Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(3): 26-31

Received: 13-03-2021
Accepted: 15-04-2021

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Bats diversity and abundance, record of *Taphozous mauritianus* E. Geoffroy St.-Hilaire, 1818 for the first time in Burkina Faso

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Abstract
Bats were sampled in five localities in Burkina Faso using mist nets from August to November 2018. This study was carried out by carrying out captures and handling in order to know the species present, their number, their sex, their reproductive status, and their age group. In total, 341 bats of eight species were captured representing 15.68% of bats species known to occur in Burkina Faso. Mauritian Tomb Bat, *Taphozous mauritianus* E. Geoffroy St.-Hilaire, 1818 is reported for the first time in Burkina Faso and represented by two individuals raising the total species for the country to 52. Bats species richness and abundance were highest at Bobo Dioulasso. Future large-scale studies in time and space could make it possible to fully appreciate the evolution of bats biodiversity in Burkina Faso, especially in the context of climate change.

Keywords: bats, diversity, *Taphozous mauritianus*, Burkina Faso

Introduction
Anthropic activities and climate change continue to disrupt biodiversity and ecosystem service provision from which bats are not spared [14, 18]. Bats represent 20% of mammalian species [36, 38]. They belong to the Order of Chiroptera [38]; and are the only mammals on the globe surface that practice active flight. In addition, adapted to nightlife, they have developed an echolocation system (or sonar system) which allows them to evolve and detect their prey in complete darkness.
In Africa, bats are among the taxa that are not well surveyed; there are many gaps in the knowledge of the distribution and even the species. This is confirmed by the description of new species these last fifteen years [18]. Which leads to the need to more sampling for the species occurrence in different habitat and their distribution.
Burkina Faso has 51 bats species, including 7 Frugivorous and 44 Insectivorous [25]. Bats have a variety of ecological niches that make them key organisms in maintaining ecosystem balance [7, 4]. Indeed, numerous studies have demonstrated the role of bats in the regulation of insect populations, in pollination and in the dispersal of seeds of many plants of ecological importance [40, 16, 10]. Fruit bats which are represented by more than 150 species play an important role in the pollination of plant species like iroko, a rare species for which pollination is provided only by fruit bats [21, 40]. Microchiroptera consume a large number of insects thus regulating their populations; they help farmers by destroying harmful insects. [14, 33] estimate that one million *Taphozous brasiliensis* in Texas can consume up to ten tonnes of insects each night. This biological control reduces the cost of pesticide use which is estimated at $ 3.7 billion per year [8]. Despite the important ecological role that bats play around the world, they are mostly overlooked and have received very little attention [24]. Bats visit a wide range of habitats provided that they harbour the insect biomass needed for their hunting activity. They can therefore be found in almost all environments, whether natural or anthropogenic. They find various sites according to their biological requirements: in caves, trees, other substratum or human constructions. Some are exclusively arboreal, others anthropophilic and some ubiquitous [10]. However, for the last fifty years, the populations of many bats species have been declining and this can be explained by human practices as well as their high rate of parasites [2].

In Burkina Faso, studies have been carried out to characterize and inventory bats [28, 35, 1, 30, 20, 29, 24, 15, 26]. However, with the anthropization of land and the context of climate change which negatively influences the ecology of bats, these data need to be updated. The key aims of the present study was to identify and describe the composition, the diversity bats in five cities in Burkina Faso

Materials and Methods

Study site

The study was carried out in Burkina Faso where we selected five (05) chief towns as the study area, Ouagadougou, Bobo-Dioulasso, Koudougou, Banfora and Tenkodogo. The sites were selected based on their accessibility and strong presence of bats. Indeed, in Ouagadougou, the Bangr-Weoogo park is a favorite site for bats. Within the environmental services of Koudougou, Tenkodogo and Banfora, there are a large number of bats. The hydrographic network of Burkina Faso is relatively dense despite the rather precarious climatic conditions and the low relief. The entire hydrographic network is linked to three main watersheds or international basins: Volta, Comoé and Niger [12].

