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ORIGINAL ARTICLE

Impacts of anthropogenic disturbances on bat communities in agricultural and forest landscapes of Côte d'Ivoire

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ABSTRACT

Bats in Côte d'Ivoire remain insufficiently studied, with existing knowledge largely restricted to a few protected areas and national parks. This study conducted in the Mount Nimba region of Côte d'Ivoire documented a rich bat diversity, with 547 individuals captured representing 27 species. One additional species was recorded outside of captures, bringing the total species richness to 28. Results indicate that species diversity was slightly higher in undisturbed habitats, although differences between disturbed and undisturbed habitats were not statistically significant, underscoring the ecological complexity and local variability of bat communities. The predominance of Pteropodidae in disturbed habitats, contrasted with the greater presence of closedhabitat insectivores in intact forest, reflects differentiated ecological adaptations and highlights the influence of habitat condition on community composition. The capture of rare or nearthreatened species according to the IUCN red list, such as *Casinycteris ophiodon*, *Scotonycteris occidentalis*, and *Hipposideros jonesi*, as well as the record of *Taphozous mauritianus* in Ivorian forest habitats, significantly enriches regional faunistic knowledge and confirms the conservation importance of the site. These findings illustrate the value of longterm monitoring combining multiple methods to better characterize bat diversity and population dynamics, particularly in the face of increasing anthropogenic pressures. Finally, this study emphasizes the need for heightened vigilance in conserving species of concern and key habitats of Mount Nimba.

INTRODUCTION

Bat biodiversity plays a crucial role in tropical ecosystems, both for their major ecological functions and for the sensitivity of their populations to anthropogenic pressures. According to Voigt and Kingston (2016), 15% of bat species worldwide are threatened, 7% are near threatened, and nearly 18% remain insufficiently documented. This vulnerability appears particularly pronounced in West Africa, where deforestation and forest conversion to agricultural land are rapidly advancing (Hansen *et al.*, 2013; FAO, 2020; Kouassi *et al.*, 2021), posing direct threats to bat diversity (Williams-Guillén and Perfecto, 2010; Ceballos, Ehrlich and Dirzo, 2017). In Côte d'Ivoire, knowledge of bats remains fragmented, concentrated mainly in a few protected areas and national parks (Gordon, 2001; Fahr and Ebigbo, 2003; Niamien *et al.*, 2010, 2015; Bitty *et al.*, 2013; Kadjo, 2015; Kadjo *et al.*, 2021), despite the ecological importance of these species (pollination, seed dispersal, insect population regulation) for both natural environments and human societies (Djossa *et al.*, 2008; Kunz *et al.*, 2011). Agricultural, rural, and urban landscapes, sometimes overlooked by scientific research, nonetheless represent crucial opportunities for an integrated approach to biodiversity conservation (Vandermeer and Perfecto, 2007; Kadjo *et al.*, 2021). Understanding how bats use these environments, as well as their adaptive strategies in response to degradation and fragmentation, has become a scientific priority (Ahumada *et al.*, 2011; Torres-Porras *et al.*, 2017).

Mount Nimba, a transboundary massif located at the intersection of Côte d'Ivoire, Guinea, and Liberia, represents a major conservation concern at the continental scale. Recognized as an exceptional African hotspot for bats, the site harbors remarkable diversity, including numerous endemic and threatened species, and serves as a critical refuge (Monadjem, Richards and Denys, 2016; Simmons *et al.*, 2021). Several regional syntheses and pioneering inventories have highlighted the importance of its varied habitats for the conservation of West African mammals

(Brosset, 2003; Wieringa and Poorter, 2004; Denys *et al.*, 2013). Yet, despite its status as a key biodiversity site, the Ivorian side of the massif and its rural and agricultural margins have received relatively little attention regarding bat studies. This lack of data limits a detailed understanding of Mount Nimba's ecological role within the West African network and hinders the implementation of conservation actions adapted to the broader landscape beyond strict reserve boundaries. In light of this, it is essential to conduct integrated research targeting both intact and modified habitats. The present study therefore aims to provide novel documentation of bat community richness and composition on the Ivorian side of Mount Nimba and in adjacent rural landscapes, to compare community structure between undisturbed and anthropogenic habitats, and to contribute to the knowledge base necessary for sustainable and effective management of this essential African hotspot, considering future scenarios of ecological fragmentation.

MATERIALS AND METHODS

Study Area and Habitats

The study was conducted in a rural zone encompassing vegetation formations within the village of Yéalé (2 km from the Reserve) and inside the Mount Nimba Reserve. Mount Nimba lies at the border of Guinea, Liberia, and Côte d'Ivoire (Fig. 1). The mountain peaks at 1768 m, extends approximately 40 km in length, and spans coordinates from 7°40′ N, 8°22′ W in the northeast to 7°29′ N, 8°32′ W in the southwest. The region is situated at the transition between Guinean equatorial and Liberian equatorial climates, creating numerous microclimates across the massif that foster exceptional biological diversity in general, and particularly for bats (Monadjem, Richards and Denys, 2016; Simmons *et al.*, 2021). Mean monthly temperatures remain constant yearround, ranging between 22 °C and 27 °C. Relative humidity reaches 80% during the rainy season, drops to 30% in the dry season, and averages 50–60% during the tornado period. Annual rainfall varies from 1470 mm to 2800 mm, and may reach 3000 mm depending on altitude (Lauginie, 2007).

The massif supports a wide diversity of ecosystems and habitats, ranging from forest formations to agricultural and rural environments, including transitional and regenerating zones. For this study, two major habitat categories were defined and sampled (Fig. 1): undisturbed habitats (UNH), comprising dense forests and riparian forests within the reserve as well as intact secondary forest fragments in rural areas; and disturbed habitats (PH), corresponding to humanmodified environments including mosaics of plantations (cocoa, coffee, rubber) and agroforestry interfaces.

