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PRELIMINARY STUDY ON *Eidolon helvum* (Kerr, 1792) POPULATION DYNAMIC IN CÔTE D'IVOIRE, WEST AFRICA

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KEYWORDS

Straw-colored fruit bats
Dynamic of the population
Season effect
Main food resources
Côte d'Ivoire

ABSTRACT

Relationship survey between diet and population size variation with regards to *Eidolon helvum* (Kerr, 1792), a near-threatened species has been achieved from August 2007 to July 2008 in the Commune of Plateau in Abidjan (Côte d'Ivoire; Western Africa). Indeed, perched bats count and excrement collection under daily dormitory have been performed with the purpose to evaluate *E. helvum* population size and dynamism (population variation) as well as to determine and/or discriminate the factors inducing that dynamism. *E. helvum* population in above mentioned experimental site, in relation to analyzed period (from August 2007 to July 2008) was estimated to 181384 ± 15013.26 . Further, findings of present study suggested an increase in *E. helvum* population size from August to November, stabilization from November to February and reduction from March to July 2008. In addition, this study exhibited both food diversity ($r=0.94$; $p < 0.0001$) and abundance ($r=0.90$; $p < 0.0001$) as preponderant features influencing analyzed *E. helvum* population fluctuations. Food sources analysis revealed that *E. helvum* consumed *Ficus exasperata* Vahl (Moraceae) ($r = 0.89$; $p < 0.0001$), *F. lutea* Vahl ($r = 0.86$; $p < 0,001$) and *F. polita* ($r=0.61$; $p < 0.05$) as main food resources. In conclusion findings of present study evoked that season and as well both food diversity and abundance are significant parameters (p -value <0.05) which influenced *E. helvum* bats specie population dynamism.

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1 Introduction

Several parameters analysis such as population size and preferential habitat, diet and species threat can contribute to a permanent fauna management (Richter & Cumming, 2006; Fleming and Racey, 2010). Chiropteran have huge systematical (Kunz & Parsons, 2009; Herkt et al., 2016), ecological (Kunz et al., 2011; Meyer et al., 2016), pharmacological (Mildenstein et al., 2016), medical and veterinary (Moratelli & Calisher, 2015; Saéz et al., 2015), economical (Kunz et al., 2011; Ghanem & Voigt, 2012; Niamien et al., 2015; Williams-Guillen et al., 2016) and conservation values (Kingston, 2013; IUCN, 2015; Niamien et al., 2015; Mildenstein et al., 2016). Despite such multiple values, only few ecological data are available about them and this happened because of their nocturnal activities and the active flying way, making difficult their study (Kunz & Parsons, 2009; Herkt et al., 2016).

In Côte d'Ivoire and particularly in Abidjan, the Commune of Plateau houses great population of straw-colored fruit bats *Eidolon helvum* (Kerr, 1792), as per IUCN (2015) report this species is near to threaten. Species *E. helvum* have significantly contribute in pollination of flower and in reconstitution of forest ecosystem (Kunz et al., 2011; Moratelli & Calisher, 2015; Meyer et al., 2016; Williams-Guillen et al., 2016). In addition to this, these frugivorous also insure seed dispersion and favor seed germination of Iroko (*Milicia excels* Welw. Moraceae), which is a threatened forest gist in West Africa (Hawthorne, 1995; Tatlor et al., 2000). Despite these ecological value and/or importance of bats, these bats colonies have been less studied (Huggel-Wolf & Huggel-Wolf, 1965; Thomas, 1983; Niamien et al., 2009; Niamien et al., 2010; Niamien et al., 2015; Niamien et al., 2017a; Niamien et al., 2017b). Thus, the Commune of Plateau, by virtue of the presence of the important community of fruit eater straw colored bats would be considered as a strategical site for the conservation of the biodiversity. In addition, central part of the Commune of Plateau is lined by different tree species, which are used as shelter by straw colored fruit bats (Thomas, 1983; Niamien et al., 2009; Niamien et al., 2010; Niamien et al., 2015). Population of this species disperses in the twiling to look for food and after eating, these fruit-eater bats return back to their accommodation site. They perched on the branches serving as roost (Figure 1). Also the gastric contain is continually excreted through the faeces and/or excrement during daily sleeping phase (Kunz & Parson, 2009).