Burkina Faso has a Sudano-Sahelian climate characterized by two very distinct seasons: a long dry season from October to April and a short rainy season from May to September [12]. The rainy season is dominated by a monsoon regime during which almost all of the precipitation takes place. According to the National Meteorological Agency, three climatic zones can be distinguished on the basis of the rainfall amounts collected annually and the thermal regime. These are from South to North: the Sudanian zone, the Sudano-Sahelian zone and the Sahelian zone (Figure 1).

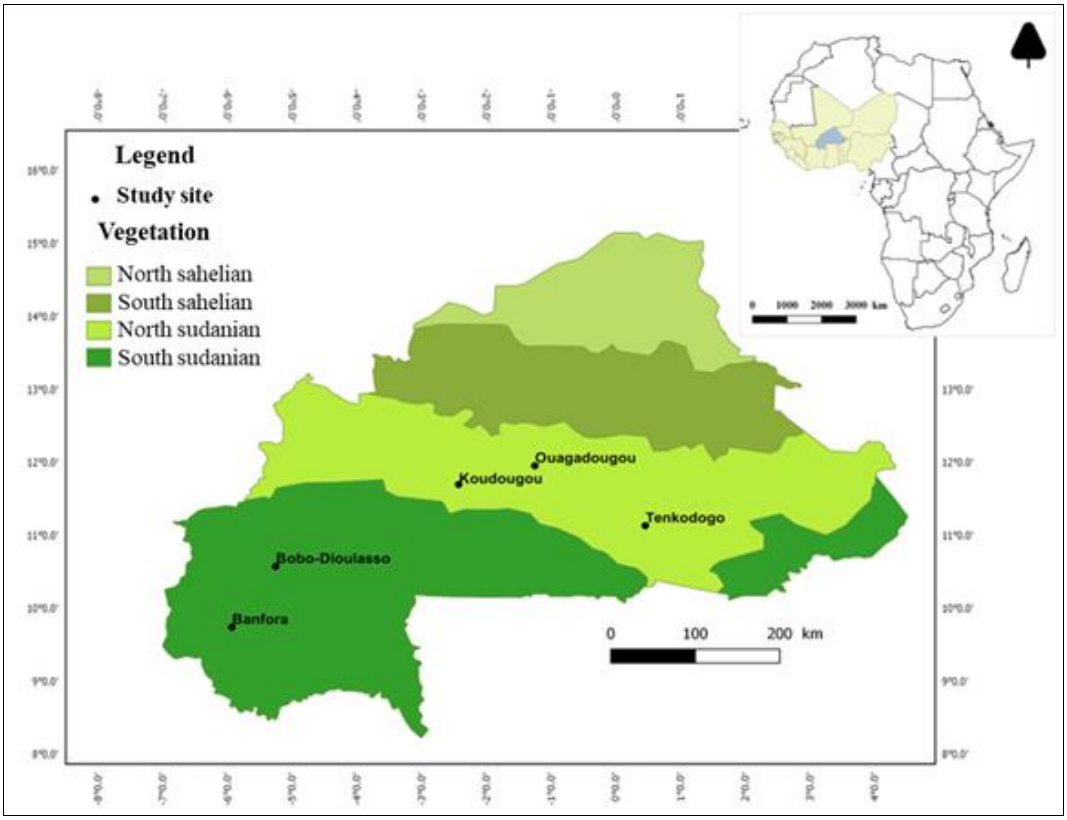

Fig 1: Maps showing the study sites

Sampling sites selection

The various water points which represent hydratation sites, the forest galleries which are feeding sites and the large buildings which are resting sites for bats were identified before the start of the capture. The cities selected for the capture of bats at the end of the survey are Bobo-Dioulasso, Banfora, Tenkodogo, Koudougou and Ouagadougou.

