

Species diversity and distribution of dwarf crocodile (*Osteolaemus tetraspis*) in bushmeat markets in Benin metropolis, Edo State, Nigeria

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ABSTRACT

This study investigated the diversity and distribution of dwarf crocodiles in eight bushmeat markets in Benin City, Edo State, Nigeria. The markets surveyed were New Benin, Oliha, Uselu, Oba Market, Ekiuwa, Ugbighokogho, Evbotubu, and Third Market between October 2022 and May 2023. A multi-method approach was employed, combining observation and measurement techniques. The Shannon-Wiener Index (H'), Simpson's Index (D), and Species Evenness (E) were calculated to determine the diversity and distribution of dwarf crocodiles. The results showed that Ekiuwa and Ugbighokogho markets had the highest Shannon-Wiener Index (H') values of 0.84 and 0.86, respectively, indicating higher species diversity.

These markets also had the lowest Simpson's Index (D) values of 0.41 and 0.39, respectively, indicating lower species dominance. Additionally, Ekiuwa and Ugbighokogho markets had the highest Species Evenness (E) values of 0.92 and 0.94, respectively, indicating a more even distribution of individuals among species. However, when considering the monthly variation, Oliha, Ugbighokogho, and 3rd Market had the highest Shannon-Wiener Index (H') values of 1.05, 1.06, and 1.05, respectively, indicating higher species diversity. The results suggest that some markets have higher species diversity and evenness, indicating a more sustainable trade. The study recommends that conservation efforts focus on regulating the trade in dwarf crocodiles and promoting sustainable harvesting practices.

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Introduction

Crocodiles and other reptiles serve various purposes in tropical regions, where they are utilized for food, traditional medicine, and ornamental items (Alves *et al.*, 2006, 2008, 2009, 2013). In areas where crocodilians coexist with human populations, local attitudes towards them can range from tolerance to hostility. Despite this, crocodiles can offer economic value through regulated harvesting, particularly in the skin trade (Caldwell, 2014). Beyond material benefits, communities may be encouraged to conserve crocodiles due to their ecological significance in sustaining wetland ecosystems (Van der Ploeg *et al.*, 2011).

In parts of West Africa, rural populations show reverence for crocodiles, often protecting them due to traditional beliefs. In certain cultures, crocodiles are symbolically linked to water availability, where their disappearance is feared to result in water scarcity (Kpéra, 2003; Kpéra *et al.*, 2004). The dwarf crocodile (*Osteolaemus tetraspis*), endemic to Africa, is the smallest extant crocodile species, easily recognized by its compact size, flattened skull, narrow snout, and characteristic body armor. It inhabits swamps, marshes, and dense forests, preying on aquatic organisms like fish, snails, and crabs. Adults typically grow up to 1.9 meters and weigh between 18 to 32 kilograms (Pauwels *et al.*, 2007; Douglas, 2010; Sprawl *et al.*, 2012; Shirley *et al.*, 2016). Anatomical adaptations, such as thick body armor and osteoderms, enhance

its survival. The species' cranial structure is similar to the Cuvier dwarf caiman, suggesting ecological convergence. It also displays a unique dental formula, including 4 premaxillary and 12-13 maxillary teeth (Walmsley *et al.*, 2013).

Two subspecies exist: the West African dwarf crocodile (*O. tetraspis*) and the Congo dwarf crocodile (*O. osborni*), each adapted to distinct environments within tropical West and Central Africa. These habitats, rich in aquatic and terrestrial biodiversity, support the survival and reproduction of *O. tetraspis*, which prefers forested and shaded areas and avoids large water disturbances (Sprawl *et al.*, 2012; Amoah *et al.*, 2021). Cave use, observed in western Gabon, may serve as a mechanism to maintain genetic diversity (Gabbatiss, 2016). Primarily nocturnal, *O. tetraspis* forages at night and remains concealed during daylight in burrows or beneath tree roots. This behavior minimizes exposure to predators and environmental stressors (Numbere & Chimezie, 2020). Its diet is flexible and varies regionally—primarily fish in the Democratic Republic of Congo, and more commonly snails and crabs in Nigeria. Plant matter occasionally appears in their diet, likely ingested incidentally (Pauwels *et al.*, 2007; Sprawl *et al.*, 2012). Breeding occurs during the rainy season (May-June), with females constructing nests of decaying vegetation near water. Eggs hatch after 85-105 days, and hatchlings measure around 28 cm. Clutches typically contain up to 10 eggs, although some can hold as many as 20 (Somaweera *et al.*, 2013). Both *O. tetraspis* and *O. osborni* are classified as vulnerable by the IUCN. However, population data remain limited due to insufficient research. Habitat degradation and hunting for bushmeat are believed to be the primary threats. Despite being found in several protected areas, the species faces local extinction risks in countries like Gambia and Liberia. Although the demand for their skins is relatively low, they are still hunted for subsistence purposes (Smolensky, 2015).

