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Nocturnal raptors populations in the coastal forest area of Côte d'Ivoire

Corresponding Authors : Dibié BernardAHON[1] *, Wadja Mathieu EGNANKOU[2] and YaoTANO[3].

1Laboratory of Biodiversity and Tropical Ecology, UFR Environnement, Jean Lorougnon-Guédé University, BP 150 Daloa, Ivory Coast
2Botany Laboratory, UFR Biosciences, Félix Houphouët Boigny University,
22 BP 582 Abidjan, Ivory Coast
3Laboratory of Zoology and Animal Biology, UFR Biosciences, Félix Houphouët-Boigny University, 22 BP 582 Abidjan, Ivory Coast

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Abstract
Nocturnal raptors populations were studied in four protected areas (Monogaga and Dassioko Classified Forests, Azagny and Banco National Parks) of the coastal forest area of Côte d'Ivoire, between December 2004 and January 2006, in order to collect reliable data which give a clear picture of nocturnal raptors populations in the studied area. The technique of replaying vocalisation or *call- playback* from the listening and observing stations in different habitats and seasons constituted the essential of the methodology adopted in this study. Results showed that despite of the numerous threats, the sampling sites possess again an important nocturnal raptors populations (45.45 % of raptors species normally found in the area). A total population of 215 individuals of five species from two families of nocturnal raptors was recorded in this study. The Azagny NP site is the most diversified (H' = 1.44) with a better distribution (E = 0.91) of these birds in this site. The bird population varies from one site to another, but very little depending on the season.The highest relative density is 3.5 and corresponds to the density of *Strixwoodfordii* in large rainy season and in small dry season in the site of Dassioko.

Keywords: Nocturnal, Raptors populations, coastal forest, Côte d'Ivoire.

Introduction

Raptors in general, are among the most vulnerable tax a to environmental disturbance [1]." Their presence has been often cited as indicative for the biological diversity of the ecosystems on which they depend, since top predators select such sites, promote ecosystem diversity by top-down predation, or provide essential resources, such as carrion for scavengers [2]." As raptors are relatively easily observed top predators, they are among the most useful higher taxa to evaluate the state of the environment over wide areas in open to semi-open areas, including savannas[2]."Raptors are an important tool to focus conservation strategies locally, regionally, and globally[3]." They can be used as "umbrella species" because their large home ranges and low densities necessitate that any protected areas encompassing viable populations or complete communities protect sufficient habitat and populations of most, if not all, other species in the food [4]." Because of their top positions in terrestrial and aquatic food webs, raptors can be used as indicators of worldwide pollution by pesticides[1]."

Raptors are popular and charismatic and several species have become significant "flagships" for increasing public interest and support of conservation programs [4].”Despite the critical importance of raptors, very few scientific studies have been devoted to nocturnal raptors in Africa, in general, and in Côte d'Ivoire, in particular, during the last decade. Although some raptor-related data are available (obtained through ad hoc observations by a few researchers or during Rapid Assessment Programs), these only mention the specific richness of the rare sites inventoried [5].” Thus, there is a lack of updated data on raptors populations. However, it is known that in West Africa, raptors populations and particularly vultures have experienced a dramatic decline over the last three decades [6, 7, 8].”In fact,with regard to raptors in general, it has been reported that almost all raptors species recorded in unprotected areas of Côte d'Ivoire have also been encountered in protected areas, particularly in national parks [9].” Unfortunately, nowadays, these protected areas that used to represent refuge sites (where the naturalist could still study the settlement of primitive habitats) for wildlife in general and raptors in particular, also suffer from intense poaching [10]”and illegal deforestation. As a result of these activities, the large fauna has been greatly reduced and continues to decline over the years [9].” However, the number of large mammals has an influence on the density and diversity of raptors. It therefore appears necessary to consider a study to evaluate the population of nocturnal raptors in order to have a clear idea of their population in Côte d'Ivoire. This study, carried out between December 2004 and December 2006, was carried out in four sites (representative of the coastal forest area), namely the classified forests of Monogaga and Dassioko, and the national parks of Azagny and Banco. The general objective of this study was to determine the population of nocturnal raptors in the study sites. The specific objectives were to determine the diversity and abundance of nocturnal raptor species in the study area and to estimate the seasonal variation in the density of each of these species at each study site.