Sampling Protocol

Sampling was conducted using standard mist nets over 66 nonconsecutive nights between February 2022 and April 2024, covering 18 sites (9 per habitat) during both dry and wet seasons. In undisturbed habitats (UNH), sites included S01, S05, S10, S13, S14, S15, S16, S17, and S18; in disturbed habitats (PH), sites included S02, S03, S04, S06, S07, S08, S09, S11, and S12 (Fig. 1). At each capture site, two to four black nylon mist nets (12 m long, 3 m high) were installed on poles (palm branches or straight young stems). Nets remained open between 18:00 and 24:00 or until bat activity decreased significantly, and were closed earlier in case of adverse weather conditions. Nets were checked regularly to remove captured bats, with inspection intervals of 15 – 20 minutes (Kunz and Parsons, 2009).

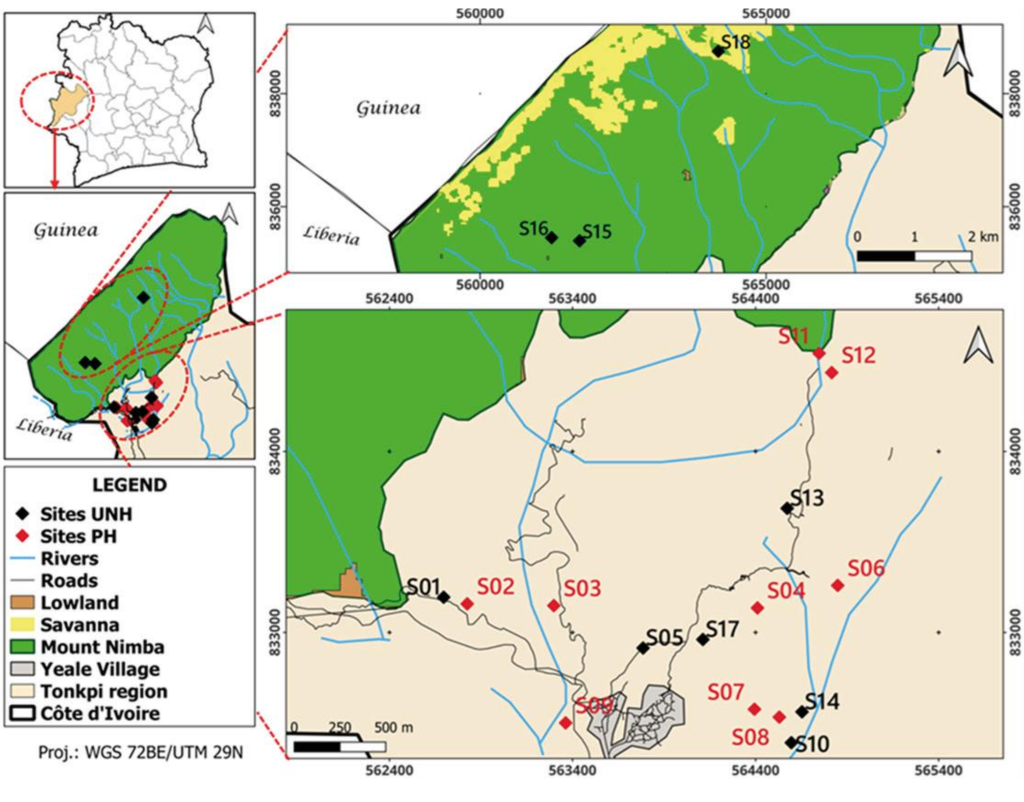

Fig. 1 - Map of the study area and capture sites location.

Each captured individual was identified, sexed, photographed, and weighed using a Pesola® balance; morphometric measurements were taken with a caliper (EcotonePoland 150/0.1 mm). Age was determined based on ossification of wing carpal joints, pelage condition, and development of mammary glands or testes (Fenton and Faure, 2017).

Species identification followed bat identification keys and guides by Happold and Happold (2013), Nesi *et al.* (2013), Kadjo (2015), and Monadjem *et al.* (2020). Taxonomic names were revised according to the updated classification proposed by Simmons and Cirranello (2025). Several cryptic species coexist in sympatry within the study area, which may complicate field identification. For individuals that could not be reliably identified in situ, specimens were collected and subsequently compared using the identification key produced by Kadjo (2015). These reference specimens originate from the Mammal Collection of Félix HouphouëtBoigny University (Abidjan, Côte d'Ivoire), which constitutes a regional reference with a total of 358 specimens and is part of the consortium of mammal collections in West Africa (Tanshi *et al.*, 2026). No molecular analyses were performed, but morphological comparisons allowed us to assign individuals to species with confidence. Bat species were also grouped into ecological guilds according to Schnitzler and Kalko (2001) and Denzinger and Schnitzler (2013), which classify bats based on flight and foraging strategies.

Handling of all captured bats followed the guidelines of the American Society of Mammalogists (Sikes and the Animal Care and Use Committee of the American Society of Mammalogists 2016), and all individuals were released at the capture site. The protocol was authorized and approved by the Ivorian Office of Parks and Reserves (OIPR) for temporary capture, handling, and release of specimens.

Data Analysis

Sampling effort was calculated as the product of the number of mist nets used (nF) and the number of sampling hours (nH), expressed in net-hours, following the recommendations of Kunz and Parsons (2009). Capture success was then obtained by dividing the number of bats captured (nC) by the sampling effort, expressed in net-hours, following Straube and Bianconi (2002). Independent sample t-tests were performed to examine whether there were variations in observed species richness, relative abundance, bat diversity (using Simpson's index), and evenness between undisturbed and disturbed forest habitats. Species accumulation curves were computed using non-parametric estimators (Jackknife-1, Chao1, Chao2) to estimate species richness based on the cumulative number of observed species (Magurran and McGill, 2011). Data were tested for normality using the Shapiro–Wilk test and for homogeneity of variances using Levene's test prior to analysis. When assumptions of normality and homogeneity of variances were not met, the Mann–Whitney U test was applied.