These crocodiles are kept in captivity in North America and Europe, where they are commonly bred in zoos. However, taxonomic uncertainties persist, particularly in regions like Nigeria, where many captive individuals may be hybrids (Shirley *et al.*, 2015). Although there is documented folklore about crocodiles in West Africa (Kpéra *et al.*, 2014), detailed knowledge of human-crocodile relationships remains sparse (Akani *et al.*, 1999; Aust, 2009; Pooley, 2016; Rice, 2018; Brackhane *et al.*, 2018; 2019; Somaweera *et al.*, 2019). While studies of crocodile ecology are growing in West Africa (Shirley *et al.*, 2009, 2018), particularly in Nigeria (Luiselli *et al.*, 1999a, 1999b, 2012), there is a significant gap in research on local perceptions regarding crocodile abundance and their utility for food or income.

Therefore, this research paper aims to investigate the species diversity and distribution of *Osteolaemus tetraspis* within the bushmeat markets in Benin Metropolis.

Materials and Methods

Study area

Benin City serves as the capital and largest metropolitan center of Edo State, situated in southern Nigeria. Notably, it ranks as the fourth-most populous city in Nigeria, according to the 2006 national census, preceded only by Lagos, Kano, and Ibadan. Benin City is located near the Benin River, situated approximately 40 kilometres (25 miles) to the north, whilst its eastern perimeter lies

320 kilometres (200 miles) from Lagos via the arterial road network. The city's municipal boundaries converge with those of several prominent neighboring towns in southern Nigeria (Fabolude & Aighewi, 2022), notably Agbor, Oghara, and Ekpoma. Benin City boasts an exceptionally fertile agricultural landscape and serves as the epicentre of Nigeria's thriving rubber industry (Ojo, 2024). Additionally, the production of palm oil constitutes a substantial sector, further underscoring the city's prominence in Nigeria's agricultural economy.

Benin has a population of over 10 million. Around 70% of the working population depends on agriculture. Benin has produced yams, cassava, corn (maize), millet, beans, and rice since the mid-1980s to achieve self-sufficiency in these staple foods. The vegetation regions can be divided into five major types: forest, grassland, tundra, desert, and ice sheet. Climate, soil, the ability of soil to hold water, and the slope, or angle, of the land all determine what types of plants will grow in a particular region.

Benin City exhibits a borderline tropical savanna climate (Köppen: *Aw*), closely approaching a tropical monsoon climate (*Am*). The city's climatic conditions are characterized by persistently high temperatures and humidity levels throughout the year (Aruya-Emmanuel, 2020).

Edo state where Benin City is situated has a tropical wet and dry or savanna climate. The city's yearly temperature is 28.78°C (83.8°F) and it is -0.68% lower than Nigeria's averages (Aruya-Emmanuel, 2020) The weather in Benin City is typically hot and humid, with average temperatures ranging from 25 to 30°C (77 to 86°F) throughout the year. The relative humidity is consistently high, often exceeding 60% (Balogun *et al.*, 2023). While the city experiences a relatively uniform climate throughout the year, there is discernible seasonal variation. The period between July and September is particularly notable for its dull and overcast weather conditions, with reduced sunshine and increased precipitation (Odiana & Idahosa-Ohio, 2023; Floyd *et al.*, 2016) (Figure 1).