Studies about the factors which influence the dynamic of fruit eater straw colored bats populations and their migration are in scarcity. In fact, some approaches have been done in Mauritania and in Kenya (Cosson et al., 1996; Richter & Cumming, 2006), but these information's are not enough to explain population

distribution and population dynamic of *E. helvum*. In Côte d'Ivoire, only Thomas (1983) has carried out studies about the migration of fruit-eater straw-colored bats. However, this author has not given any information about the causes of the variation among the population size and pattern of migration.

The general hypothesis is that the variations of abundance are according to availability of the food. The present study carried out from August 2007 to July 2008, is a contribution to a better knowledge of the ecology of fruit-eater straw-colored bats in order to insure a rational and lasting management. It aims specifically at determining the numbers of straw-colored fruit bats, their dynamic and to evaluate the influence of the availability of the food on the abundance fluctuations.

2 Materials and Methods

2.1 Study site

The Commune of Plateau stretches out between longitudes 4°10' and 4°50' West and latitudes 5°10' and 5°80' North, on a surface area of 2.5 km². It is located in the center of Abidjan (South of Côte d'Ivoire).

Abidjan has humid equatorial climate regime, characterized by four seasons as following: small dry season from August to September, small rainy season from October to November, a long dry season (from December to March) and a long rainy season from April to July) (Brou, 1997).

2.2 Data collection

2.2.1 Population size

The population size of the straw-colored fruit bats in the Commune of Plateau was determined by counting the perched and sleeping bats (Kunz, 2003; O'Shea et al., 2003; Krebs, 2006; Hayes et al., 2009; Hayman et al., 2012). Visits were done on Saturdays during day light from 7 Am to 5 Pm to take into account the poaching activities (Niamien et al., 2015). Counting has been performed on Saturdays, except from football match days in Felix Houphouët-Boigny stadium adjoining the study zone. In fact, the spectators cry during football matches bring out a massive flight of bats (Mann et al., 2002; Hayes et al., 2009; Nordt & Klenke, 2013). That counting was done in 16 roosting sites (Figure 1), before the waking up and the massive agitation of bats, by counting the perched bats on branches of each tree, from its base towards the extremity whatever the age and the sex, usually counting carried out manually but some time help of the binoculars was also taken (Kunz, 2003; O'Shea et al., 2003; Krebs, 2006; Hayes et al., 2009; Hayman et al., 2012; Niamien et al., 2017 b).