Capture bats

Bats usually come out at nightfall to feed, regardless of their diet, insectivorous or frugivorous. The capture period extended from August to November 2018. The installation of Vohwinkel mists nets (length: 6 or 12 m, height: 2.80 m, 5 layers, mesh: 16 mm, denier: 70/2) started at 5 p.m. Five mist nets were used at each sampling point. The nets were open from nightfall from 6 p.m. until 5 a.m. depending on the abundance of bats. On these sites, the nets were placed in several places (houses, vegetation galleries, along the water points). PVC pipes and nylon threads were used to fix the nets. The nets were monitored every 15 minutes to remove the captured bats so that they did not injure themselves by becoming entangled in the net or that they were not attacked by predators. The bats were released with care to the wing clearances, as the bats entered the nets with their wings outstretched and then folded them back. Each captured bat was placed in a cotton bag and kept until it was identified.

To avoid any direct contact with bats, we have used Personal Protective Equipment in line with the "Code of ethics for the practice of catching bats" designed as part of the National Plan of Chiroptera Actions 2009-2013.

Identification of bats

Several parameters were considered for the identification of bats: the weight of the specimens, the sex, the age class (juvenile, sub-adult or adult), the reproductive status and standard morphometric variables.

Bats were weighed (in grams) in bags using a precision 0.25 g Pesola brand spring balance; 1 and 2 g depending on the size of the specimen. The weighing was carried out according to the method of [14] Epstein et al. (2016). Sex was determined by observation of the genitals. Indeed, males and females are easily recognizable by their genitals. The observation of the morphological characters (presence of cartilaginous epiphyseal flats in the bones of the fingers in juveniles), made it possible to determine the age classes.

The reproductive status of males (reproductive or non-reproductive) was determined based on the size of the testes. That of females (nulliparous, pregnant, lactating or post-lactating) by abdominal palpations, observations and pinching of the breasts. The callipers allowed us to measure the standard morphometric variables of bats. Before being released, the bats were marked with an indelible marker (on the head) to avoid recounting them in case of recapture. Bats were identified using the identification keys of Grassé (1955), Rosevear (1965), Hayman and Hill (1971); Bergmans (2002) [19, 37, 23, 5].

Data analysis

Statistical analysis of the data was carried out, with the aid of the R. 3.3.3 statistical software. A Shapiro-Wilk test was used to check for normality of the data which proved the data not to be normally distributed therefore non-parametric tests were used in the analysis of data. Pearson's Chi-squared test was used to test for significance in parasitic load among the age categories, the sexe and reproductive status of bats. A Kruskal-Wallis H test was used to compare biological parameters and the Wilcoxon-Mann-Whitney test to compare the medians of two biological parameters. Past 2.17 C software was used to calculate the ecological indices used to characterize bats diversity. The calculated indices were:

- The specific richness of bats, determined by the total number of species found in each site;
- The Shannon diversity index, H' [31], estimates stand diversity and is determined by the following formula:

$$H' = -\sum_{i=1}^{s}[(\frac{q_i}{Q})\log_2(\frac{q_i}{Q})],$$

where q_i represents the number of individuals of taxon *i* and *Q* represents the total number of individuals in the habitat*;*

- Diversity is greater when all taxa observed have the same abundance.

$$H'_{max} = \log_2 S,$$

where *S* is the total number of taxa in the stand;

- The Simpson diversity index, estimates stand diversity and is determined by the following formula:

$$D = \sum_{i=1}^{s} q_i(q_i - 1))/(Q(Q-1)),$$

-The Pielou equitability index, J' [31], which estimates the individuals equipartition in the habitat. It is calculated by the formula

$$J' = \frac{H'}{H'_{max}}.$$

Results

A total of 341 bats from eight species were captured representing 15.68% of the bat species known to occur in Burkina Faso (Table 1). A large number of frugivorous bats were captured, with *Epomophorus gambianus* (Ogilby, 1835) being the most abundant specie. *Scotophilus leucogaster* (Cretzschmar, 1826) was the most abundant Insectivorous bats species.