Study site/site selection

This study was carried out across eight bush-meat markets (New Benin, Oliha, Uselu, Oba Market, Ekiuwa, Ugbighokogho, Evbotubu, and Third Market) within the Benin Metropolis, Edo State. Benin City, situated in the south-south geo-political region of Nigeria, is a major urban hub with coordinates 6.3350° N, and 5.6037° E, as shown in Figure 1 above. It is about 64 kilometres from the Gulf of Guinea, and it serves as a significant industrial and cultural center. The city's economy thrives on rubber and oil production (Ikponmwosa, 2020), with a population nearing 1.2 million (Balogun & Onokerhoraye, 2017). Benin City's residents predominantly trace their heritage to the rich Edo culture. Visitors can explore various attractions, including historic palaces, museums, lush parks, and vibrant cultural festivals that take place throughout the year (Ogoanah and Omejife, 2017).

Data collection and sampling technique

Eight to ten crocodile traders each were sampled from the eight bushmeat markets. The bushmeat markets include New Benin, Oliha, Uselu, Oba Market, Ekiuwa, Ugbighokogho, Evbotubu, and Third Market.

This study employed a multi-method approach, combining observation and measurement techniques. At the bushmeat market, the number and species of crocodiles were counted and

recorded. To facilitate measurement, graduated sticks and tape rules were used, enabled by the fact that many crocodiles were restrained or weakened (Eniang *et al.*, 2020). The measured crocodiles were categorized into three size groups: Small Sized Dwarf Crocodile (SSDC, 50-60 cm or approximately 2ft), Medium Sized Dwarf Crocodile (MSDC, 70-90 cm or approximately 3ft), and Large Sized Dwarf Crocodile (LSDC, 100-120

cm or approximately 4ft) (San-Diego, 2015). Additionally, interviews and focused-group discussions involving recorded oral interviews were conducted to understand how marketers acquire, preserve, and trade these crocodile species, whether dead or alive, until they are sold (Ogorode *et al.*, 2023; Eniang *et al.*, 2020). The dwarf crocodiles shaded for sale are represented in Figure 2 and 3.

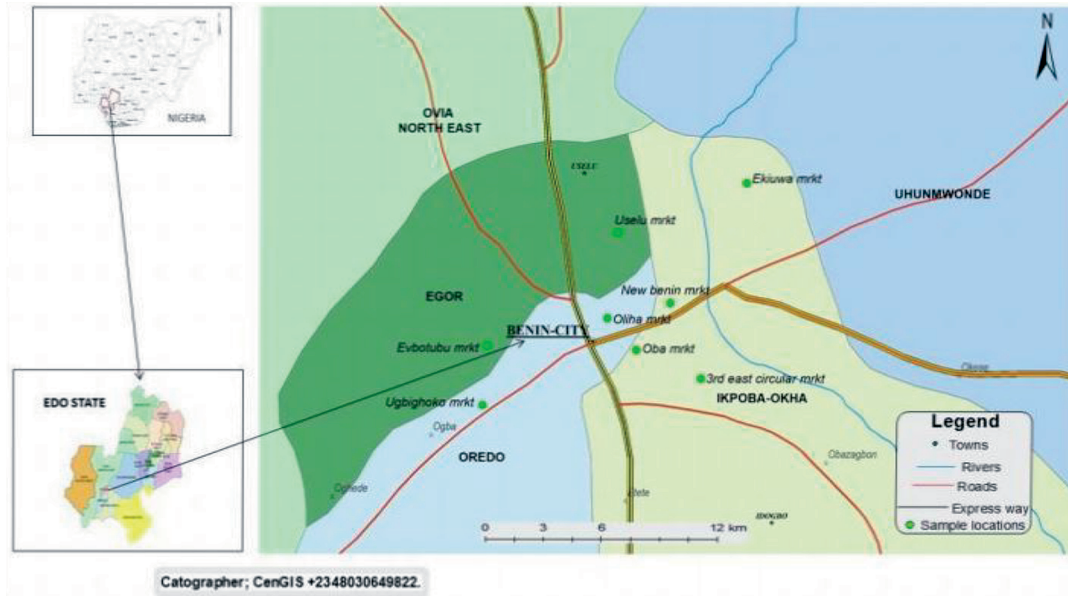


Figure 1. Map of study area showing the metropolitan locations which includes: Oredo, Egor, Ikpoba-Okha Ekenwan, Etsako-West Ovia North East with Ikpoba Slope, a long sloppy hill in the middle of the town, Benin City and a large River with a bridge at the extreme. Each of the locations has a market where bushmeats such as crocodiles, Pangolins, antelopes, land snails and so on are sold as represented on the map.