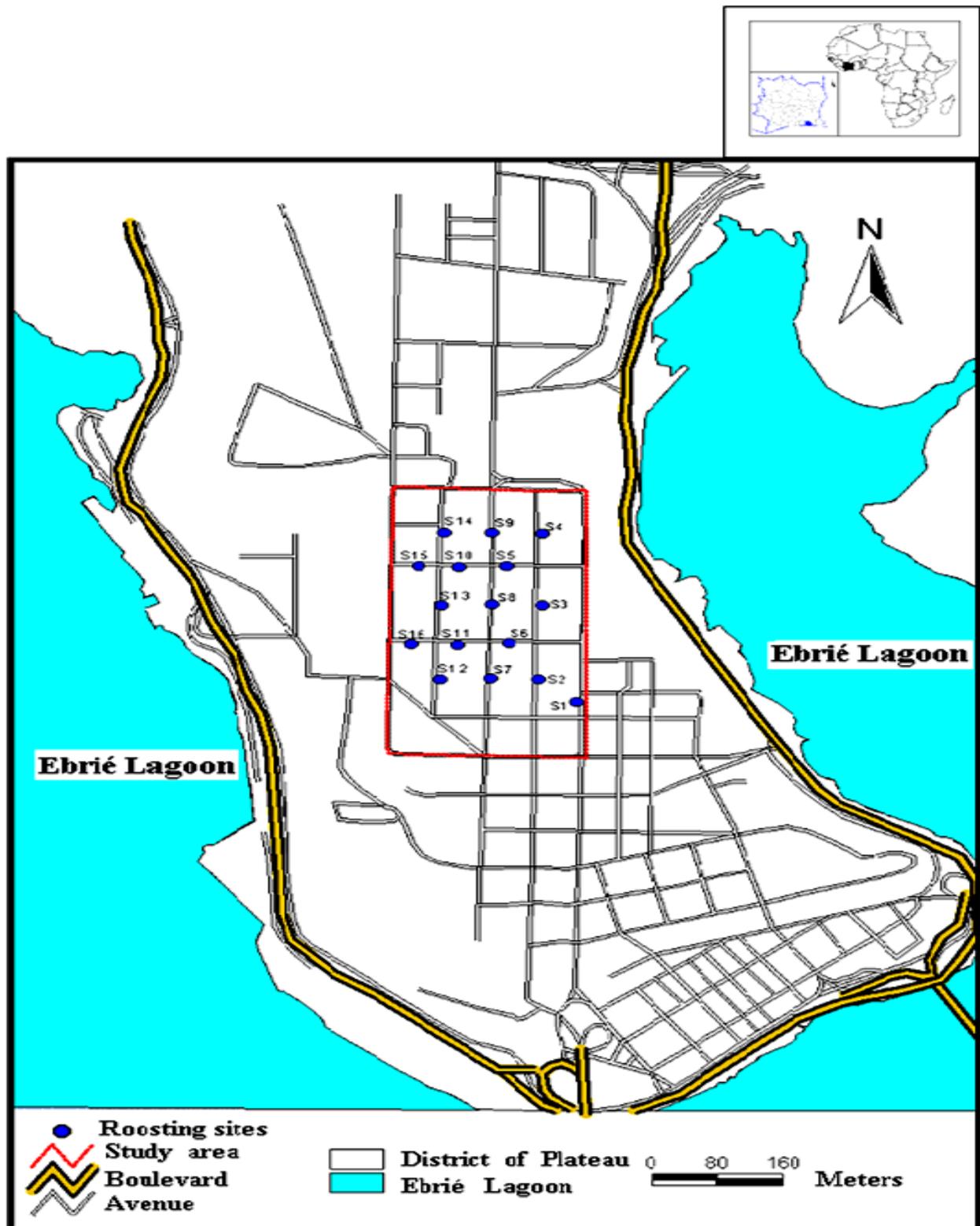


Figure 1 Cartography of 16 roosting sites of straw-colored fruit bats in the Commune of Plateau in Abidjan from August 2007 to July 2008.

2.2.2 Diet composition

2.2.2.1 Faeces collection

The diet of the straw-colored fruit bats in Plateau Commune was studied by analyzing their faeces and/or excrement composition (Thomas, 1988; Niamien et al., 2009, Niamien et al., 2017a). The excrement was collected from August 2007 to July 2008 under the daily roosting sites (Figure 1). Excrement was collected with the help of spatula and referenced pill machines (site and month). Collection preferentially were executed on Sundays with the purpose to take into account sweeping activities of the pavement of the Commune of Plateau, which is going on the working days, which likely eliminate bat excreted faeces and/or excrement (Niamien et al., 2009; Niamien et al., 2017a).

2.2.2.2 Sort out and identification of taxons

In the laboratory, the content of each pill machine is spilled on a sieve of 1 mm of mesh. Excrement washed with water in order to isolate the seeds. These isolated seeds were identified with the help of keys suggested by Hutchinson & Dalziel (1963) and Aké-Assi (2001, 2002) and then the collection of reference of National Floristic Center of the University Félix Houphouet-Boigny (Côte d'Ivoire). The vegetable species of faeces only constituted of pulp were determined on the basis of their color, texture and smell (Thomas, 1982; Thomas, 1984; Thomas, 1988; Niamien et al., 2009; Niamien et al., 2017a). Indeed, the taxon were identified and counted.

2.2.3 Expression of diet results

2.2.3.1 Abundance relative of food

The abundance of food in the nature and particularly in the nutrition zone is explained by the great frequency of items in the faeces. On this basis, the index of the food abundance was estimated by counting the items species found in the faeces of the straw-colored fruit bats (Thomas, 1982; Thomas, 1988).

2.2.3.2 Diversity index of Shannon-Weaver (H')

The calculated diversity index of Shannon (H') on the basis of abundance relative to each vegetable species present in the straw-colored fruit bats excrement (Ramade, 2012), permitted to determine the specific diversity of the exploited food resources by straw-colored fruit bats. It varies from 1 to 5; as following:

$$H' = -\sum (ni/N) \ln (ni/N)$$

Where as

ln = Natural logarithm,

ni = number of faeces and/or excrement in an item i,

N = Total examined faeces and/or excrement number. The present Shannon index (diversity index) was calculated with GWBASIC software.