Materials and Methods

Materials

The study material consisted mainly of :

- A Global Positioning System (GPS - Garmin) to record the geographical coordinates of the transects used;
- A dictaphone (Sony ®; Cassette-Corder; TCM-150) connected to a micro-directional microphone for recording unknown vocalisations;
- A compact disc player (MDM - 14) and speakers (Sony) to listen to the cries and songs of the birds;
- A compact disc: N°7 of the Claude Chappuis Collection [11];”
- A pair of binoculars (8*42; multi-coated; 114 m / 1000 m) for birdwatching;
- Bird identification guides [12, 13, 14];”
- A watch to situate us in time and a compass to orient us;
- A headlamp and a large torch (Garrity ®);
- A map of each study site to locate the different study environments.

Methods

Description of study sites

The four study sites are located in the area of evergreen dense humid forest in southern Côte d'Ivoire (Figure 1), in the Grand Domaine Guinéen [15].” The Monogaga Classified Forest (MCF, 4°48'N, 6°26'W) has a surface area of 39,828 ha, and an average annual rainfall of 1178 mm. The vegetation belongs to the fundamental type of *Eremospathamacrocarpa* and *Dyospirosmannii*[16].”The relief is quite undulating with altitudes of 24-131 m. Two permanent rivers form the natural limits of the forest: the Nonoua in the north and the Brimay in the west. The fauna is typical of the forests of the Guinean block.The Dassioko Classified

Forest (DFC, 5°3'N, 5°52'W) has a surface area of 12,540 ha and an average annual rainfall of l400 mm. Its vegetation is *Eremospathamacrocarpa* and *Diospyrosmannii*[16].”The relief is rugged with altitudes of 10-80 m. The hydrographic network is dominated by two coastal rivers: the Dagbe and the Kloukoleu. Its fauna of large mammals is typical of the forests of the Guinean block. It is still relatively intact and all species are probably still present. Azagny NP