Figure 2. Dwarf crocodile shaded for sale at the Oliha Market, Benin City. The species shaded on the table are tied with ropes on their legs to ensure that they cannot move from one position. The mouth is opened and castrated with a stick then tied with a rope to avoid dangerous bites on customers and the sellers. This captivity technique makes the animal weak and become nearly dead on the table. The species is black in color with armored skin for protection and defense.



Figure 3. Freshly supplied dwarf crocodile shaded at Ekiuwa market for sale. The species are lined up according to their sizes. Being tied with ropes on their legs to their body to avoid movement and mouth castrated with sticks to avoid biting. The tails of the species are well decorated with sharp blades which are flipped at random when still very active. They are shaded on the table for visibility. Other animals like land snails, pangolins and antelopes are shaded and hunged for visibility close to the crocodile.

Data analysis/statistical analysis

The Shannon-wiener index (H) representing diversity, Simpson index (D) representing dominance of species, and Species evenness (E) representing distribution among species were employed to analyse the data collected:

Shannon-Wiener Index (H') $H' = - \sum (ni/N) * \ln(ni/N)$
 where ni is the abundance of species i, and N is the total abundance.

Simpson's Index (D) $D = \sum (ni/N)^2$

Species Evenness (E) $E = H'/\ln(S)$.
 where S is the number of species.

Results

From Table 1, a total of 8 traders were interviewed at intervals in each market, providing valuable insights into the bushmeat trade. According to the traders, the bushmeat markets have been in existence for over a century, with 2 traders confirming this. The traders also reported that they bring bushmeats and crocodiles to the markets frequently, depending on sales and requests by traders. This was confirmed by 4 traders. In terms of preservation methods, 3 traders reported that dead crocodiles are preserved through roasting or smoking. The traders also provided information on the sales volume of crocodiles. According to 5 traders, the weekly average sales range from 5 to 10 crocodiles. The study also investigated the uses of crocodile species. According to 5 traders, the crocodile species is used largely for medicinal purposes, with a few used for food and very few resold for money. The traders reported that they obtain croco-

diles from hunters and fishermen and sometimes travel to the riverside. This was confirmed by 5 traders.

From Table 2, the Calculated H' values for the diversity of species in different markets include: New Benin (0.69), Oliha (0.73), Uselu (0.63), Ekiuwa (0.84), Ugbighokogho (0.86), Evbotubu (0.65), 3rd Market (0.71) while the calculated D values in the market read: New Benin (0.53), Oliha (0.51), Uselu (0.58), Ekiuwa (0.41), Ugbighokogho (0.39), Evbotubu (0.56), 3rd Market (0.52). The Calculated E (Species evenness) values read: New Benin (0.83), Oliha (0.85), Uselu, (0.79), Ekiuwa (0.92), Ugbighokogho (0.94), Evbotubu (0.81), Third Market (0.84). The results suggest that: Ekiuwa and Ugbighokogho markets have the highest Shannon-Wiener Index (H') values, indicating higher species diversity, Secondly, Ekiuwa and Ugbighokogho markets also have the lowest Simpson's Index (D) values, indicating lower species dominance. Ekiuwa and Ugbighokogho markets have the highest Species Evenness (E) values, indicating a more even distribution of individuals among species. From the results obtained, Ekiuwa and Ugbighokogho stand out.

From Table 3, the Calculated H' values for diversity of the dwarf crocodile species read: New Benin (1.03), Uselu (1.01), Oba (1.02), Ekiuwa (1.04), Oliha (1.05), Ugbighokogho (1.06), Evbotubu (1.04), Third Market (1.05). The Calculated D values for the Simpson index for dominance of dwarf crocodiles read: New Benin (0.55), Uselu (0.57), Oba (0.56), Ekiuwa (0.54), Oliha (0.53), Ugbighokogho (0.52), Evbotubu (0.54), Third Market (0.53). The Calculated E values for species evenness read: New Benin (0.83), Uselu (0.81), Oba (0.82), Ekiuwa (0.84), Oliha (0.85), Ugbighokogho (0.86), Evbotubu (0.84), Third Market (0.85).

