Original Research Article

Diversity and abundance of chiropteran ectoparasites in Abidjan district, Côte d'Ivoire

.

ABSTRACT

Aims: The aim of this study is to produce information on the diversity and abundance of ectoparasites in bats in Côte d'Ivoire.

Place and Duration of Study: It was carried out in 2021 in the Abidjan district, in the forest relics of the Zoo National Abidjan (ZNA) and the Institut Pasteur de Côte d'Ivoire (IPCI) Adiopodoumé site.

Methodology: The first step was to capture and identify the bats, then for each bat collected, ectoparasites were collected and identified using the Walker and Ramel keys.

Results: In the course of this study, 89 bats were collected, most of them adult (91%) and female (50.6%). Most belonged to the genera *Micropteropus* (41.6%) and Eidolon (40.4%). Ectoparasites were collected at a rate of 20.22% (+/- 0.187), and identification revealed *Nycteribiabiarticulata* (69.7%) and *Ornithodoroserraticus* (30.3%), belonging to the insect and tick classes respectively. A causal link was established in the univariate analysis ($p<5\%$) between the presence of the parasite and the bat species collected.

Conclusion: These results provide non-exhaustive information on the diversity and abundance of bat ectoparasites in the Abidjan district.

This research needs to be extended to the whole of Côte d'Ivoire, in order to identify the ectoparasites that are potential vectors of zoonoses transmitted by ectoparasites in a One Health concept.

Keywords: Chiroptera - External parasite - Zoonosis - Surveillance

1. INTRODUCTION

The order Chiroptera is the most diverse order of placental mammals after Rodentia, with nearly 1,400 species, i.e. a quarter (¼) of all mammal species known at the time of writing (1;2;3).

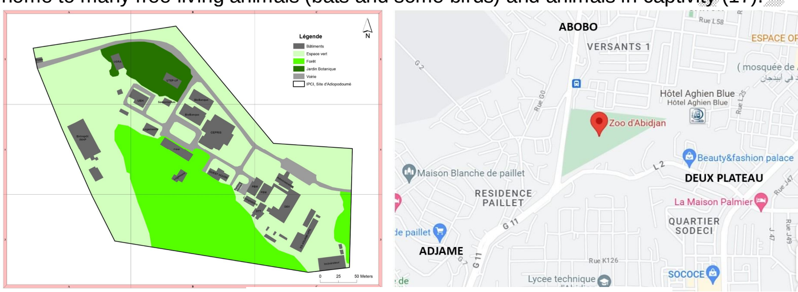
Many studies have highlighted them as the predominant host of both internal and external parasites (4; 5; 6; 7).

External parasites (ectoparasites) are small organisms that live and feed on the integument of various hosts, some of which can colonise the host's body cavities (8). Some of these ectoparasites are potential vectors of disease in mammals, particularly chiropterans and rodents (9; 10). In a large part of the world, knowledge of bat ectoparasites is still limited. Most ectoparasites share co-evolutionary links with their hosts, as many of them remain on their hosts for most of their lives, while others are only present during the various reproductive stages of the host, such as gestation or lactation (11). The diversity of bat habitats makes them natural hosts for ectoparasites and therefore excellent models for studying host-parasite relationships, given their extremely diverse taxonomy and behaviour (12). In Côte d'Ivoire, studies on chiropterans have provided some insight into the diversity of this fauna, which currently accounts for 24% of the country's known mammals (13; 14; 15; 16). However, in Côte d'Ivoire, very few documented studies have reported on the host-parasite relationship that exists between chiropterans and the parasites that live in their environments. The aim of our study, which is the first of this initiative, is to produce information on the diversity and abundance of ectoparasites in bats in the Abidjan district. For this study, we tested the following hypotheses: 1) bats in the Abidjan district harbour ectoparasites; 2) the diversity and abundance of ectoparasites influenced by the bat species; 3) the diversity and abundance of ectoparasites influenced by the bat collection area.