Boxplots were used to illustrate relationships between species richness, abundance, evenness, and diversity across disturbed and undisturbed habitats.

We employed non-metric multidimensional scaling (NMDS), a non-linear ordination method based on Jaccard similarity, to arrange the 18 sampled sites and visualize similarities in species composition. NMDS relies on ranks of dissimilarities rather than absolute distances, with "stress" serving as a measure of distortion (McCune and Grace, 2002). Data were square-root transformed prior to analysis to reduce the influence of the most abundant species and better balance the contribution of rare species. Additionally, an analysis of similarity (ANOSIM) using a Jaccard distance matrix was conducted to evaluate differences in bat community composition between habitat types (Clarke, 1993). The ANOSIM R statistic ranges from 0 to 1: values close to 1 indicate strong dissimilarity between habitat groups, whereas values near 0 indicate high similarity (Clarke, 1993). Finally, a similarity percentage analysis (SIMPER) was performed to determine the contribution of each species to overall dissimilarity. Species were characterized based on their relative abundance following Stotz *et al.* (2019). Categories were defined as follows: dominant (Do) if $Fr \geq 5\%$; regular (Re) if $1\% \leq Fr < 5\%$; rare (Ra) if $0.2\% \leq Fr < 1\%$; and accidental (Ac) if $Fr < 0.2\%$. All analyses were conducted in RStudio (Version 2025.05.01, build 513) with R (v. 4.3.0).

RESULTS

Species Richness and Diversity of Bats

A total of 547 bat individuals were captured during the study, representing 27 species, 16 genera, and six families (Table 1). In addition, one further species, *Hypsinathus monstrosus* H. Allen, 1861, was occasionally identified through direct visual observation and its characteristic call in dense forest, without capture, bringing the total richness to 28 species. The cumulative sampling effort across habitats reached 1638 net-hours, with a capture success of 0.334 bats per net-hour (Table 1). Analyses using non-parametric estimators based solely on captures suggest that actual richness may be higher. The Chao2 estimator indicated 46.06 ± 2.14 species, while Jackknife-1 estimated 35.47 ± 3.94 species. Species coverage relative to estimated richness was approximately 60%, as indicated by the rarefaction curve, which had not yet reached an asymptote (Fig. 2). Our results show slightly higher species richness in undisturbed habitats (21 species; Shannon H = 2.132) compared to disturbed habitats (20 species; Shannon H = 2.113).

The Chao1 estimator predicted 30 species for undisturbed habitats and 22 species for disturbed habitats. NMDS ordination revealed spatial structuring of sites according to species composition. Sites from undisturbed habitats appeared relatively clustered, reflecting a certain homogeneity, whereas sites from disturbed habitats showed greater dispersion in ordination space (Fig. 3). The two-dimensional ordination faithfully represented community structure with a stress value of 0.156, indicating good approximation quality. ANOSIM revealed no significant differences between bat assemblages of disturbed and undisturbed habitats ($R = 0.108$; $p = 0.072$). However, SIMPER analysis showed that observed dissimilarity between habitats was explained by a restricted core of species. *Myonycteris leptodon* contributed approximately 7.4% of dissimilarity, followed by *Nanonycteris veldkampii*

Table 1 - List of captured bats. **UNH**: Undisturbed Habitat; **PH:** Disturbed Habitat; **Ab:** Total Abundance; **Ar:** Total relative Abundance; **Cat Ab**: Abundance category; **Sta:** Conservation status; **Do:** Dominant species; **Re**: Regular species; **Ac:** Accidental species; **Ra**: Rare species; **LC**: Least Concern; **NT**: Near Threatened; **Insec.**: Insectivores