The results suggest that Oliha, Ugbighokogho, and Third Market have the highest Shannon-Wiener Index (H') values, indicating higher species diversity. Oliha, Ugbighokogho, and Third

Table 1. Oral questions in bushmeat markets in Benin metropolis, Benin City, Edo State, Nigeria.

| S/N | Oral questions | General response presented by traders | Numbers of traders' interview at intervals in each market (sampling number of 8) |
|-----|--|---|--|
| 1 | How long has these Bushmeat Markets been in existence? | Over a century | 2 |
| 2 | How often do they bring bushmeats and crocodile to these markets? | Frequently depending on sales/request by traders | 4 |
| 3 | How do you preserve the crocodile species particularly the near dead ones? | Dead ones are roasted/smoked | 3 |
| 4 | How many crocodiles do you sell daily or weekly? | 5-10 (weekly average) | 5 |
| 5 | What do people use the crocodile species for? | Largely medicine Few for food Very few resell for money | 5 |
| 6 | Where do you get the crocodile species from? | Hunters and fishermen/transport to riverside | 5 |

Table 2. Abundance of dwarf crocodiles in Bush meat markets in Benin City Edo State, Nigeria (2016-2017).

| Year | New Benin | Oliha | Uselu | Ekiuwa | Ugbighokogho | Evbotubu | Third market |
|------|-----------|-------|-------|--------|--------------|----------|--------------|
| 2016 | 20 | 20 | 10 | 100 | 120 | 10 | 20 |
| 2017 | 14 | 18 | 12 | 126 | 116 | 15 | 12 |

Source: Ogoanah & Omijie, 2017.

Table 3. Species abundance of dwarf crocodile in Bushmeat Markets in Benin Metropolis Edo State Nigeria (2022-2023).

| Markets | Sizes of dwarf crocodile | Oct. 2022 | Nov. 2022 | Dec. 2022 | Jan. 2023 | Feb. 2023 | Mar. 2023 | Apr. 2023 | May 2023 | Total |
|---------------------|--------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-------|
| New Benin Market | LSDC | 3 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 6 |
| | MSDC | 2 | 5 | 2 | 0 | 0 | 1 | 3 | 2 | 15 |
| | SSDC | 1 | 2 | 0 | 1 | 1 | 0 | 1 | 4 | 10 |
| Uselu Market | LSDC | 0 | 1 | 4 | 2 | 1 | 0 | 0 | 1 | 9 |
| | MSDC | 2 | 3 | 0 | 1 | 0 | 0 | 3 | 1 | 10 |
| | SSDC | 1 | 0 | 0 | 0 | 3 | 0 | 1 | 1 | 6 |
| Oba MarketMarkets | LSDC | 0 | 1 | 2 | 0 | 5 | 0 | 0 | 1 | 9 |
| | MSDC | 0 | 2 | 0 | 0 | 2 | 4 | 2 | 1 | 11 |
| | SSDC | 1 | 3 | 0 | 5 | 1 | 3 | 4 | 1 | 15 |
| Ekiuwa Market | LSDC | 12 | 3 | 5 | 5 | 7 | 4 | 7 | 7 | 50 |
| | MSDC | 8 | 5 | 7 | 7 | 6 | 5 | 5 | 14 | 57 |
| | SSDC | 5 | 2 | 4 | 3 | 2 | 6 | 3 | 10 | 35 |
| Oliha Market | LSDC | 3 | 3 | 1 | 1 | 0 | 3 | 2 | 2 | 15 |
| | MSDC | 4 | 4 | 0 | 4 | 6 | 1 | 1 | 1 | 20 |
| | SSDC | 2 | 1 | 1 | 2 | 2 | 3 | 1 | 2 | 14 |
| Ugbighokogho Market | LSDC | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 1 | 16 |
| | MSDC | 3 | 4 | 3 | 0 | 2 | 2 | 3 | 2 | 19 |
| | SSDC | 2 | 2 | 4 | 1 | 3 | 2 | 1 | 3 | 17 |
| Evdotubu Market | LSDC | 3 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 14 |
| | MSDC | 3 | 4 | 0 | 3 | 5 | 2 | 0 | 2 | 19 |
| | SSDC | 5 | 3 | 1 | 2 | 1 | 1 | 2 | 3 | 18 |
| Third Market | LSDC | 4 | 1 | 0 | 1 | 2 | 0 | 2 | 3 | 13 |
| | MSDC | 4 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | 16 |
| | SSDC | 1 | 1 | 3 | 0 | 1 | 1 | 2 | 0 | 9 |

