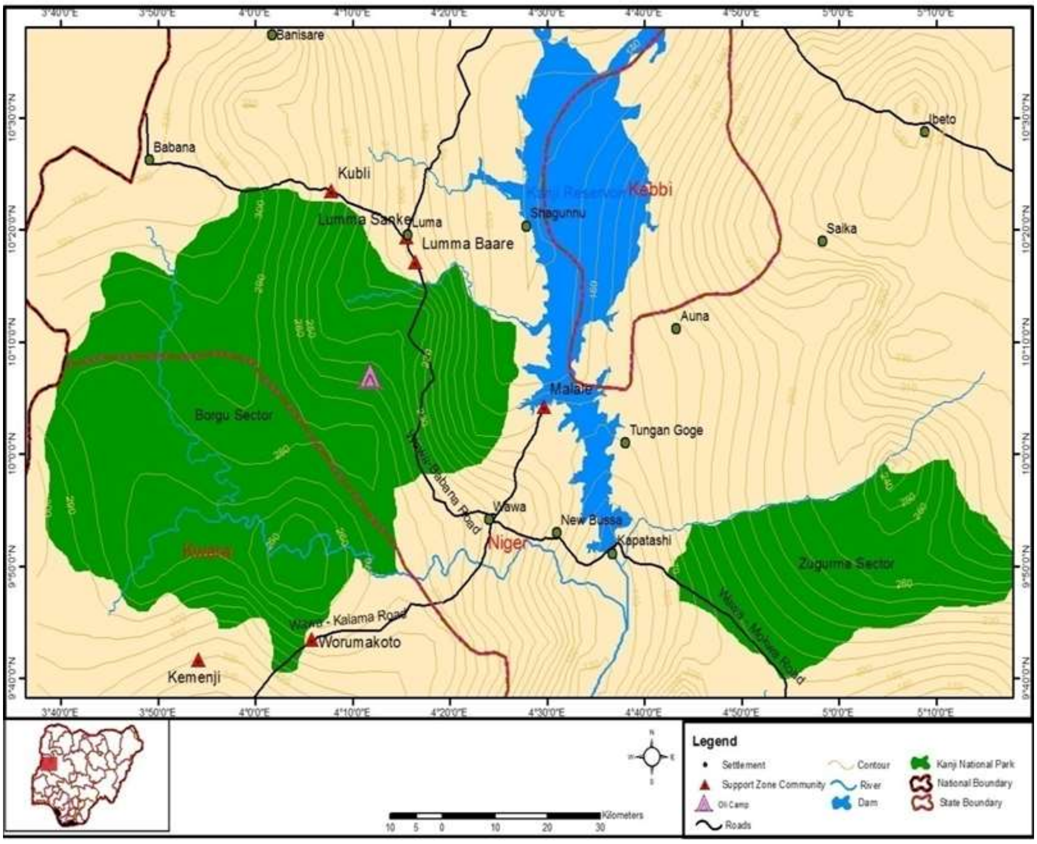

Figure 1. Map of the study area. Source: Lateef, 2021.

2.3 Data Collection

Ten transect strips of 2 km x 10 m each were laid in five ranges (Oli, Kuble, Doro, and Kali in Borgu sector and Ibbi range in Zugurma), randomly selected from seven ranges in KLNP. A Visual Encounter Survey (VES) was conducted along each transect to assess snake diversity and relative abundance, following a structured approach with transect lines and time limits as outlined by Eniang et al. (2004). Visual walks were performed along the transects to document the snake species present in the area.