Families / Species.	**Trophic Guild**	**UNH**	**PH**	**Ab**	**Ar (%)**	**Cat Ab**	**Sta**
Pteropodidae		**86**	**188**	**274**	**50.09**		
Casinycteris ophiodon (Pohle, 1943)	Frugivores	1	0	1	0.18	Ac	NT
Epomops buettikoferi (Mastschie, 1899)	Frugivores	2	1	3	0.55	Ra	LC
Megaloglossus azagnyi Nesi Kadjo et Hassanin, 2012	Nectarivores	5	1	6	1.10	Re	LC
Myonycteris angolensis (Bocage, 1898)	Frugivores	41	61	102	18.65	Do	LC
Myonycteris leptodon K. Andersen, 1908	Frugivores	15	90	105	19.20	Do	LC
Nanonycteris veldkampii (Jentink, 1888)	Frugivores	12	12	24	4.39	Re	LC
Rousettus aegyptiacus (É. Geoffroy St.-Hilaire, 1810)	Frugivores	9	19	28	5.12	Re	LC
Scotonycteris occidentalis Hayman, 1947	Frugivores	1	4	5	0.91	Ra	LC
Hipposideridae		**102**	**110**	**212**	**38.76**		
Doryrhina cyclops (Temminck, 1853)	Insec. Closed-space	1	1	2	0.37	Ra	LC
Hipposideros beatus (K. Andersen, 1906)	Insec. Closed-space	1	0	1	0.18	Ac	LC
Hipposideros cf. ruber (Sundevall, 1846)	Insec. Closed-space	67	81	148	27.06	Do	LC
Hipposideros fuliginosus (Temminck, 1853)	Insec. Closed-space	1	0	1	0.18	Ac	LC
Hipposideros jonesi Hayman, 1947	Insec. Closed-space	24	35	59	10.79	Do	NT
Macronycteris gigas (Wagner, 1845)	Insec. Closed-space	1	0	1	0.18	Ac	LC
Nycteridae		**9**	**16**	**25**	**4.57**		
Nycteris arge Thomas, 1903	Insec. Edge-space	1	0	1	0.18	Ac	LC
Nycteris gambiensis (K. Andersen, 1912)	Insec. Closed-space	3	4	7	1.28	Re	LC
Nycteris grandis Peters, 1865	Insec. Closed-space	2	2	4	0.73	Ra	LC
Nycteris hispida (Schreber, 1774)	Insec. Edge-space	0	3	3	0.55	Ra	LC
Nycteris macrotis Dobson, 1876	Insec. Closed-space	0	7	7	1.28	Re	LC
Nycteris nana (K. Andersen, 1912)	Insec. Edge-space	1	0	1	0.18	Ac	LC
Nycteris thebaica É.Geoffroy Saint-Hilaire, 1813	Insec. Closed-space	2	0	2	0.37	Ra	LC
Rhinolophidae		**14**	**7**	**21**	**3.84**		
Rhinolophus fumigatus Rüppell, 1842	Insec. Closed-space	8	4	12	2.19	Re	LC
Rhinolophus landeri Martin, 1838	Insec. Closed-space	6	3	9	1.65	Re	LC
Vespertilionidae		**0**	**13**	**13**	**2.38**		
Afronycteris nanus (Peters, 1852)	Insec. Edge-space	0	1	1	0.18	Ac	LC
Pseudoromicia rendalli (Thomas, 1889)	Insec. Closed-space	0	5	5	0.91	Ra	LC
Scotophilus nux Thomas, 1904	Insec. Edge-space	0	7	7	1.28	Re	LC
Emballonuridae		**2**	**0**	**2**	**0.37**		
Taphozous mauritianus É. Geoffroy Saint-Hilaire, 1818	Insec. Edge-space	2	0	2	0.37	Ra	LC
Diversity index							
Total Abundance		**197**	**350**	**547**			
Species richness		**21**	**20**	**27**			
Trapping effort (net-hours)		**936**	**702**	**1638**			
Trapping success (bats per net-hours)		**0.228**	**0.456**	**0.334**			
Shannon_H		**2132**	**2.113**				
Equitability_J		**0.700**	**0.705**				
Chao-1		**30**	**22**				

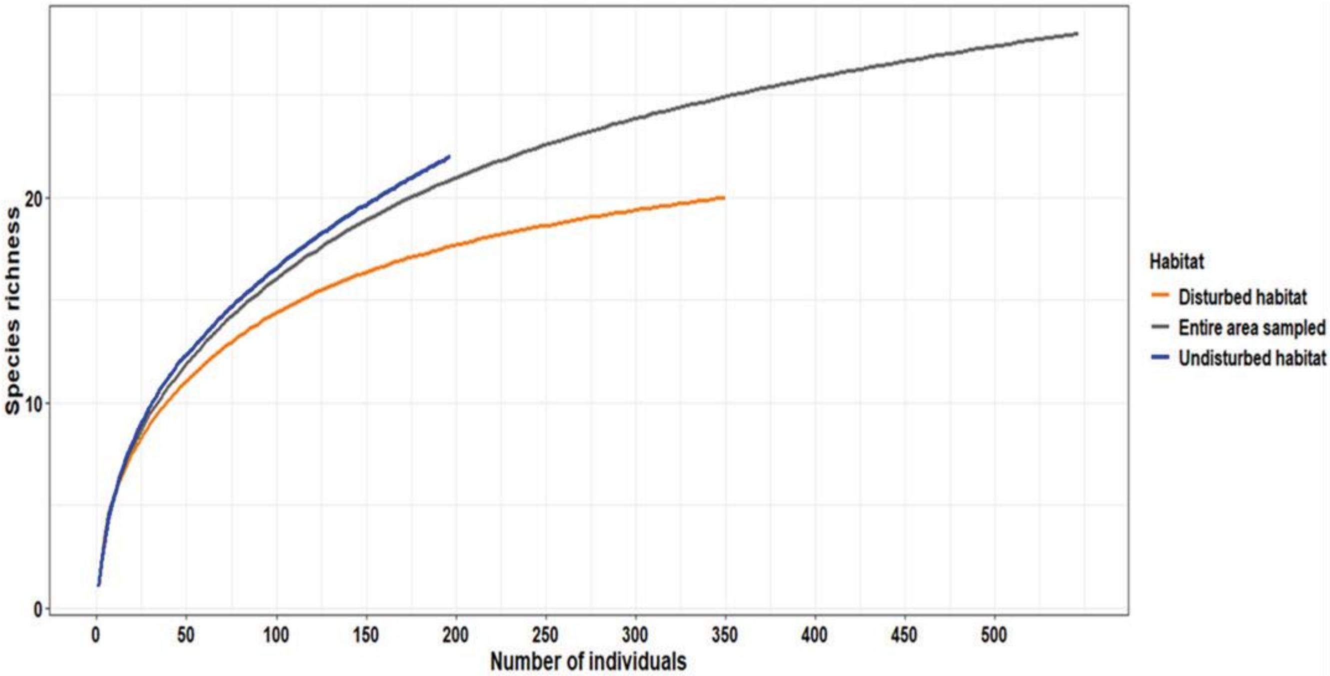

Fig. 2 - Rarefaction index curve.