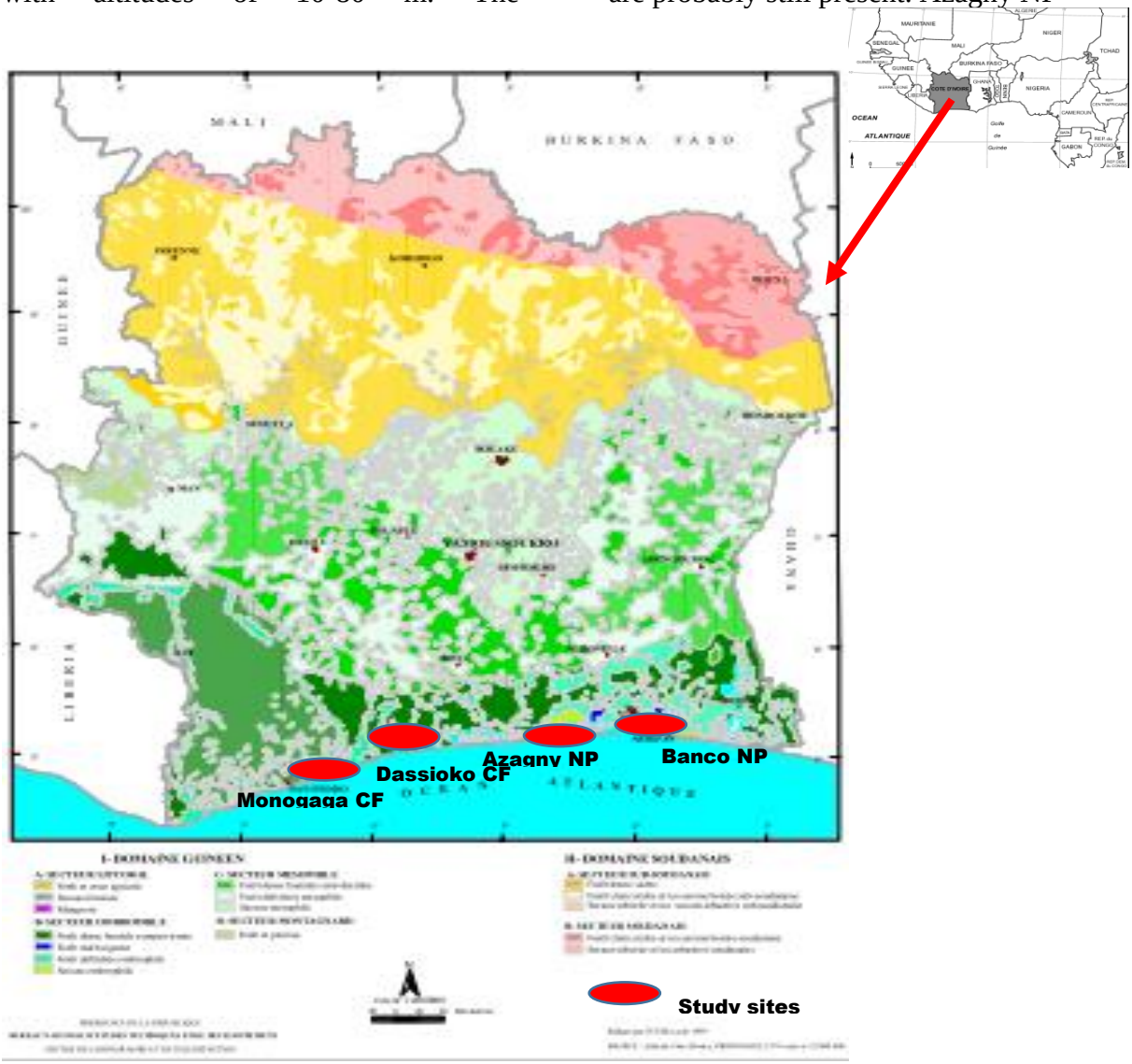

Figure 1: Map of major plant formations in Côte d'Ivoire showing study sites (Brou, 2005 modified)

(ANP, 5º10'N, 4º50'W), located in the Sub-Prefecture of Grand-Lahou, has an area of 19,400 ha [17].”A Wetland of International Importance (Ramsar site) and Important Bird Area, the AzagnyNP is one of the Bird Endemism Areas of the Upper Guinean Forest. The average annual rainfall is between 1500 and 2000 mm. Its vegetation consists of forest formations (coastal and dry land), swamp forests, coastal thickets, swamps, lagoon savannahs and mangrove swamps. The AzagnyNP has a low relief, formed by plateaus with an altitude of between 40 and 100 m. The hydrographic network is represented by the Bandama River, the Ebrie Lagoon and the Azagny Canal. The Banco National Park (BNP, 5°23'N,

4°3'W) is an exceptional case of protected forest located in the heart of the district of Abidjan with an area of 3,474 ha. The average annual rainfall is 2 000 mm. The forest is one of the last remnants of psammohygrophic forest. Dominant or common species include *Turraeanthusafricanus, Lophiraalata, Parkiabicolor, Piptadeniastrumafricanum* and *Heisteriaparviflora*. Its relief is represented by very marked slopes. The Banco River constitutes the main part of its hydrographic network. Its original fauna of great diversity has almost disappeared under the effect of poaching. The climate of the region is sub-equatorial [18]"with four seasons: two dry seasons (large dryseason LDS from December to March and small dry season SDS from August to September) and two rainy seasons (large rainy season LRS from April to July and small rainy season SRS from October to November). The harmattan only appears for a few days, in early and/or late January.