2. MATERIAL AND METHODS

2.1 Study area and period

This work was carried out in Côte d'Ivoire by setting up net traps on two sites, namely the wooded perimeter around the site of the Institut Pasteur de Côte d'Ivoire (Adiopodoume site) WGS84 (Latitude: 5.31874808; Longitude: -4.13539601) and the Abidjan National Zoo WGS84 (Latitude: 5.380995; Longitude: -4.004645) from 22 December 2020 to 28 January 2021. Located in Adiopodoumé, the 17-hectare Adiopodoume site is made up of a degraded secondary forest that was used to build the institute's infrastructure facilities. The Abidjan National Zoo, currently estimated at around 18 hectares, is located in the commune of Cocody, precisely at the intersection of the roads linking the communes of Abobo and Adjamé to the Plateau-Dokui and Deux Plateau districts. It is made up of secondary forest that is in a very advanced state of degradation. It is home to many free-living animals (bats and some birds) and animals in captivity (17).



A) Institut Pasteur of Côte d'Ivoire, Adiopodoumé site **B) Abidjan National Zoo, limits and situation**

Figure 1: Administrative map of the study area

2.2. Capturing and identifying bats

At the Institut Pasteur and Zoo National d'Abidjan, trapping was carried out continuously throughout the study. Three mist nets at four (4) levels and of different sizes (12, 9, and 6 metres), each 3 metres high and 12 metres long, were set up in the undergrowth of each site using bamboo fixed in the ground and ropes to hold them in place. The mist nets were sSet up from 6.30 in the evening and taken down before 6.30 in the morning.,Tthe traps ~~visited~~ were checkedevery 30 minutes to remove the bats so that they doidnot injure themselves by becoming entangled in the mesh of the nets. They weare placed in individual cotton bags and hung from a branch or rope provided for this purpose. The animals were then taken to the Animal Resource Management Unit (UGRA) of the Institut Pasteur de Côte d'Ivoire (IPCI) at the Adiopodoumé site for identification of the bat species and ectoparasites. To identify the bats, information such as weight, sex, age, physiological state, and, using a ruler, the various measurements (forearms, fingers, head, body, and tail) of each bat were determined according to a determination key described by Kadjo and Coll. (16).

2.3. Collecting ectoparasites

After each capture, the bats were taken back to the Animal Resource Management Unit (UGRA) of the Institut Pasteur de Côte d'Ivoire (IPCI) at the Adiopodoumé site. Once at the Unit, some of the animals underwent flash anaesthesia with Isoflurane, while others were directly inspected in their entirety. Animal inspection and ectoparasite collection were carried out under SHPII in the UGRA laboratory, in compliance with biosafety measures. Ectoparasites were collected using blunt-tipped forceps, sometimes aided by a binocular magnifying glass. The parasites collected were then immersed in jars containing 70 percent° alcohol (11). Each jar was then identified with the animal's ID number and stored at room temperature, pending identification of the parasites collected. For each bat sampled, the examiner recorded the number of parasites collected. Once the ectoparasites had been collected, the bats were each placed in transport bags containing fruit and then transported to their capture areas to be released.

2.4 Identification of ectoparasites

The ectoparasites were then identified in the laboratory of the Institut Pasteur's Entomology and Herpetology Unit (UEH). They were identified using an OPTIKA binocular magnifier and dichotomous identification keys. The insects were first separated from the ticks. ~~The identification key of~~ Walker and Ccoll's (18) identification key~~.(18)~~was used for tick identification, and that of RamelRamel's(19) identification key was used for insect identification. The sSpecimens were sorted according to their stage of development and then identified by genus and species.

2.5. Data analysis

After data management of the database using MS Excel. The actualData analysis was carried out using R software version 4.2.1 (MacOS) on the Rstudio 2022.07.1 editor. It The data analysis consisted of consisted firstly of a univariate analysis known as the descriptive method for calculating means, standard deviations and confidence intervals, and secondly of aand multivariate analysis. for calculating the p-value and the Chi2 test.

3. RESULTS AND DISCUSSION

3.1.Results

3.1.1. Identification of bats

A total of 89 bats were collected at the two sites, i.e.,tThe wooded area around the InstitutPasteur site at Adiopodoumé and the forest at Zoo National Abidjan.

3.1.1.1. Distribution of bats according to species

Among the 89 captureobservations, the majority were species belonging to the genus *Micropteropus*, with 37 individuals, i.e.,. 41.6%, followed by the species *Eidolon helvum*, with 36 individuals, i.e., 40.4% (Table 1).

TABLE 1I: DISTRIBUTION OF COLLECTIONS ACCORDING TO SPECIES (N=89).