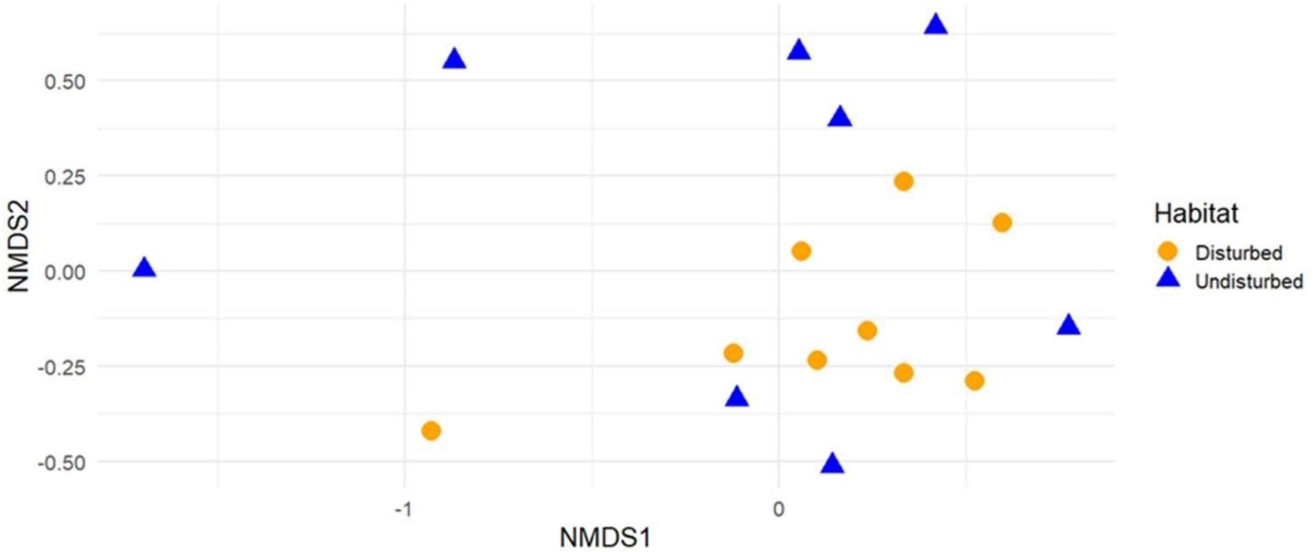

Fig. 3 - NMDS ordination, showing the difference between undisturbed (UNH) and disturbed (PH) habitat sites based on the composition and abundance of bat species using the jaccard index as a measure of similarity.

(7.1%), *Rousettus aegyptiacus* (6.7%), and *Myonycteris angolensis* (6.4%). Together, these four species accounted for nearly 28% of total dissimilarity. At a secondary level, *Megaloglossus azagnyi* (6.2%), *Nycteris gambiensis* (5.9%), and *Nycteris macrotis* (5.1%) also contributed notably. Other species, such as *Scotophilus nux*, *Hipposideros cf. ruber*, and *Nycteris grandis*, had more modest contributions (< 4% each).

Structure and Composition of Bats by Habitat

Regarding distribution across habitats, 14 species (51.85% of captured species), belonging to 10 genera and four families, were captured in both habitat types. These included seven Pteropodidae species (*Epomops buettikoferi, Megaloglossus azagnyi, Myonycteris angolensis, Myonycteris leptodon, Nanonycteris veldkampii, Rousettus aegyptiacus*, and *Scotonycteris occidentalis*), three Hipposideridae species (*Doryrhina cyclops, Hipposideros cf. ruber*, and *Hipposideros jonesi*), two Nycteridae species (*Nycteris gambiensis* and *Nycteris grandis*), and two Rhinolophidae species (*Rhinolophus fumigatus* and *Rhinolophus landeri*). Seven species (25.93%), belonging to five genera and four families, were captured exclusively in undisturbed habitats. These included one Pteropodidae species (*Casinycteris ophiodon*), three Hipposideridae species (*Hipposideros beatus*, *Hipposideros fuliginosus*, and *Macronycteris gigas*), two Nycteridae species (*Nycteris arge* and *Nycteris nana*), and one Emballonuridae species (*Taphozous mauritianus*). In contrast, six species (22.22%), belonging to four genera and two families, were restricted to disturbed habitats. These included three Vespertilionidae species (*Afronycteris nanus*, *Pseudoromicia rendalli*, and *Scotophilus nux*) and three Nycteridae species (*Nycteris hispida*, *Nycteris macrotis*, and *Nycteris thebaica*).

Bat Abundance

In terms of abundance, the highest number of bats was captured in disturbed habitats (PH), with 350 individuals (63.99%), compared to 197 individuals (36.01%) in undisturbed habitats (UNH) (Fig. 4). The mean number of individuals per species was 12.96 in PH versus 7.30 in UNH. However, the Student's t-test revealed no statistically significant difference in abundance ($t = 1.0139$; $df = 42.27$; $p = 0.3164$). The most predominant family was Pteropodidae with 274 individuals (50.09%), followed by Hipposideridae with 212 individuals (38.76%), while the least abundant family was Emballonuridae, represented by only two individuals (0.37%). Analysis of bat community proportions distinguished four abundance categories: dominant species representing 80.80% of individuals (N = 442; 5 species), regular species accounting for 13.16% (N = 72; 7 species), rare species with 4.75% (N = 26; 8 species), and accidental species with 1.28% (N = 7; 7 species) (Table 1).