Methods of Data collection and analysis

Four transects of 4 km each were carried out in each study site. Of these four transects, three were made in a linear fashion, two of which were located in a forest area (well conserved) within the protected area and the third in a man-made area (located inside or outside the protected area). The fourth "L"-shaped transect, 2 km of which are along a watercourse, and 2 km perpendicular to this watercourse, was located within the protected area in a well-conserved forest area. Five listening stations, 1 km apart, were observed on each of the transects of the study sites, i.e. a total of 80 stations on all four sites.A compact disc of the cries and songs of West African birds [11]"for the census of night raptors was previously prepared and placed in the player of an audio system. The inventory of nocturnal raptors was carried out in the four study sites, on 16 transects (i.e. 4 / site) from listening stations (80 in total, i.e. 5 / transect) previously defined in good weather (absence of rain and high winds). The call playback method was used. The observations generally began at 7 pm (half an hour after dark) and ended at 11 pm. At each station, the vocalizations of 11 species were reviewed and notes were taken on the species heard or seen. The duration of each vocalization broadcast was 1 minute and the waiting period between two successive vocalizations was 2 minutes. At the different stations, we moved at least 20 m away from the camera to allow the nocturnal birds of prey present to approach. The possible responses of the birds were listened to, identified and noted. With the help of the torches, the foliage and tree tops were prospected. The protocol was used on all listening stations at each study site, on the same transects, four times a year (large dry season LDS, large rainy season LRS, small dry season SDS and small rainy season SRS). This corresponds to 256 hours of effective night observations in the field in 64 sessions or nights. As the vocalisation or presence of a large species of NR can prevent a small species from manifesting itself, for fear of being captured by the first, care was taken to predefine an order for the replay of vocalisation of the main species (11 in total) in West Africa, likely to be encountered in coastal forest zones. On the basis of this criterion (species size), vocalisations were issued successively, from the smallest to the largest species according to the relative sizes provided by [14]:" Sandy Scops Owl *Otusicterorhynchus* (Shelley, 1873) (18 - 22 cm); Red Chested Owlet *Glaucidiumtephronotum* Sharpe, 1875 (20-24 cm); African Wood Owl *Strixwoodfordii* (Smith, 1834) (23-28 cm); Barn Owl *Tyto alba* (Scopoli, 1769) (33-35 cm); Maned Owl Jubula*lettii* (Buttikofer, 1889) (33-36 cm); Fraser's Eagle Owl *Bubo poensis* (Fraser, 1823) (34-37 cm); Akun Eagle Owl *Bubo leucostictus* (Hartlaub, 1855) (38-48 cm); Greyish Eagle Owl *Bubo africanus*

(Temminck, 1821) (43-48 cm); Rufous Fishing-Owl *Scotopeliaussheri* Sharpe, 1871 (43-51 cm) and finally the à la Pel's Fishing Owl *Scotopeliapeli* (Bonaparte, 1850) (55 - 63 cm).All data were recorded in Microsoft excel sheet. These data collected in the field made it possible to calculate the various parameters related to the notion of specific richness, cumulative number, frequency, relative abundance, kilometer index of abundance (KIA) and Shannon diversity Index (H') of raptors for each site using R software version 2.8.0. Mean relative densities (mean KIA per 4 km) of raptor species by study site and season were also calculate. The systematics, nomenclature, bio geographical status and conservation status of the species inventoried are taken from [14]."