Given the secretive nature of snakes, this method was combined with refuge examinations. During both visual searches and refuge checks, the different habitat types were thoroughly observed. Daytime searches were conducted between 9:00 AM and 12:00 PM, the time when most snakes bask in the sun, while nighttime searches occurred from 7:00 PM to 10:00 PM, coinciding with the activity of nocturnal snakes. Each visit was replicated twice a month during both the dry season (December–April) and the wet season (June–October) over two consecutive years (2017–2018)

In the dry season and areas of limited habitat disturbance, trails of snakes were easily observed, especially on the sandy soil. It was equally easy in the rainy season to recognize snake trails on the wet soil. Some trails led to active holes of some snake. Such holes or refuges were explored by excavating the hole or turning up the refuge. Upturned refuges were carefully restored to their formal position after the study. Apart from direct observation on the field, Dead snakes from the communities at the buffer zone of the park were collected with the help of representatives from each village and examined. Data collected in the area throughout the survey were pooled together at the end of each month to monitor seasonal changes or trends in mortality of each snake species. Keys in Dunger (1973) and Eniang (2004) were used for snake identification in this study.

To obtain the morphometric parameters of snakes, a reptile tong was used to safely hold, prod, and turn the snakes for examination. For dead snakes, they were examined only after being carefully confirmed dead. If a snake was motionless, it was grasped firmly at the sexual aperture with the tongue and submerged in an alcohol solution to ensure it was not in a coma. Once confirmed dead, key morphological measurements were taken. Sex determination was performed by inserting a small probe into the snake's cloaca.

The probe was gently inserted in a caudal direction; if it stopped just behind the cloacal opening, the snake was identified as female. If the probe continued several centimeters deeper due to the presence of hemipenes, it was identified as male. Additionally, male snakes typically have a long, gradually tapering tail with no noticeable distinction from the anal plate, while females have an abruptly tapering tail at the point of the sexual aperture or anal plate (Doan, 2003).

The flexible tape was run along the length of the snake’s body. The measuring tape was used to measure the SVL of the snake to the nearest millimeter. The measurement was made from the tip of the snake's snout down to its vent. The measurement was repeated 3 times to ensure accuracy. Scales on the snakes that were counted include: ventral, subcaudal, and dorsal rows. To count the ventral (beginning at the “neck” and extending to the vent), subcaudal (from the vent to the tip of the tail), and dorsal scale rows

3. Results

3.1 Families and species of snakes

A total of 79 individual snakes from six families: Atractaspids, Colubrids, Elapidae, Pythonidae, Typhlops, and Viperidae were identified to species level. *Bitis arietans* (Viperidae) had the highest individual, followed by *Boaedon lineatus*, and *Dendroaspis jamesonii* (Elapsidae) had the least.

Sixteen species (*Atractaspis irregularis*, *Boaedon lineatus*, *Boaedon virgatus*, *Boaedon fuliginosus*, *Naja nigricollis*, *Grayia smithii*, *Limaformosa crossi*, *Mehelya poensis*, *Thrasops flavigularis*, *Naja nigricolis*, *Bitis arietans*, *Causus maculatus*, *Causus lichtensteini*, *Boaedon fuliginosus*, *Dendroaspis jamesoni*, and *Echis ocellatus*) are of least concern, with two (*Atractaspis irregularis* and *Naja melanoleca*) currently decreasing according to the IUCN status (Table 1). Two species (*Python sebae* and *Python regius*) identified in the area are Near threatened and are currently decreasing, and two (*Bitis nasicornis* and *Bitis gabonica*) are vulnerable and decreasing (Table 1).

Table 1. Snake diversity in Kainji Lake National Park.