Table 1: Bats biodiversity

Family	Subfamily	Genus	Species
Pteropodidae Gray, 1821	Rousettinae Andersen, 1912	*Epomophorus* Bennett, 1836	*Epomophorus gambianus* (Ogilby, 1835),
		Micropteropus Matschie, 1899	*Micropteropus pusillus* (Peters, 1868)
	Eidolinae Almeida, Giannini and Simmons, 2016	*Eidolon* Rafinesque, 1815	*Eidolon helvum* (Kerr, 1792)
Nycteridae Van der Hoeven, 1855	Nycteroidea Van der Hoeven, 1855	*Nycteris* G. Cuvier and E. Geoffroy, 1795	*Nycteris macrotis* Dobson, 1876,
Emballonuridae Gervais, 1855		*Taphozous* E. Geoffroy St.-Hilaire, 1818	*Taphozous mauritianus* E. Geoffroy St.-Hilaire, 1818
Molossidae Gervais, 1856	Molossoidea Gervais, 1856	*Chaerephon* Dobson, 1874	*Chaerephon pumilus* (Cretzschmar, 1830),
Vespertilionidae Gray, 1821	Vespertilioninae Gray, 1821	*Neoromicia* Roberts, 1926	*Neoromicia guineensis* (Bocage, 1889)
	Scotophilinae Van Cakenberghe and Seamark, 2008	*Scotophilus* Leach, 1821	*Scotophilus leucogaster* (Cretzschmar, 1826)

Diversity and abundance of bats depending on the sites and their diet

Of the 8 bats species captured, the diversity and abundance of the species was higher at Bobo-Dioulasso (07 species for 90 individuals) than at the other sites; Banfora (05 species for 64 individuals), Tenkodogo (03 species for 68 individuals), Ouagadougou and Koudougou (02 species for each and 69 and 50 individuals respectively). Insectivorous were represented by 5 species and frugivorous by 3 species (Figure 2).