2.3 Statistical analysis

Before any analysis, the distribution of normal data was checked by using the Shapiro-Wilk test. The average numbers of straw-colored fruit bats were compared to variances analysis. Correlation between straw-colored fruit bats numbers and (i) the diversity of consumed resources, (ii) the abundance of food and (iii) the main food resources respectively were realized via a Spearman correlation test. Finally, the Linear Generalized Model has permitted to test the diversity effects of the consumed items and the abundance of food on the distribution of straw-colored fruit bats. The present analysis was performed by using STATISTICA software (version 7.1).

3 Results

3.1 Numbers and temporal variations

The present survey based on 48 observations, performed in Plateau Commune from August 2007 to July 2008, recorded a straw-colored fruit bats number ranging between 11687 (minimum value relative to July) and 308409 (maximum value relative to November) (Table 1). Monthly average of bat population in the present processed experimental site has been estimated to 181384 ± 15013.26 (Table 1). Further, February and November months have been recorded as exhibiting the highest number of bats ratio as opposed to March, April, May, June and July month (p-value <0.05) (Table 1).

In addition, the present analysis showed a significant increase of processed straw-colored fruit bats population size from August to November (ddl = 3; F = 31.15; p < 0.001). The same survey evidenced the stabilization of that population from November to February (ddl = 3; F = 2.1; p > 0.05) and its noticeable progressive falling down from March to July (ddl = 4; F = 15; p < 0.001) (Table 1). Comparative statistical and/or clustering analysis evidenced a significant difference (p-value <0.05) between both dry and raining seasons in assessing bats population dynamism (Table 1).

3.2 Food availability

Findings of study revealed eleven fruits tree species viz., *Carica papaya* L. (Caricaceae), *Elaeis guineensis* Jacq. (Arecaceae), *Ficus benjamina* L. (Moraceae), *Ficus exasperata* Vahl (Moraceae), *Ficus lutea* Vahl (Moraceae), *Ficus polita* Vahl (Moraceae), *Ficus sp.* (Moraceae), *Ficus sur* Forssk. (Moraceae),

Table 1 Descriptive statistic survey of straw-colored fruit bats population size variation from August 2007 to July 2008 in Plateau Commune.

Months	Statistical parameters							
	Minimum	Mean	Maximum	Median	¼ Quartil	¾ Quartil	Variance	p-value
August	202804	205850.13 ± 1801 ^d	210929	204833.5	203343	208357	12983869	0.5
September	204679	210200 ± 2396 ^d	215721	210200	206442	213958	22974311	0.57
October	196898	199656 ± 1291 ^e	202254	199736	197477	201835	6671256	0.96
November	304015	306646 ± 959 ^a	308409	307080	305263	308029	3684855	0.16
December	283936	288720 ± 2574 ^b	296016	287464	285528	291912	26503339	0.36
January	273153	280446 ± 3087 ^c	287738	280446.5	275799	285093	38124373	0.13
February	304406	304700 ± 187 ^a	305231	304581.5	304435	304965	141364.7	0.18
March	172718	174536 ± 1173 ^f	177890	173768	172928.5	176143.5	5508457	0.2
April	100885	102637.5 ± 736 ^g	104392	102636.5	101546.5	103728.5	2172251	0.14
May	68424	70456 ± 843 ^h	72478	70461	69240	71671.5	2847997	0.44
June	19422	20422 ± 550 ⁱ	21952	20157	19649	21195	1213021	0.48
July	11687	12340 ± 303 ^j	13015	12329	11841.5	12838.5	368018	0.051

ddl = 11 ; F = 44.99 ; p = 0.0017 ; a month with high number of bats, b: month with moderate number of bats ; c, d, e, f, g, h, i: months with weak number of bats.

Ficus umbellata Vahl (Moraceae), *Mangifera indica* L. (Anacardiaceae) and *Psidium guajava* L. (Myrtaceae) as a part of straw-colored fruit bats diet. Among these, fruits of *F. exasperata*, *C. papaya*, *F. polita* and *M. indica* are the most exploited one. In addition, excluding *M. indica*, the majority of the eaten fruits by the straw-colored fruit bats were more abundant during the long dry season (Figure 2).

Also, obtained and/or computed Shannon variability index (H') highlighted the diversity of food resources and advised nutriment increase from August (1.8) (small dry season) to February (2.3) (long dry season), which exhibited the peak and/or maximum value of processed Shannon index. However, this index (H') decreased from March (2.01) (long dry season) to June (long rainy season) which corresponded to the minimum reaching Shannon index value (1.5). Finally, the diversity of exploited items has increased in July (1.6), matching to the end of the long rainy season (Figure 3).