Species	AabsoluteFreéquencies (n)	Rrelative Frequencies (%)
Eidolonhelvum	36	*40.,4*
Hypsignathusmonstrosus	12	*13.,5*
Micropteropussp	37	*41.,6*
Pipistrellussp	4	*4.,5*

3.1.1.2. Distribution of bats according to sex and age.

Of the 89 bats collected, 45 (50.6%) were females, and adults represented the majority, with 81 observations (91%) (Table 2II).

TABLE 2II: breakdown of observations by sex (n=89)

Sex	Aabsolute Freéquencies (n)	Rrelative Frequencies (%)
Female	45	*50.,6*
Male	44	*49.,4*

3.1.2. Diversity and abundance of ectoparasites in relation to collection areas and bat species.

3.1.2.1. Prevalence of ectoparasites as a function of bat capture areas.

Among the 89 bats, 20.22% [20.13-20.30] carried ectoparasites for the entire study. No ectoparasites were found on the bats captured at the Adiopodoumé site.Two ectoparasites were identified, namely insects of the species *Nycteribiabiarticulata* (hermann, 1804) (n=39), i.e. 69.7%, and ticks of the species *Ornithodoroserraticus* (n=17), representing 30.3% of ectoparasites (Table~~II~~3).

TABLE 3~~II~~: Diversity and abundance of ectoparasites according to the areas where bat species were captured.

Group	Family	Gender	Taxons	Study area			
				Forêt IPCI	Zoo National	Cumulative number	relative Frequencies (%)
Insect	*Nycteribiidae*	*Nycteribia*	*N. biarticulata*	0	39	39	69,7
Mite	*Argasidae*	*Ornithodoros*	*O. erraticus*	0	17	17	30,3
Total			**2**	**0**	**56**	**56**	**100**

Comment [CM1]: Genus or Gender?

Bivariate analysis showed that there was no statistically significant link (p= 0.074) between the presence of ectoparasite species and the collection site (Table 4).

Comment [CM2]: Mention the specific statistical technique used if Chi-square or t-test describe them here.

Table 4: Distribution of ectoparasites according to collection area (N=89)

		PRESENCE OF ECTOPARASITES		
		YES N *(%)*	**NO N *(%)***	**TOTAL**
SITE	**FORET IPCI**	**0 *(0,0)***	**15 *(21,1)***	**15**
	ZNA	**18 *(100,0)***	***56 (78,9)***	**74**
TOTAL		**18 *(100,0)***	**71 *(100,0)***	**89**

3.1.2.2. Prevalence of ectoparasites according to bat species

However, there was a statistically significant link (P< 0.001) between the presence of parasites and the bat species collected (Table 5~~V~~).

Table 5~~V~~. Distribution of ectoparasites by species (N=89). The relative percentages of the species are in parentheses.

		PRESENCE OF ECTOPARASITES		
		YES N *(%)*	**NO N *(%)***	**TOTAL**
	Eidolonhelvum	***17 (94,4)***	**19 *(26,8)***	**36**
GENDER AND SPECIES	*Hypsignathusmonstrosus*	***0 (0,0)***	***12 (16,9)***	**12**
	Micropteropus	***1 (5,6)***	***36 (50,7)***	**37**
	Pipistrellus	***0 (0,0)***	***4 (5,6)***	**4**
TOTAL		**18 *(100,0)***	**71 *(100,0)***	**89**

Comment [CM3]: Genus or Gender?

3.1.2.3. Ectoparasite species present on bat species

Both types of ectoparasite (tick and insect) were collected on the bat species *Eidolon helvum*, but only one insect was collected on the bat of the genus *Micropteropus* (Table 6~~VI~~).

Table 6~~VI~~. Matrix of bat species and their parasites.

SPECES OF BATS	**NU~~O~~MBER**	**FREQUENCY~~E~~ (%)**	**PARASITES**
EIDOLONHELVUM	**55**	**98.~~,~~21**	***Nycteribiabiarticulata***
			Ornithodoros. erraticus