In terms of relative abundance, the most common species were *Hipposideros cf. ruber* (N = 148; 27.06%), followed by *Myonycteris leptodon* (N = 105; 19.20%) and *Myonycteris angolensis* (N = 102; 18.65%). Conversely, the least abundant species included *Afronycteris nanus*, *Casinycteris ophiodon*, and five others, each with an occurrence frequency of only 0.18% (Fig. 5). The Wilcoxon test revealed a highly significant difference in the distribution of species abundances ($V = 378$; $p < 0.001$). At the habitat level, the most abundant species in undisturbed habitats were *Hipposideros cf. ruber* (N = 67; 34.01%), followed by *Myonycteris angolensis* (N = 40; 20.30%) and *Hipposideros jonesi* (N = 23; 11.66%). In disturbed habitats, *Myonycteris leptodon* (N = 91; 26%) was the most abundant, followed by *Hipposideros cf. ruber* (N = 81; 23.14%) and *Myonycteris angolensis* (N = 62; 17.71%). The least abundant species across habitats included *Scotonycteris occidentalis, Doryrhina cyclops*, *Nycteris arge*, and *Macronycteris gigas*, each representing 0.29% (Fig. 5).

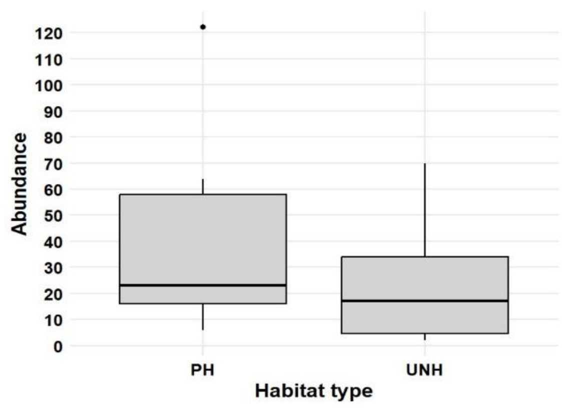

Fig. 4 - Boxplots comparing the variation in bat abundance across different habitat types (UNH: Undisturbed; PH: Disturbed).

Distribution of functional guilds across habitats

Four functional guilds were identified: frugivores bats, nectarivores bats, edge-space insectivores, and closed-space insectivores (Fig. 6). In terms of species richness, closed-space insectivores were the most represented guild in both undisturbed and disturbed habitats, with 11 species in each (Fig. 6). In terms of relative abundance, closed-space insectivores were most abundant in undisturbed habitats with 112 individuals, whereas frugivores bats were most abundant in disturbed habitats with 191 individuals. Edge-space insectivores and nectarivores were poorly represented in both habitat types (Fig. 6). Statistical tests indicated that the difference in relative abundance of frugivores between habitats was highly significant ($\chi^2 = 48.49$; $df = 1$; $p < 0.001$). Closed-space insectivores also showed a significant difference ($\chi^2 = 5.02$; $df = 1$; $p = 0.025$). In contrast, nectarivores and edge-space insectivores did not show significant differences, likely due to their low numbers. Overall, the global test across all guilds confirmed a significant difference in community composition between habitats ($\chi^2 = 18.07$; $df = 3$; $p < 0.001$).

Community Characterization and Conservation Status

Based on the IUCN Red List (2026), among the species recorded in this study, 26 are classified as Least Concern (LC), while two species are listed as Near Threatened (Table 1): Jones's leaf-nosed bat (*Hipposideros jonesi* Hayman, 1947), and Pohle's fruit bat (*Casinycteris ophiodon* (Pohle, 1943)). It is also noteworthy that *Taphozous mauritianus* É. Geoffroy Saint-Hilaire, 1818 was captured in a secondary forest within the rural zone adjacent to Mount Nimba in Côte d'Ivoire (Fig. 7). This observation is particularly remarkable in this Ivorian forest environment, as the species had not previously been reported in such habitat. Widely distributed across sub-Saharan Africa and Madagascar, *Taphozous mauritianus* É. Geoffroy Saint-Hilaire, 1818 is generally associated with savanna and woodland environments (Monadjem *et al.*, 2017, 2020). These records significantly enrich knowledge of the local distribution of species that have been rarely documented in the study region.

DISCUSSION

This study enhances knowledge of bat diversity and community structure on the Ivorian slope of Mount Nimba, a region that remains under-documented for certain taxonomic groups. In total, 547 individuals representing 27 species were captured, corresponding to a capture success of 0,334 bats per net-hour. With the addition of one species identified through auditory and visual observation, total recorded richness reached 28. This level of diversity and abundance appears relatively high compared to values reported in other West African regions using similar mist-netting methods (Bitty *et al.*, 2013; Bakwo Fils *et al.*, 2021; Kadjo *et al.*, 2021). This difference may partly be explained by the particular faunal richness of Mount Nimba, recognized for its exceptional biodiversity and high bat diversity (Bohoussou, 2014; Monadjem, Richards and Denys, 2016). Although species coverage reached 60%, the rarefaction curve suggests that actual richness may be higher than observed. By comparison, studies by Monadjem,