Results

Diversity, relative abundance and importance of sites for the conservation of nocturnal raptors A total of 215 individuals of five species of nocturnal raptors from two families were observed in four seasons in the four study sites (Table 1). Among these species, only the Rufous Fishing-Owl *Scotopeliaussheri* Sharpe, 1871, observed in Azagny NP, is listed as threatened in the *Vulnerable* (VU) category [19]"and endemic to West Africa. The other four species are listed as *Least Concern* (LC). These species of nocturnal raptors observed are all qualified as *Resident* (R) on Ivorian territory. In terms of vulnerability and diversity, Azagny NP appears to be the most important of the four study sites. This site is home to the only nocturnal raptor species of conservation interest and also has the highest index of Shannon diversity (H') and equitability (E) with values of 1.44 and 0.91 respectively.In terms of abundance, on the basis of the equal importance of each of the species and individuals encountered in these study sites, an order of importance of the different sites has been established at three levels, At the family level, among the Tytonidae, the only species of this family was observed at DCF and BNP. This means that for this family, only these two sites are more important. In the Strigidae, the four sites require the same order of importance in that each has three species;

At the species level, the number of three species was obtained at each of the four sites. This means that for this group of raptors, the four sites sampled seem to have the same order of importance,In terms of individuals, the numbers of individuals are 64 for each of the CDF and BNP sites; 44 and 43 respectively for the ANP and MCF.

Table 1: Biogeographic status and relative abundance of species recorded at the study sites

Bs	Scientific name	Commun name	MCF		DCF		ANP		BNP	
			CE	Fr (%)	CE	Fr (%)	CE	Fr (%)	CE	Fr (%)
	Tytonidae									
R	*Tyto alba*	Barn Owl	0	0	4	6.25	0	0	4	6.25
	Strigidae									
R	*Bubo africanus*	Greyish Eagle Owl	3	06.98	0	0	0	0	0	0
R	*Bubo poensis*	Fraser's Eagle Owl	8	18.61	8	12.31	8	18.18	24	37.50
R	*Scotopeliaussheri*	Rufous Fishing-Owl	0	0	0	0	12	27.27	0	0
R	*Strixwoodfordii*	African Wood Owl	32	74.42	52	81.25	24	54.55	36	56,25

Species numbers	**3**	**3**	**3**	**3**
Species populations	**43**	**64**	**44**	**64**
Shannon diversity index (H')	**1.05**	**0.84**	**1.44**	**1.25**
Equitability (E)	**0.66**	**0.53**	**0.91**	**0.79**

- MCF: Monogaga Classified Forest; DCF: Dassioko Classified Forest; ANP: Azagny National Park; BNP: Banco National Park; Bs: Biogeographic status; R: Resident species; ECU: Cumulative numbers; Fr (%): Relative frequency.

Comparison of mean relative densities of each species (mean KIA per 4 km) across study sites and seasons of the 80 relative seasonal densities, 32 or 40% are zero (Table 2). With the exception of *Strixwoodfordii* and *Bubo poensis*, all other species of nocturnal raptors have at least half of their relative densities zero. Seasonal relative densities of each of these nocturnal raptor species vary very little from season to season within sites.

Table 2: Mean relative densities (mean KIA per 4 km) of raptor species by study sites and seasons.

	MLD	MLR	MSD	MSR	DLD	DLR	DSD	DSR	ALD	ALR	ASD	ASR	BLD	BLR	BSD	BSR
Tyto alba	0	0	0	0	0.25 ± 0.5	0.25± 0.5	0.25± 0.5	0,25 ± 0,5	0	0	0	0	0.25± 0.5	0.25± 0.5	0.25± 0.5	0.25± 0.5
Bubo africanus	0.25 ± 0.5	0	0.25 ± 0.5	0,25 ± 0,5	0	0	0	0	0	0	0	0	0	0	0	0
Bubo poensis	0.5 ± 1	0. 5 ± 1	0.5 ± 1	0.5 ± 1	0.5 ± 1	0.5± 1	0.5±1	0.5± 1	0,75 ± 1	0.5± 1	0.5. ± 1	0.5 ± 1	1.5 ± 1.91	1.5± 1.91	1.5± 1.91	1,5 ± 1.91
Scotopeliaussheri	0	0	0	0	0	0	0	0	0,75 ± 1,5	0.75 ± 1,5	0.75 ± 1.5	0.75 ± 1.5	0	0	0	0
Strix woofordii	2 ± 0,82	2 ± 0,82	2 ± 0,82	0,5 ± 0,82	3,25 ± 1,5	3,5±1,29	3.5 ±1,29	3.5 ± 1.29	1.5 ± 1	1.5 ± 1	1.5± 1	1.5 ± 1	2.25±1.71	2.25±1.71	2.25±1.71	2.25± 1.71