LSDC, large sized dwarf crocodile; MSDC, medium sized dwarf crocodile; SSDC, small sized dwarf crocodile.

Market also have the lowest Simpson's Index (D) values, indicating lower species dominance the dwarf crocodiles.

Oliha, Ugbighokogho, and Third Market have the highest Species Evenness (E) values, indicating a more even distribution of individuals among the dwarf crocodile species (Figure 2).

Discussion

The oral interview on the bushmeat markets in the metropolis yielded insightful results regarding the traders' perceptions and operational practices. The first question queried the longevity of these bushmeat markets. The responses indicated that these markets have been in existence for over a century, reflecting their deep-rooted presence in the community. This longstanding tradition suggests that the trade of bushmeat, particularly crocodile species, is not only a means of livelihood but also part of the cultural fabric of the region, which is evident in recent literature (Petrozzi *et al.*, 2016; Trefon, 2023). When asked how frequently traders supply bushmeats and crocodiles to the market, the consensus was that this process occurs frequently, often depending on sales and specific requests from traders. This variability in frequency indicates a responsive supply chain that adapts to market demands, as implied by McNamara *et al.* (2016) and Walenlign *et al.* (2019). Preservation methods for crocodile species, especially those in a near-death state, were discussed, revealing that traders typically roast or smoke the meat. The smoking process not only aids in preservation but also enhances the flavor profile, making it more appealing to customers. The preservation tech-

nique showcases the traders' adaptability and their efforts to minimize waste in a market where the freshness of the product is vital (Cowlshaw *et al.*, 2005; Ahmadi *et al.*, 2018).

In terms of sales, traders reported an average sale of five to ten crocodiles weekly. This figure underscores the interest and demand for crocodile meat in local markets, indicating a sustainable level of consumption where both traders and consumers find value (Thorbjarnarson, 1999). The most significant use of crocodile species, as articulated by the traders, is in medicine, with a smaller fraction being utilized for food and even fewer being resold for profit (Moshoeu, 2017). This finding highlights the cultural and medicinal significance attributed to crocodiles, which may drive ongoing demand despite potential ethical or conservation concerns surrounding the trade. The source of crocodile species primarily stems from hunters and fishermen, with transportation occurring to riverside locations before reaching the markets. This sourcing method illustrates the interconnectedness of local communities and natural resources, emphasizing the need for sustainable practices to protect both wildlife and the livelihoods that depend on them (Burgos-Ayala *et al.*, 2020).

The findings of this study indicate that Ekiuwa and Ugbighokogho bushmeat markets exhibit higher species diversity, lower species dominance, and a more even distribution of individuals among species. These results are consistent with recent studies on dwarf crocodiles, which have highlighted the importance of habitat diversity and evenness in maintaining a healthy population (Riley & Huchzermeyer, 2009). It was also found that dwarf crocodiles in habitats with higher vegetation diversity and evenness had higher population densities and greater genetic di-

versity (Van Asch *et al.*, 2019; Cao *et al.*, 2020). Similarly, a study by Eaton *et al.*, (2009) reported that dwarf crocodiles in areas with more even distributions of resources had lower levels of competition and aggression.

The high species diversity and evenness values observed in Ekiuwa and Ugbighokogho markets may be attributed to the proximity to Okomu National Park where the presence of suitable habitats and resources, such as vegetation, water, and prey are obtainable (Thorbjarnarson and Eaton 2004; Eaton and Barr 2005; Eaton 2006; Shirley 2007; Shirley *et al.* 2009). These markets may serve as important hubs for dwarf crocodile populations, providing connectivity and facilitating gene flow between different habitats.