MICROPTEROPUSSP	**1**	**1,;79**	***Nycteribiabiarticulata***

3.2. **DISCUSSION**

In this study, four genera of Chiroptera were identified. These are the genera *Eidolon, Hypsignathus, Micropteropus* and *Pipistrellus*. Studies carried out in several regions of Côte d'Ivoire have identified species belonging to these genera and several other Chiroptera genera (14; 20; 16). The genera ***MICROPTEROPUS*** and ***EIDOLON*** were the majority, with [ADD THE TOTAL NUMBER OR PERCENT HERE] and [ADD THE TOTAL NUMBER OR PERCENT HERE] individuals, respectively. The two species identified in this study, *Eidolon helvum* and *Hypsignathusmonstrosus*, are megachiropters. A study carried out by Niamien and Coll (21)on the population of hammerhead bats, *Hypsignathusmonstrosus*, in the plateau commune of Abidjan showed that this species has a marked preference for ***TERMINALIA CATAPPA*** l. (Combretaceae) breeding sites, and the~~eat~~ numbers varied according to tree species and season.
Eidolon helvum was the ~~majority~~ commonspecies, yet this species has conservation status, as it is classified as vulnerable in certain regions (Cite). A~~nd a~~ccording to Rickettsand Coll. (22), among mammals, chiropterans constitute a group of threatened species, some of which have seen their numbers decline at a~~nparticularly~~ alarming rate
~~In the second species identified in this study~~For the~~,~~*Hypsignathusmonstrosus*, ~~there is a very~~a pronounced sexual dimorphism between males and females was observed(23). In addition to being larger, these males have a monstrous face and a wingspan exceeding one metre.

Several studies have shown that bats are infected by a wide variety of endoparasites and ectoparasites, and up to 1999, around 756 taxa were associated with bats worldwide (24). In this study, two species of ectoparasites were identified, namely insects of the species *Nycteribiabiarticulata* and ticks of the species *Ornithodoroserraticus*. The data collected demonstrate the presence of ectoparasites in the district's bats, and analysis of the data shows that the diversity and abundance of ectoparasites are influenced by bat species p< 0, 001. These results corroborate some of the hypotheses put forward prior ~~to~~ inthis study.

According to Parola and Raoult(25), ticks of the genus *Ornithodoros* are known to be vectors of relapsing fever, which is an infection caused by certain species of Borrelia in humans. ~~And i~~In birds, ticks of the genus *Ornithodoros* are known to be reservoirs of medically important pathogenic bacteria found worldwide(26). In Algeria, the species *Ornithodoroserraticus*has been found in rodent burrows in the east of the country (27).

In Côte d'Ivoire, knowledge of soft ticks (*Ixodida: Argasidae*) is incomplete. Further studies are needed to determine the specific composition of *Argasidae* and the diseases they could transmit. Precise knowledge of the distribution of these ticks and their monitoring are vital for defining areas at risk of tick-borne diseases and for establishing appropriate tick control and prevention measures. Against this backdrop, ~~ongoing~~ tick monitoring is an ongoing need in our regions.The insect species *Nycteribiabiarticulata* identified in this study was also collected from a bat species in L~~l~~atvia (28). Several species of *Nycteribia* in the Nycteribiidae family have been identified in bats in several studies (29; 30; 31).

A number of emerging diseases are transmitted by haematophagous ectoparasitic arthropods. These diseases are unique in that the diversity and complexity of the epidemiological cycles of the pathogens responsible complicate their study and monitoring. In addition, current climatic changes and the transformation of landscapes caused by mankind are creating new environments and changing the existing dynamics within certain ecosystems, sometimes creating favourable conditions for the establishment of new disease outbreaks ~~of disease,~~ and, therefore, for their emergence. It is, therefore, important to understand these ectoparasites in order to better combat the diseases they could transmit.

4. CONCLUSION

In Côte d'Ivoire, studies have identified numerous bat species in different biotopes, as well as ectoparasites in the environment and on animals. However, none of these studies had focused on bat ectoparasites. This study, which is one of the first of its kind, highlights the presence of insects and the haematophagous tick *Nycteribiabiarticulata* and *Ornithodoroserraticus* on bats at two sites: the wooded area around the Institut Pasteur site at Adiopodoumé and the forest at Zoo National Abidjan. The vast majority of these ectoparasites were identified on the *Eidolon helvum*, a species classified as vulnerable in other countries, which nests in the business centre of Côte d'Ivoire's economic capital. The *Ornithodoroserraticus* tick has also been identified as a vector of animal and human diseases. Côte d'Ivoire, therefore,

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has a strong interest in stepping up its research into the diversity of ectoparasites on wildlife in order to understand their diversity~~,~~and~~but~~ also to step up surveillance of the diseases that these ectoparasites could transmit.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

IPCI: Institut Pasteur of Côte d'Ivoire

ZNA: Zoo National of Abidjan
UGRA: Unit of Animal Ressources Management
UEH: Unit of Enthomology and Herpetology