3.3 Correlations between the number of straw-colored fruit bats and the availability of food

Relationship analysis between straw-colored fruit bats numbers and diversity of items was also assessed during the study. The Spearman correlation test showed a strong correlation between bats numbers and the diversity of the eaten items (N=12; r = 0.94; p < 0.0001). In fact, the Generalized Linear Model revealed that

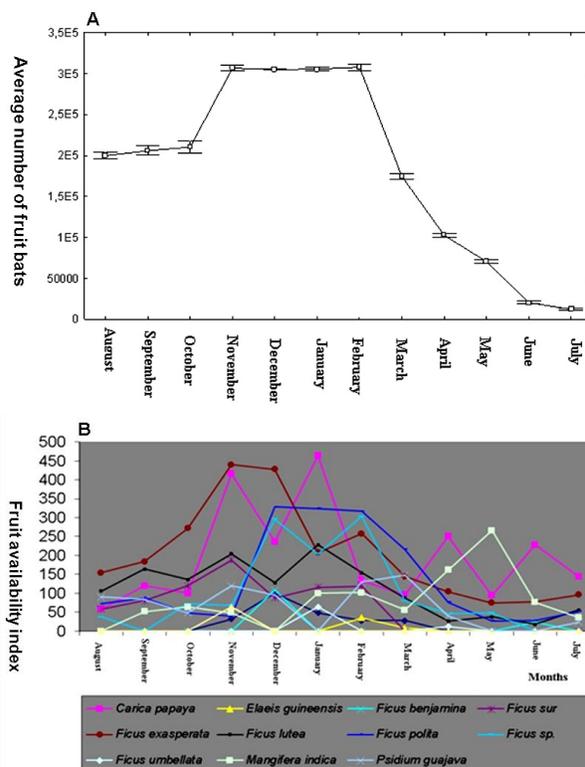


Figure 2 Variations of the straw-colored fruit bats population size (A) according to the food availability (B) of the Commune of Plateau in Abidjan from August 2007 to July 2008.

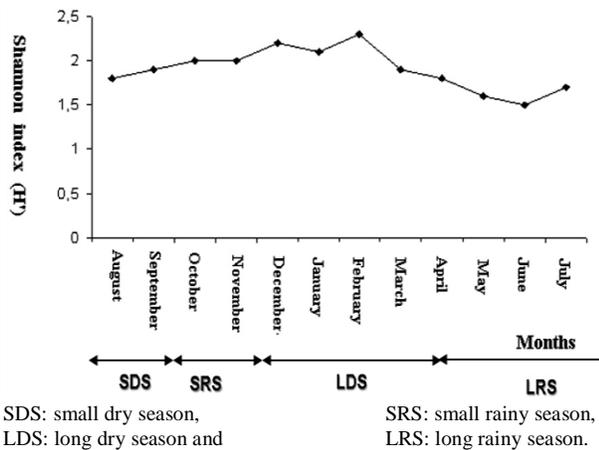


Figure 3: Monthly variations of food diversity exploited by the fruit bats *Eidolon helvum* in the Commune of Plateau in Abidjan from August 2007 to July 2008.

the distribution of straw-colored fruit bats in our experimental site was according to the diversity of exploited food resources (GLM: ddl = 11; W = 68,89 ; $p < 0.001$).

Further, relation survey between straw-colored bats numbers and food abundance was also carried out in present study. Result of this study suggested a strong agreement (high correlation) between straw-colored fruit bats number and food abundance (N=12; $r=0.90$; $p < 0.0001$). Indeed, the performed Generalized Linear Model survey certified that observation by highlighting the distribution of straw-colored fruit bats in the Commune of Plateau as influencing the abundance of exploitable food resources (GLM: ddl = 11; W = 86.12; $p < 0.001$).

As regards straw-colored fruit bats main food resources, findings of study suggested four fruits species trees i.e. *C. papaya*, *F. exasperata*, *F. lutea* and *F. polita* (Figure 2), as regularly and most exploited. In addition, in except of *C. papaya* ($r=0.31$; $p > 0.05$), the correlation test of rank of Spearman revealed that the numbers of *E. helvum* are significantly linked to *F. exasperata* ($r=0.89$; $p < 0.0001$), of *F. lutea* ($r=0.86$; $p < 0.001$) and of *F. polita* ($r=0.61$; $p < 0.05$) fruits availabilities. Consequently, *F. exasperata*, *F. lutea* and *F. polita* are the main fruit species, responsible of the variation of the straw-colored fruit bats on one hand and on the other hand, determine the migration of straw-colored fruit bats, a near-threatened species in our experimental site (Commune of Plateau; Abidjan Côte d'Ivoire).