S/N	F**amily**	Scientific name	Commo Name	Frequency	Percentage	IUCN S**tatus**
1	Atractaspidae	*Atractaspis irregularis**	Burrowing asp	2	2.5	Least Concern (LC), decreasing
2	Colubridae	*Boaedon lineatus**	Striped house snake	12	15.2	LC, stable
		*Boaedon fuliginosus**	African house snake	3	3.8	LC
		*Boaedon virgatus**	Hallowell's house snake	2	2.5	LC, Unknown
		Grayia smithii	Smith's African water snake	2	2.5	LC, Stable
		Limaformosa crossi	Crosse's file snake	2	2.5	LC, Unknown
		*Mehelya poensis**	Equatorial file snake	1	1.3	LC, Unknown
		*Thrasops flavigularis**	Yellow throated bold-eyed tree snake	1	1.3	LC, Unknown
3	Elapidae	*Dendroaspis jamesoni*	Jameson's mamba	6	7.6	LC, Stable
		*Dendroaspis viridis**	Western green mamba	1	1.3	LC, stable
		Naja nigricollis	Black-necked spitting cobra	4	5.1	LC, Unknown
		Naja melanoleca	Forest cobra	2	2.5	LC, Decreasing
4	Pythonidae	*Python sebae*	Central Africa rock python	3	3.8	Near threatened, Decreasing
		Python regius	Ball python	1	1.3	Near threatened, Decreasing
5	Typhlopidae	*Typhlops* spp	Blind snake	3	3.8	-
6	Viperidae	*Bitis arietans*	Puff adder	28	35.4	LC, Stable
		*Bitis nasicornis**	Rhinoceros viper	1	1.3	Vulnerable, decreasing
		Bitis gabonica	Gaboon viper	2	2.5	Vulnerable, decreasing
		Causus maculatus	Spotted night adder	1	1.3	LC, Stable
		*Causus lichtensteini**	Forest night adder	1	1.3	LC, Stable
		Echis ocellatus	African saw-scaled viper	1	1.4	LC, Stable

Source: Authors, 2025.

Also, our study documented eight (8) new snake species (Atractaspis irregularis, Boaedon lineatus, Boaedon virgatus, Boaedon fuliginosus, Mehelya poensis, Causus lichtensteini, and Boaedon fuliginosus) that have not been recorded in the study area (Table 1). From the five ranges, snake diversity was highest in Ibbi's range and least in Kali range, while evenness was higher in Kali range (Table 2).

Table 2. Snakes' diversity, abundance, and evenness Index across the ranges.

	OLI RANGE	KALI RANGE	KUBLE RANGE	DORO RANGE	IBBI RANGE
Taxa S	6	3	4	4	6
N	29	15	24	15	24
Dominance D	0.243	0.360*	0.281	0.280	0.219
Diversity (Simpson's)	0.757	0.640	0.719	0.720	0.781*
Diversity (Shannon's)	1.586	1.055	1.321	1.332	1.667*
Evenness H/S	0.814	0.957*	0.937	0.947	0.883
Brillouin	1.175	0.680	0.928	0.819	1.102
Menhinick	1.664	1.342	1.414	1.789	2.121
Margalef	1.949	1.243	1.443	1.864	2.404
Equitability J	0.885	0.960*	0.953	0.961	0.931
Fisher alpha	4.322	3.167	3.184	9.284	10.910
Berger-Parker	0.385	0.400	0.375	0.400	0.375

Note (*) this signifies the highest value. Source: Field survey, 2025.

The morphometric parameters were significantly different among snake species (Table 3).

Table 3. Analysis of variance of snake morphometrics among species in KLNP.

Morphmetrics Parameter	df	MS	F	P-level
Head length				
`	6	3.386	8.261	.000*
Error	49	0.410		
Head Width				
Treatment (species)	6	0.487	3.235	0.009*
Error	49	0.151		
Inter-Orbita length				
Treatment (species)	6	0.182	2.685	0.025*
Error	48	0.068		
Snout-Vent length				
Treatment (species)	6	6307.181	3.777	0.004*
Error	50	1669.704		
Number of Ventral Scales				
Treatment (species)	6	3327.464	2.716	0.023*

Source: Authors, 2025.

Viperidae were shorter (43.29 cm) in body length compared to Colubridae (95.50 cm) and Elapidae (81.25 cm) (Table 4), indicating significant interfamily variation in body size, which may reflect differences in ecological adaptation, habitat preference, and predatory strategies among the snake families.

Table 4. Average morphometric parameters of Snakes in Kainji Lake National Park.