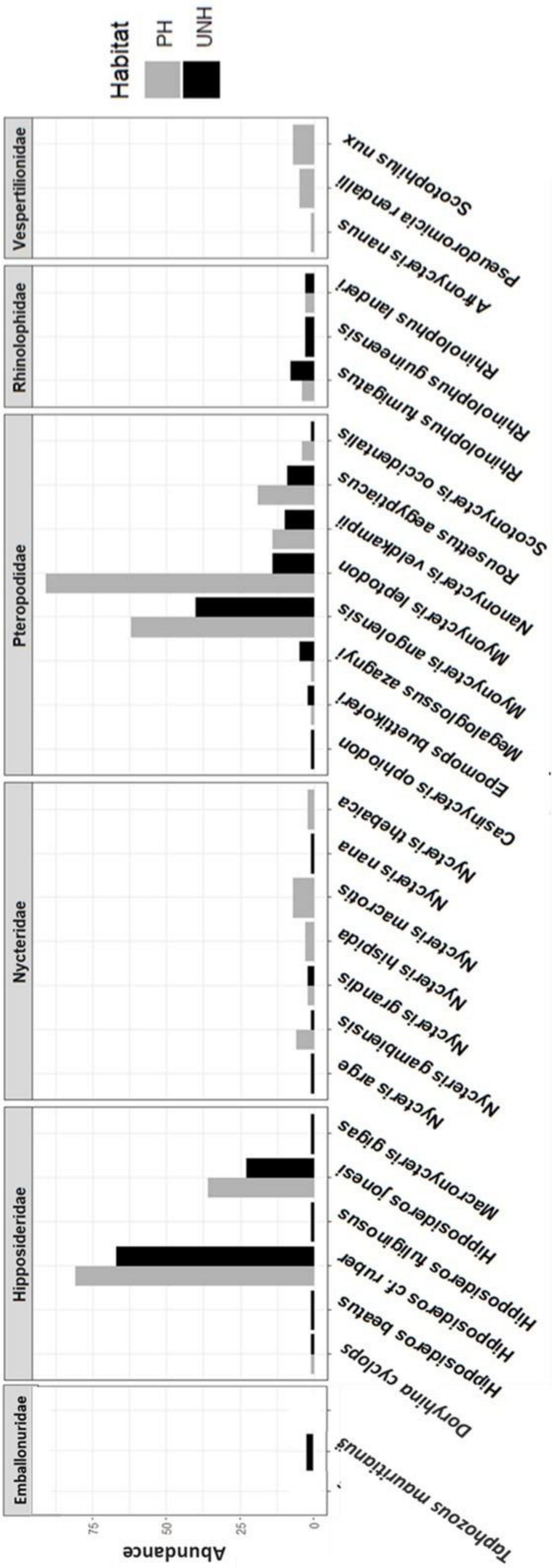

Fig. 5 - Distribution of species abundance based on habitats (UNH: Undisturbed Habitat; PH: Disturbed Habitat).

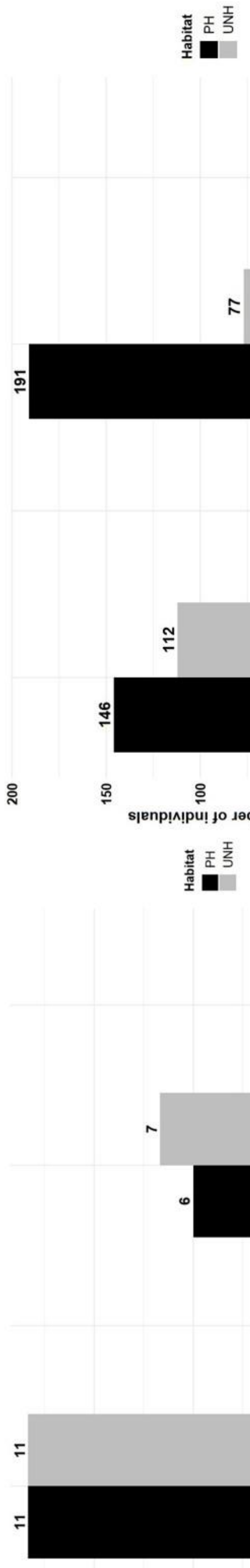

Fig. 6 - Proportion of functional bat guilds in undisturbed habitat (UNH) and disturbed habitat (PH) on species richness (A) and abundance (B).

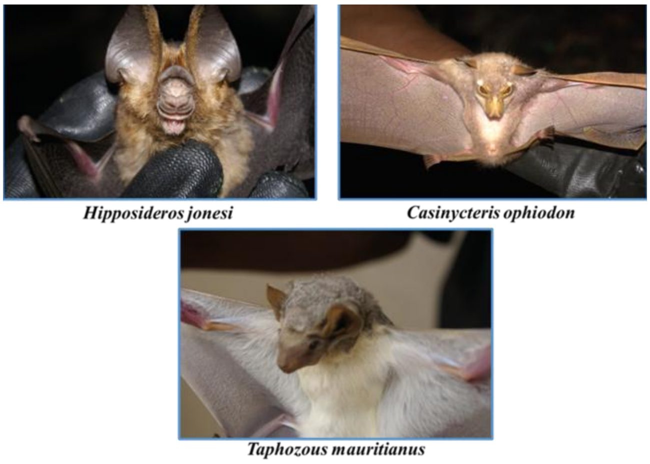

Fig. 7 - Some species with particular status. (Photograph by Didier KOUADIO).

Richards and Denys (2016) on the Liberian and Guinean slopes revealed greater diversity, with 48 species identified.

This difference highlights the importance of continuing inventories to detect potential cryptic or occasional taxa not yet recorded. Species richness varied across habitats; however, differences in richness and diversity between disturbed and undisturbed habitats were minor and statistically non-significant. This lack of marked effect corroborates observations by Waghiiwimbom *et al.* (2019) in Cameroon as well as those of Bakwo Fils *et al.* (2021) in the Afromontane Forest biome of Western Cameroon: the complexity of bat ecological responses, their mobility, and the local variability of environmental effects often render trends subtle or non-linear (Kunz and Fenton, 2003). The presence of species common to both habitats is likely due to their adaptability to diverse ecological conditions (Kadjo *et al.*, 2021). Conversely, the presence of species restricted to certain habitats, particularly insectivores, may be explained by echolocation adaptations for foraging and navigation in cluttered environments (Law, Chidel and Tap, 2011).