The research results indicate relatively low diversity, dominance, and evenness values for dwarf crocodile populations across eight different locations. While some locations show slightly higher values than others, the overall range is narrow, suggesting a fairly homogeneous distribution of species within these populations (Eaton *et al.*, 2009; Bouquin, 2008; Van Asch *et al.*, 2019)

Shannon-Wiener Index (H'): The H' values (ranging from 1.01 to 1.06) are quite low. Most ecological studies reporting diversity indices for reptile populations, especially those with limited species richness, will often show higher values (Ficetola *et al.*, 2013; Pincheira-Donoso *et al.*, 2013). Studies on other crocodilian species, or even broader herpeto-faunal surveys, frequently report H' values exceeding 2 or even higher depending on habitat complexity and species richness (Kafash *et al.*, 2020). This low H' suggests that the dwarf crocodile populations studied might be dominated by a single or very few species, even if they appear diverse at a coarse level. Recent literature emphasizes the importance of functional diversity within ecosystems by these megafauna species (Malhi *et al.*, 2016; Pimiento *et al.*, 2020). Crocodiles and alligators play a vital role in maintaining healthy ecosystems, and their decline could have far-reaching consequences, according to a recent study (Eversole *et al.*, 2015). These large reptiles contribute to ecosystem balance by creating complex burrow systems that provide shelter for other animals and by preying on invasive pests that damage crops (Somaweera *et al.*, 2020). However, up to 38% of the ecological functions performed by crocodilian species are under threat, highlighting the need for enhanced conservation efforts. Other researchers have consistently shown that large predators particularly, crocodiles play a vital role in maintaining the balance and health of ecosystems on land and in the ocean (Heithaus *et al.*, 2008a; Ritchie *et al.*, 2012; Ripple *et al.*, 2014).

Simpson's Index (D): The D values (0.52 to 0.57) are indicative of relatively low dominance. A value closer to 1 indicates dominance by a single species. The values obtained suggest a reasonably even distribution, albeit still within a narrow range. This aligns with the low H' values, implying a potentially limited number of species contributing to the community structure. According to Evans (2016), who studied the impact of habitat fragmentation on crocodilian populations was of the view that fragmentation could lead to reduced diversity and increased local dominance, even if overall regional diversity is higher. Habitat fragmentation poses a significant threat to biodiversity worldwide (Fahrig 2003; Fletcher *et al.* 2018; Ewers & Didham 2006). When habitats are destroyed or degraded, they often break into smaller, isolated fragments, disrupting delicate ecosystem balances and imperiling

species survival (Raghubanshi & Tripathi 2009). The widespread clearance of natural forests and subsequent fragmentation of remaining areas has become a pressing global concern (Echeverría *et al.* 2006, 2008).

Species Evenness (E): The E values (0.81 to 0.86) show relatively high evenness. This suggests that the few species present are fairly evenly distributed in terms of abundance within each location. However, the high evenness coupled with low diversity suggests a community that is likely not highly complex. This was supported in Pyron, (2010) that ecological communities comprise various species coexisting in the same space and time. Researchers have identified three diversity levels within these communities: Local diversity which refers to the variety of species within a specific habitat, habitat transition diversity which measures changes in species diversity across different habitats or environmental gradients and regional diversity which encompasses both local and transition diversity, providing a broader landscape perspective (Bestelmeyer *et al.*, 2003; Pavoine & Bonsall, 2011). Enhanced conservation efforts are necessary to protect dwarf crocodile populations and their habitats. Habitat preservation and restoration, education and outreach programs, and sustainable management of bushmeat trade are crucial for maintaining ecosystem balance and biodiversity.

Conclusions

This study emphasizes the importance of habitat diversity and evenness in maintaining healthy dwarf crocodile populations and highlights the need for enhanced conservation efforts.

Recommendations

The following recommendations were made: i) conduct ecological assessments of wild *Osteolaemus tetraspis* populations; ii) implement sustainable harvesting guidelines, particularly in biodiversity hotspot markets; iii) promote alternative livelihoods and conservation education to reduce dependence on crocodile trade; iv) engage local communities and traders in co-managed conservation initiatives; v) establish monitoring programs to track trade volumes and species diversity across markets.

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