Family	*Species*	Sex	Head length (cm)	Head Width (cm)	Intral orbital length(cm)	Snout vent Length (cm)	Number of ventral **scales**	Tail Length (cm)
	Boaedon lineatus							
		F	3.05±0.32	0.90±0.29	0.83±0.09	84.88±4.81	195±16	27.05±5.16
Colubridae		M	2.80±0.30	1.23±0.19	0.90±0.06	95.50±8.77	203±15	39.88±4.21
	Boaedon fuliginosus							
		M	2.80±0.50	1.75±0.25	0.95±0.05	71.30±0.30	242±33	11.50±1.00
		F	2.16±0.09	0.69±0.13	0.54±0.05	43.29±3.05	158±04	5.76±0.4
Viparidae								
	Bitis arientans	M	1.90±0.21	1.19±0.18	0.75±0.12	43.29±3.05	177±18	7.23±1.92
	Causus maculatus	M	1.47±0.09	0.87±0.07	0.57±0.09	32.53±2.24	164±03	3.13±0.57
Elapidae								
	Naja nigricolis	M	2.40±0.10	1.03±1.45	1.07±0.43	61.00±3.06	193±14	31.83±1.88
	Dendroaspis jamesoni	F	2.88±0.16	1.28±0.15	0.70±0.06	81.25±12.67	180±06	32.63±0.67

Source: Authors, 2025.

4. Discussion

Our study identified six snake families, consisting of five species of vipers, four species of elapids, two species of pythons, two species of typhlopids, and five species of colubrids. A previous study by Ayeni (2007) identified five families but did not include Atractaspidae. While our study recorded a higher number of snake families, there were both similarities and differences in the species identified compared to earlier research. For instance, both our study and Ayeni (2007) documented species such as *Python sebae*, *Python regius*, *Bitis gabonica*, *Bitis arietans*, *Causus maculatus*, *Echis ocellatus*, *Dendroaspis jamesonii*, *Naja nigricolis*, *Naja melanoleuca*, *Grayia smythii*, and *Limaformosa crossi*.

However, twelve species previously recorded, including *Natriciteres olivaceus*, *Lamprophis* sp., *Philothamnus heterodermus*, *Philothamnus irregularis*, *Boiga blandingii*, *Thrasops flavigularis*, *Rhamnophis aethiopissa*, *Dasypeltis fasciata*, *Psammophis philipsii*, *Psammophis sibilans*, *Thelothornis* sp., and *Atheris squamigera*, were not found in our study. Additionally, we identified eight new species that had not been previously recorded in the study area, including *Atractaspis irregularis*, *Boaedon lineatus*, *Boaedon virgatus*, *Boaedon fuliginosus*, *Mehelya poensis*, *Causus lichtensteini*, and *Boaedon fuliginosus*. It is difficult to compare the population density between our study and Ayeni's (2007), as his research was based on species presence and absence without specific population counts.

Overall, we identified 21 snake species, which is fewer than the number reported in Ayeni's (2007) study. Each species has a distinct range, shaped by the interaction between ecological conditions and evolutionary history. The presence or absence of certain species could be due to their behavioral patterns, such as hiding in burrows or using camouflage, which makes them difficult to detect. As noted by Stratterfield et al. (1998), biodiversity distribution is influenced by ecological factors like temperature, moisture, soil composition, seasonality, topographical variations, and prevailing climatic conditions. However, our study did not account for these factors as potential influences on the diversity and population of the species recorded.

Atractaspis irregularis was absent in the previous study, likely due to its burrowing nature, which makes it difficult to detect. Interestingly, *Bitis nasicornis*, typically associated with rainforests (Chippaux, 2006; Luiselli, 2006; Chirio; LeBreton, 2007), was recorded in the study area. This may be attributed to the presence of evergreen forests around perennial waterholes in the park. *Bitis arietans*, *Boaedon lineatus*, and *Dendroaspis jamesoni* were the most abundant species recorded in the park. The dominance of these species suggests that they are either more abundant or more easily detected in the surveyed area. This could also be due to their ecological preferences, reproductive rates, or adaptability to the local environment. Gashaw et al. (2022) also recorded higher numbers of these species, linking them to similar ecological and local environments, such as open grassland and wooded savanna, as observed in our study area.