Unlike species richness, disturbed habitats yielded greater abundance, with more individuals captured in these mosaic environments. Although this difference was not significant, it may be attributed to greater availability of food resources and roosts, facilitating exploitation (Korine *et al.*, 2016). In our survey, the family Pteropodidae was the most represented in terms of captures. This pattern may be linked to their high abundance in the study area, adaptability, and presence across diverse habitats (Bakwo Fils, 2009; Bakwo Fils *et al.*, 2021; Kadjo *et al.*, 2021), the availability of fruiting trees (Hodgkison *et al.*, 2003; Niamien *et al.*, 2010, 2017), and the presence of numerous caves used as refuges and breeding sites (Russo, Cistrone and Jones, 2005; Denys *et al.*, 2013). Their dominance is also likely related to the use of mist nets at understory level, a method more effective for capturing low-flying frugivores (Meyer *et al.*, 2011). Although Hipposideridae were well represented, underestimation of other insectivores families is a frequent phenomenon in studies relying solely on mist nets, which are less effective for species with highly efficient echolocation (Bakwo Fils, 2009; Bakwo Fils *et al.*, 2021; Kadjo *et al.*, 2021). For example, Rhinolophidae and some Vespertilionidae can easily detect and avoid nets due to versatile flight and echolocation systems (Kingston *et al.*, 2003; Parsons, Jones and Greenaway, 2003), which may explain the absence of Molossidae and most Emballonuridae in our captures. The use of harp traps or elevated mist nets would be a recommended complementary alternative to improve sampling efficiency for these taxa, particularly Rhinolophidae and certain Vespertilionidae that frequently evade groundlevel nets (MacSwiney, Clarke and Racey, 2008; Kunz and Parsons, 2009).

Guild structure differed significantly between habitat types, likely reflecting uneven resource distribution. According to Hodgkison *et al.* (2003), bat abundance is influenced bytemporal and spatial variation in food resources, which in turn affects species numbers in particular habitats (Duchamp *et al.*, 2007; Pinto and Keitt, 2008). Our results show that frugivores bats were significantly more abundant in disturbed habitats than in undisturbed habitats (X^2 = 48.49; $p < 0.001$). This strong representation of frugivores in disturbed habitats may reflect increased availability of food resources such as fruiting trees, often favored by anthropogenic disturbance (Happold and Happold, 2013; Monadjem, Richards and Denys, 2016). These trends align with Fahr, Kock and Fahr (1996), who noted the ecological flexibility of frugivores bats capable of exploiting modified environments. Conversely, the significant dominance (X^2 = 5.02; $p = 0.025$) of closed-space insectivores in undisturbed habitats may be attributed to the nature of their echolocation signals. These species use low-intensity, high-frequency calls associated with low wing loading, adapted for foraging and movement in cluttered environments close to vegetation (Law, Chidel and Tap, 2011).

It should be noted that undisturbed sites were grouped based on ecological conservation status, regardless of management context. This approach is consistent with practices in bat ecology, where habitat quality is the key determinant of community composition (Kunz *et al.*, 2011; Meyer, Struebig and Willig, 2016). This distinction underscores a methodological aspect that warrants further exploration and opens perspectives for future comparative analyses (Struebig *et al.*, 2008).

A notable strength of this work lies in documenting rare or species of conservation concern. Their capture confirms the relevance of this fieldwork and its contribution to Ivorian biodiversity and regional biogeography. Morphometric measurements recorded for key species such as *Casinycteris ophiodon, Taphozous mauritianus*, fall within ranges reported by Bergmans (1989), Hassanin (2014), Kadjo (2015) and Monadjem *et al.* (2020). This consistency supports species identification, while also reminding that individual and local variability can sometimes obscure traditional morphological diagnoses (Happold and Happold, 2013). The occasional observation of *Casinycteris ophiodon*, absent from most recent inventories despite historical records (Coe, 1975; Verschuren, 1977; Wolton, Ridley and Kingdon, 1982; Monadjem, Richards and Denys, 2016), highlights the cryptic and likely fragmented nature of its populations in West Africa. Similarly, the detection of *Taphozous mauritianus* in Ivorian forest habitats (where it is primarily known from savanna) constitutes a notable ecological extension, recently documented for the first time in Burkina Faso by Thiombiano *et al.* (2021). These findings suggest potential ecological plasticity, though long-term monitoring is needed to determine whether such observations reflect permanent establishment or occasional passage. From a conservation perspective, the presence of three Near Threatened species on the IUCN Red List (2026) renews concerns raised by Lamah, Traoré and Doré (2021) regarding the impact of habitat modifications in Mount Nimba and its immediate surroundings. However, given the scale of this study and the low number of rare species recorded, it does not allow precise evaluation of population dynamics.

In conclusion, our findings suggest that forest loss has strong repercussions on bat species richness and functional diversity. Moreover, different guilds respond differently to habitat attributes. These results reveal that disturbed habitats containing forest fragments are important for bat conservation, particularly for adaptable species less sensitive to habitat disturbance, which prefer fragmented landscapes for foraging and commuting. Thus, the presence of such habitats around primary forests may support ecological needs of certain species by providing attractive areas for feeding and roosting along edges and open zones. Although disturbed vegetation supports higher bat diversity, conversion of pristine forests into human-dominated landscapes may be detrimental to forest specialists sensitive to human disturbance. Therefore, understanding species' habitat requirements and how human-induced disturbance affects species distribution and abundance is essential to determine their sensitivity to fragmentation and risk of local extinction, which is critical for developing effective species-specific conservation strategies (Cazalis *et al.*, 2020).

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AUTHOR CONTRIBUTIONS

All authors participated in the conception and planning of the study. KKNDB prepared the equipment and carried out data collection. KACA provided the data required for mapping and contributed critically and actively to the preparation of maps. KKNDB drafted the first version of the manuscript. KKNDB and AES performed statistical analyses and data testing. AES, KB, and GBSE contributed critically to the interpretation of results. KKNDB, KB, and GBSE discussed the analyses and results and participated in revising the final manuscript. All authors read and approved the final version of the manuscript.

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DATA AVAILABILITY

All data are available from the corresponding author upon request.

DECLARATIONS

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