4 Discussion and conclusions

Food seems to be the main cause conditioning straw-colored fruit bats population dynamism. Then, size increasing as regards straw-colored fruit bats population from August to November seems to be linked to the diversity and the abundance of food resource

(Cosson et al., 1996; Richter & Cumming, 2006; Durant et al., 2013; Cisneros et al., 2015). Afterwards, food limitation would ensure the upholding of straw-colored fruit bats numbers from November to February (Figure 2). Then, this food proportion may normalize analyzed straw-colored fruit bats population size guaranteeing and ensuring their daily needed energy (Cumming & Bernard, 1997; Fleming & Eby, 2003; Richter & Cumming, 2006; Klingbeil & Willing, 2010). Finally, observed reduction as regards straw-colored bats population size for March seems to be dictated and/or associated to the fall of food resource availability (Figures 2). From this on, the individual producers would migrate from March to July, to profit from peaks of food abundance in order to satisfy their high need in energy (Fleming & Eby, 2003; Richter & Cumming, 2006; Durant et al., 2013; Kingston, 2013; Cisneros et al., 2015).

The population size variation reveals that the largest numbers of straw-colored fruit bats are observed in the long dry season (Table 1). That same observation was done on the colony of straw-colored fruit bats of Accra, Ghana (Hayman et al., 2012). That could be explained by the fact that the diversity and abundance peaks of food occur in this season, reducing the latter (food) competition. That manna charm the straw-colored fruit bats, since that fruits are produced to attract the frugivorous (Gautier-Hion, 1990; Richter & Cumming, 2006; Fahr & Kalko, 2011; Hagen & Saho, 2011; Cisneros et al., 2015).

Result of study evidenced *F. exasperata*, *F. lutea* and *F. polita* as the most exploited food resources (Figure 2) linking them to the consistent variations observed in the present analyzed bats population. In the National park of Kasanka (Zambia), four fruit species are the most eaten by the colony of straw-colored fruit bats. There are *Syzygium guineense guineense* (Wild.) Dc. (Myrtaceae), *S. guineense huillense* (Hiern) F. White (Myrtaceae), *Upaca banguelensis* Müll. Argr. (Euphorbiaceae) and *U. kirkiana* Müll. Argr. (Euphorbiaceae), which are resulted the main food resources responsible of abundance fluctuations (Richter, 2004; Richter & Cumming, 2006).

In scope of that study, the relative availability of food (diversity and abundance) was calculated on the basis of the collected faeces and/or excrement under the daily dormitory sites of straw-colored fruit bats of the Commune of Plateau. That choice is linked to the fact that the feeding zone of that frugivorous is up to now not determined. These facts could constitute an obstacle to the suitable evolution of food availability. However, that deficiency can be skirted. In fact, results about food availability obtained from excrement collected under the dormitory are representative of food variation obtained in natural area (Thomas, 1982; Thomas, 1988). For a more complete evaluation of food resources availability, the determination of the feeding sites of the straw-colored fruit bats of the Commune of Plateau in Abidjan is

indispensable. Therefore, the linear transect methods and scores methods as used by Chapman et al. (1994) and Richter & Cumming (2006) would be to test.

Considering as a whole, the present analyzed straw-colored fruit bats population in the Commune of Plateau increased from August to November, was stable up to February before falling down from March to July. The greatest numbers as regards that population size were observed during the long dry season and the weakest during long rainy season. The straw-colored fruit bats population number claimed to be in agreement with food resource diversity and abundance. Also, our findings exhibited *F. exasperata*, *F. lutea* and *F. polita* fruit trees as responsible of bats population dynamism and/or variation as well as migration activities. Therefore, the present study suggested straw-colored fruit bats population size and diversity and as well reproduction needed and food resource availability as selective factors influencing the latter's population fluctuation and migration. To ensure the upholding of the integrality of this population of this species (a near-threatened species), the protection of their key food resources is indispensable. It goes through determining and protecting of nutrition zones. In addition, the services in charge of protecting the fauna could proceed to growing these main fruit resources in order to reduce the impacts of straw-colored fruit bats population and its immigrants on the surrounding plantations of industrial fruit trees avoiding conflicts able to increase their vulnerability.

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Conflict of Interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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