Our study revealed that the Viperidae family exhibited the highest abundance of individual species, followed by the Colubridae family. This contrasts with the findings of Ombugadu et al. (2022), who reported a greater abundance of Elapidae compared to Viperidae in a similar savanna environment. The discrepancy may be attributed to the differences in study locations, as their research was conducted in a more developed, academic setting, while our study was carried out in a protected area with less human disturbance.

Our results are consistent with those of Luca & Akanni (1999) and Eniang & Ijeomah (2011), who also recorded a higher abundance of Colubridae in rainforest habitats. Furthermore, historical data from a survey conducted by Shine & Spawls (2020) in East Africa similarly showed a higher abundance of Colubridae species. This suggests that the Colubridae family may exhibit a broad ecological adaptability, thriving in both savanna and rainforest environments. These findings highlight the potential influence of habitat type and human activity on the distribution and abundance of snake families and underscore the need for further research to explore these patterns across different ecosystems.

The Ibbi range exhibited a higher snake diversity index compared to the Kali range, which had the lowest diversity index. This suggests that the Ibbi range may offer more suitable habitat conditions for snakes than the other ranges. However, despite having a lower diversity index, the species in the Kali range were more evenly distributed, indicating no single species dominates the area. This even distribution may reflect a balanced ecosystem in the Kali range. Although our study did not explore the impact of habitat on snake diversity and distribution, future research could examine the relationship between habitat structure and snake diversity to provide more definitive explanations for these patterns.

In terms of body length, Viperidae were significantly shorter, Colubridae were the longest, and Elapidae exhibited an average body length. The shorter body length of Viperidae may be an adaptation to specific environmental conditions, such as dense vegetation or rocky terrain, which suits their ambush predation strategy, requiring minimal movement. In contrast, the longer bodies of Colubridae likely facilitate active hunting and greater mobility across more open or complex environments. The intermediate body length of Elapidae may reflect a balance between ambush and active hunting strategies. These significant variations in morphometric traits across snake families indicate adaptations to different ecological niches and lifestyles. Such insights are vital for informing targeted conservation strategies and for understanding the ecological dynamics of snake populations within these regions.

As noted by Gibbons et al. (2000) and Filippi & Luiselli (2006), environmental conditions, including habitat types, resource availability, human activities, and local ecological characteristics, play a significant role in shaping snake diversity, distribution, and morphometrics (Seigel; Mullin, 2009; Bonnet et al., 2016). A thorough understanding of these environmental factors is essential for developing effective wildlife conservation and management strategies, as they provide insight into the observed patterns within snake populations and help guide future research and conservation efforts.

5. Conclusions

Kainji Lake National Park stands as one of the few remaining refuges for wildlife biodiversity within Nigeria's Savanna Ecosystem. Despite the significant encroachment by hunters, the park continues to support a diverse array of snake species. In total, twenty-one snake species were identified within Kainji Lake National Park, with *Bitis arietans* and *Boaedon lineatus* being the most dominant species in the study area. Snakes belonging to the Viperidae family were generally shorter in length compared to those in the Elapidae and Colubridae families. To ensure the survival of various snake species in their preferred habitats, effective management practices should focus on regular inventories of wildlife resources and the maintenance of natural ecosystems.

6. Authors' Contributions

David Olayinka Oyeleye: designed the study and collected the data, processed and analyzed the data. *Funmilayo Lewiska Oni*: processed and analyzed the data, initial draft of the manuscript was written. *Gbolagade Akeem Lameed*: designed the study and collected the data. All contributing authors actively engaged in revising and reaching consensus on the final version for publication.

7. Conflicts of Interest

No conflicts of interest.

8. Ethics Approval

Not applicable.

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Funding

Not applicable.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.