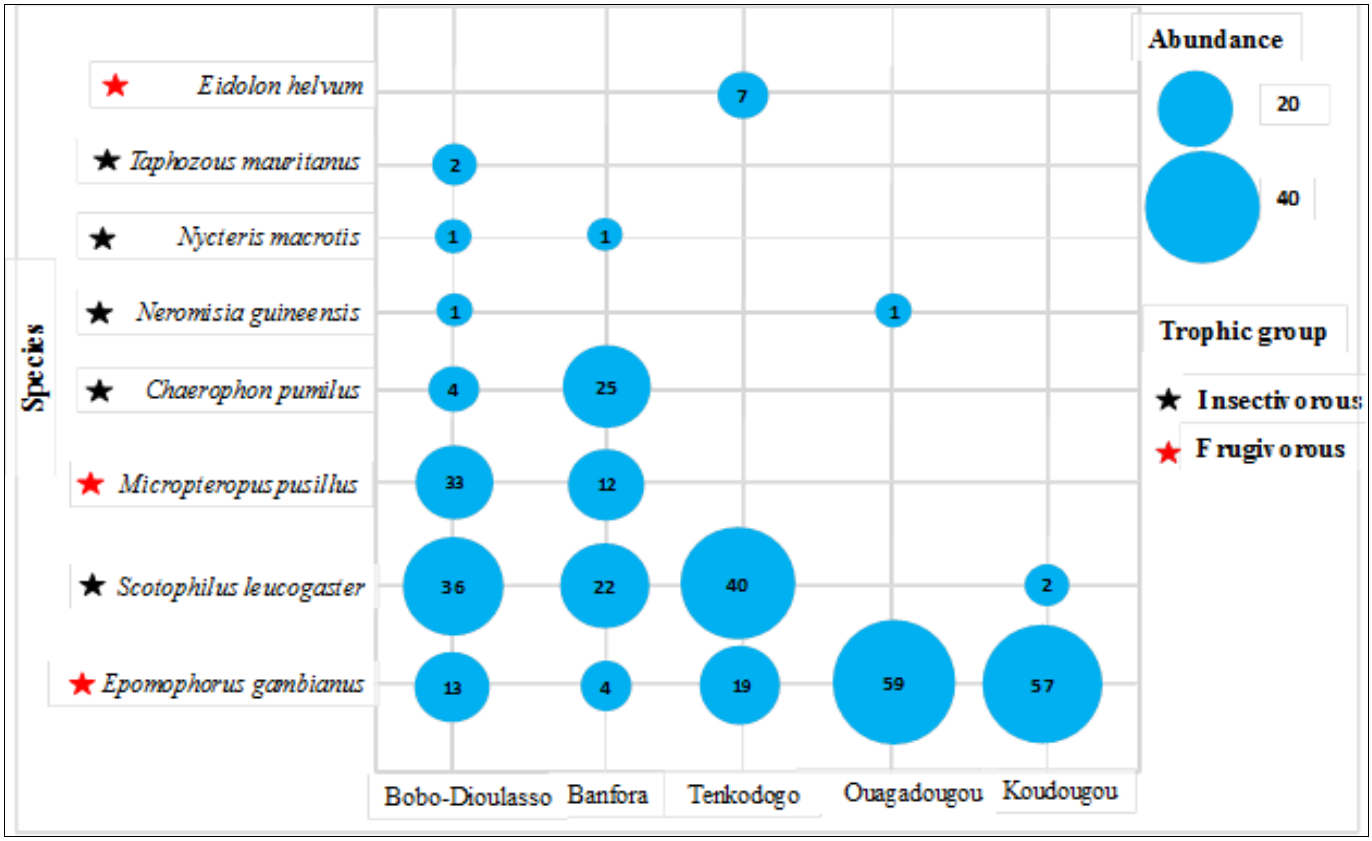

Fig 2: Abundance of bats according to sites and their trophic group

Table 2 shows that for the Shannon and Weaver specific diversity index, the most diversified sampling site was of Bobo Dioulasso while the least diversified are Banfora and Ouagadougou. This index, which is sensitive to changes in the importance of the rarest species, contrasts with the result of the Simpson specific diversity index, which is sensitive to changes in the importance of the most abundant species. The Simpson index presents the Bobo-Dioulasso and Banfora sites as the most diverse. Piélou's fairness shows that the distribution is more equitable in Tenkodogo and Banfora.

Table 2: Abundance and Diversity indices of bats according to sites

Sites	Bobo-Dioulasso	Banfora	Ouagadougou	Tenkodogo	Koudougou
S	7	5	2	3	2
Simpson D	0.68	0.69	0.03	0.52	0.06
Shannon H'	1.34	1.30	0.08	0.89	0.15
Equitabilité J'	0.69	0.80	0.12	0.80	0.21

H'= Shannon diversity index, S= Total number of taxa in the site, J'= Pielou equitability index, D = Simpson diversity index.

Distribution of bats according to sex, reproductive status and age class

On all the bats captured, the Chi-square test showed a significant difference in the sex of the bats (x^2= 7.62, df = 1, p = 0.0057). The distribution of bats from 196 female bats resulted in 112 nulliparous, 07 pregnant, 01 lactating and 76 post-lactating. The 145 male bats were divided into 102 breeders and 43 non-breeders (Table 3). Depending on the age groups, we obtained 216 adults and 125 sub-adults.

Table 3: Distribution of bat species according to their sex and reproductive status

	Female				Male	
Reproductive status	**Nulliparous n(%)**	**Pregnant n(%)**	**Lactating n(%)**	**Post-breastfeeding n(%)**	**No reproductive n(%)**	**Reproductive n(%)**
Micropteropus pusillus	20(5.87)	0(0)	0(0)	11(3.23)	6(1.76)	8(2.35)
Epomophorus gambianus	35(9.97)	7(2.05)	1(0.29)	43(12.61)	34(10.26)	32(9.38)
Scotophilus leucogaster	49(14.37)	0(0)	0(0)	5(1.47)	3(0.88)	45(13.2)
Taphozous mauritianus	0(0)	0(0)	0(0)	0(0)	0(0)	2(0.59)
Neoromicia guineensis	0(0)	0(0)	0(0)	0(0)	0(0)	2(0.59)
Eidolon helvum	2(0.59)	0(0)	0(0)	3(0.88)	0(0)	2(0.59)
Chaerephon pumilus	6(1.76)	0(0)	0(0)	14(4.11)	0(0)	9(2.64)
Nycteris macrotis	0(0)	0(0)	0(0)	0(0)	0(0)	2(0.59)
Total	112(32.56)	7(2.05)	1(0.29)	76(22.3)	43(12.9)	102(29.93)