MLD: Monogaga Large Dry season; MLR: Monogaga Large Rainy season; MSD: Monogaga Small Dry season; MSR: Monogaga Small Rainy season; DLD: Dassioko Large Dry season; DLR: Dassioko Large Rainy season; DSD: Dassioko Small Dry season; DSR: Dassioko Small Rainy season; ALD : Azagny Large Dry season; ALR: Azagny Large Rainy season; ASD: Azagny Small Dry season; ASR: Azagny Small Rainy season; BLD: Banco Large Dry season; BLR: Banco Large Rainy season; BSD: Banco Small Dry season; BSR: Banco Small Rainy season

Discussion

This study revealed the presence of five of the 11 species (i.e. 45.45%) of forest nocturnal raptors likely to be found in the study area and 215 individuals in four seasons. These results showed that despite the numerous threats (poaching, illegal clearing, pollution, etc.) to which the sites are exposed, they still have a large population of nocturnal raptors. Indeed, the weather, the duration of field visits and the habitat covered are important factors in monitoring raptors [20]"and this is particularly true for raptor habitats in humid forests [9]." Also, since monitoring has been carried out in habitats with different visibility, it is difficult to draw definite conclusions on the relative abundance of species. Nevertheless, the sampling and monitoring of raptor populations carried out during this study at different sites in the coastal forest zone of Côte d'Ivoire, in several habitats and in different seasons of the year, seem to be sufficient to assess the current stands of this group of birds in this part of the country. Overall, the results of this study give a general idea of what each species represents in the seasonal stand at each site. These results vary from site to site and very little by season. They are comparable as they were obtained under the same study conditions (same observer, same schedules, same sampled transects, etc.). However, due to differences in interspecific behaviour, they rarely reflect the actual diversity, relative abundance and density of all elements of the community. With this in mind, it should be mentioned that a species not observed does not necessarily mean its absence from the site. Indeed, the difficulties in detecting raptors in tropical environments and especially in dense forest zones, take away a great deal of significance from these different indices [9]."Nevertheless, since all species are about equally likely to be seen or heard, the proportions obtained are assumed to be representative.

In terms of specific variability, the number of three NR species recorded in each of the four sites during this study appears very low. Indeed, according to the different distribution maps of RN species [14],"13 species of Strigidae are likely to be found in the forest zone of Côte d'Ivoire. Thus, the work of [21]"has enabled one species of nocturnal raptor to be noted in the FC of Bossématié and six species of this group of birds in the Béki CF. Six species were recorded by [22]"in Taï NP. This relatively low number could be attributed not only to the numerous human disturbances (poaching, illegal clearing, fishing by poisoning, etc.) recorded in the sites, but also to the species' own ecology, given that some species require specific habitats. However, the results of this work are more or less similar to those of Thiollay [9]"in Taï NP (4 species), [23]"in Yapo-AbbéCF (5 species), [24]"in Haute Dodo CF (4 species) and Cavally CF (3 species), [25, 26]" respectively in the Sassandra region (2 species) and in BNP and Anguédou CF (3 species). In terms of H' and E indices, the Azagny site seems to be the one with the most diversified population in NR (H' = 1.44) with equitably better distributed species (E = 0.91). This fact could be attributed to the diversity of habitats on this site, since each species requires a very specific habitat. On the other hand, the Dassioko site, although hosting the largest number (67) of NR, is the least diverse (H'= 0.84) in species, which are equitably poorly distributed (E = 0.53). Indeed, the quasi-uniformity of most of the forest on this site does not seem to favour NR diversity. *Bubo africanus* was observed at the MCF site, outside its preferred biotope and far from its known range in Côte d'Ivoire. Indeed, it is known as a savannah species [27, 28]" and its presence in forest areas suggests that it is not strictly dependent on this characteristic habitat (the savannah) but that it is capable of adapting to the new conditions of the new habitat (the forest) in which it has been recorded. It appears to be a tolerant

species and does not require any habitat specificity. The observation of this species in the said site confirms the results of[29]"and [14]" who have already reported its presence in the coastal forest zone of Côte d'Ivoire.

In terms of relative abundance, only one species (*Strixwoodfordii*) is more abundant and largely dominates the raptor population of the sites. The fact that the number of species and individuals does not vary or varies very little with the seasons is probably linked to the sedentary nature of all the species recorded in this study. This confirms the work of [27]." Indeed, according to this author, the forest area that initially covered the entire area studied, and even the secondary forest that succeeded it in most localities, are characterised by very stable (apparently) bird populations during the year. This implies very low numerical fluctuations (low fecundity, long life span) and a remarkable sedentary lifestyle for most species. Thus, no clear seasonal changes in the bird population in general could be detected in large forests, both qualitatively and quantitatively. This would be a well-known fact in all tropical forests. Our work revealed that the highest density (3.25 ± 1.5) is that of the African Wood Owl *Strixwoodfordii,* obtained at the Dassioko site in each season. This result is similar to those of [27]"who states that *Strixwoodfordii* is by far the most abundant NR in all forest types.

Conclusion

The study showed that at the nocturnal raptor's populations level, the sampled sites still have a relatively raptor stand in that they contain more than 45.45 % of the nocturnal raptor species normally found in the area. Seasonal populations of the diurnal raptors of these sites vary both by site and no vary by season. Thus, for each site sampled, one species (*Strixwoofordii*) is more abundant and largely dominate seasonal population where it's present. The highest relative density is 3.5 and corresponds to the density of *Strixwoodfordii* in large rainy season and in small dry season in the site of Dassioko.Also, among the sites, AzagnyNP has a more diverse raptor population with the most evenly distributed species. Overall, the results of this study showed that despite the numerous threats (poaching, illegal clearing, pollution, etc.) to which the sites are exposed, they still have a relatively population of nocturnal raptors. This implies that appropriate conservation actions and adequate measures need to be taken in the sites in order to save the biodiversity survivors in general, and this population of nocturnal raptors in particular.

List of abbreviations

ALD : Azagny Large Dry season; ALR: Azagny Large Rainy season; ANP: Azagny National Park; ASD: Azagny Small Dry season; ASR: Azagny Small Rainy season; BLD: Banco Large Dry season; BLR: Banco Large Rainy season; BNP: Banco National Park; BSD: Banco Small Dry season; BSR: Banco Small Rainy season; Bs: Biogeographic status; CF: Classified Forest; DCF: Dassioko Classified Forest; DLD: Dassioko Large Dry season; DLR: Dassioko Large Rainy season; DSD: Dassioko Small Dry season; DSR: Dassioko Small Rainy season; ECU: Cumulative numbers; E: Equitability; Fr (%): Relative frequency; GPS: Global Positioning System; H': Shannon Diversity Index; KIA: Kilometric Index of Abundance; LC: Least Concern; MCF: Monogaga Classified Forest; R: Resident species; VU: Vulnerable; MLD: Monogaga Large Dry season; MLR: Monogaga Large Rainy season; MSD: Monogaga Small Dry season; MSR: Monogaga Small Rainy season; NR: Nocturnal raptors.

Data Availability

As this manuscript is published by an open access journal, the results will be available on the publication website of this journal.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Authors' contributions

DBA actively contributed to the collection of ornithological data in the field and was the main editor of the manuscript. WME collected the field data on the vegetation of the study site and participated in the writing of this paper. YT participated in the data analysis and the writing of the manuscript. All authors have read and approved the final manuscript.

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Supplementary Materials

No additional documents were provided as part of this study.

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