n = Number of each individuals per species (%) = Percentage

Discussion

The total species richness is 08 species in 08 genera and 05 families. This richness is still low compared to the number of bats species known and those already identified in Burkina Faso. Indeed, according Kangoye et al. (2012) [24], 51 species of bats are recorded in Burkina Faso, distributed over 24 genera and 09 families. The difference could be due to the short inventory time and the habitats covered; while Kangoyé et al. (2012, 2015a, 2015b) [24, 25, 26] sampled in all habitats across the country, our study was limited to some habitats in cities. Longer sampling periods and consideration of additional habitats may be necessary to achieve a complete inventory [15]. All these species have already been reported in several West African countries.

On March 02, 1969 in Barga (9 km NE), Vaden, R.E. collected two specimens identified respectively as *Taphozous perforatus* and *Taphozous mauritianus* and deposited at the RMCA (Royal Museum for Central Africa) under the numbers 97.077-M-3172 and 97.077-M -3173.

Taphozous mauritianus specimen deposited under number 97.077-M-3173 was re-identified as *Taphozous perforatus* and this leads to say that *Taphazous mauritianus* had never been identified in Burkina Faso.

However, despite the shortened sampling period, this species was identified in this study in Burkina Faso, representing a new record for the country; thus, increasing the specific richness of bats from Burkina Faso to 52 species. Two individuals of *Taphozous mauritianus* were recorded in Bama (10 º39'01.9''N; 4º45'23.8''W) at 31 km from Bobo Dioulasso for the first time. This dorsal pelage grizzled, belly and throat pure white unlike *Taphozous perforatus* whose dorsal pelage uniformly dark chocolate brown, sepia brown, greyish-brown or ashy-brown. This insectivorous species has been reported as widely distributed in sub-Saharan Africa and Madagascar [27, 17, 22]. *Taphozous mauritianus* is associated with arid and wooded habitats such as savannahs and can roost solitary in a variety of habitats including rocky surfaces, tree trunks and walls. *Epomophorus gambianus* was the most abundant species. The specimens of this species were collected in gallery forests, fruit trees plantations such as *Andansonia digitata*, *Mangifera indica*, *Vitellaria paradoxa* and *Ficus carica.* According to [32], *E. gambianus* and most other fruit bats prefer certain foods among those available.

Bobo Dioulasso showed a greater specific richness, followed by Banfora and Tenkodogo. Koudougou and Ouagadougou had a low diversity, with 2 species each. Bobo Dioulasso is located in the Sudanian climatic zone, where the vegetation is important and the flora is clearly dominated [6]; This justifies the high presence of bat species in this city. Indeed, the variability of the bat species richness could be explained by the presence of food resources and the specificity of bats to these food resources. These results agree with of Marshall (1985) [32], who report that, the biology of bats, especially their migration, is influenced by the distribution and timing of food availability. The abundance of females compared to males may be part of different foraging behaviors and intra-specific competition. Female bats take longer to search for food and therefore more susceptible to capture. According to Senior et al., 2005 [39] and Dietz et al., 2006 [11], females require large amounts of energy and nutrients and feed longer and in different habits because of their mating system. On the other side, males spend little time looking for food, especially during the mating season [3]. The low number of pregnant and lactating bats in this study does not synchronize with the rainy season. Our capture period was largely a rainy period (August to October) where there is an abundance of food resource therefore a favourable breeding season for bats. Numerous studies have shown a synchronization of the breeding calendar and that of the rains and in all probability a direct consequence of the influence of seasonality on trophic availability [42].

Conclusion

During this study, 08 species distributed over 8 genera and 5 families were identified. This study brings the number of bats species present in Burkina Faso to 52 species with the discovery of *Taphozous mauritianus*. The highest abundance and specific richness were in Bobo Dioulasso. A new inventory study that is broader in time and in space will be able to fully appreciate the evolution of the biodiversity of bats in Burkina Faso, especially in the context of climate change.

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