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Spatial and seasonal distribution of Bee Pollinator Species in a Sudanese Agro-ecological System in Burkina Faso, West Africa

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ABSTRACT

Bees are the most important pollinators of many crops and wild plant species. The ecosystem service of pollination provided by these insects is crucial to maintain overall biodiversity and to secure crop yields worldwide. Especially improving the livelihood of smallholders in developing countries through higher crop yields is essential for achieving global food security and poverty reduction. However, ecosystem degradation, depletion of plant species, habitat fragmentation, use of insecticides and global warming constitute severe threats to these organisms with some being clearly at risk of extinction. Despite the great ecological and economic importance of bees as pollinators, hardly anything is known about the bee species in West Africa and particularly in Burkina Faso. The study aimed to assess bee communities of a Sudanese agro-ecological system in Burkina Faso. We investigated the diversity and abundance of bees in near-natural savannah habitats and in nearby fields of the main cash crops (cotton, sesame) at three sites in the south of the country. Bees were caught with 288 colored pantraps for the duration of one year, covering the dry and rainy season. A total of 105 species of bees belonging to 32 genera and 4 families (Apidae, Megachilidae, Halictidae, and Colletidae) were identified. The most diverse family was Halictidae (sweat bees) with 41 species. The family of Apidae (including honey bees, bumble bees and stingless bees) was the most abundant family including 92.57% of specimens collected. In this study, the stingless bee Hypotrigona gribodoi was the most abundant species with 74.55% of all specimen. However, general conclusions have to be drawn with caution, since species abundances can greatly differ from year to year. During our study time, we noticed that the greatest number of species and specimens of bees were obtained in the dry season because of the longer duration of the season. However, the peak of the diversity and abundance of bees was observed in the rainy season especially in July and August (months of intense rains). The assessment of bee species and their seasonal distribution is an important scientific basis for the establishment of appropriate management strategies and can be implied in terms of sustainable agricultural practices that insure better productivity due to bee pollination service provision and biodiversity conservation.

Keywords: Biodiversity - Pollination - Bees - Ecosystem service - Agriculture - Burkina Faso.

INTRODUCTION

Bees play an outstandingly important role as pollinators in all temperate to tropical ecosystems and pollination ranges on one of the foremost places when it comes to quantifying the economic value of animal mediated ecosystem services. Approximately, 90% of angiosperm plant species depend on animals for pollination and sexual reproduction that avoids inbreeding with its longer-term consequences of losing genetic variability. In the short term loss of pollination can lead to a 40% yield reduction in cultivated plants [1]. What did cause just bees to attain such a prominent role? Bees use pollen as main food for their larvae. Many bees don't collect whatever they may find while flying just from one to the next flower. Rather they show an often very pronounced tendency towards the preference of a limited number of flowering plant species. Since pollen harvesting often requires some complex behavior which the bees at least partly have to learn. Under such circumstances one is better off when preferring a limited set of easy to handle plants or even when fully specializing on a single species with this technique. Bees are central place foragers, they have a "nest" to which they come back regularly when collecting food. Plants offering bee's pollen and /or nectar at the right time, in attractive but not too large quantities will support the tendency of the bees (out of technical reasons) of preferring a certain plant type while this is available in sufficient quantity. This strengthens the tendency towards flower constancy on the bee's side from which the plant profits by strongly increasing the probability of receiving pollen from some alien conspecifics.

As much as 75% of agricultural crop species are, to some degree, reliant on animal pollination [2]. Pollination, in particular by bees improves seed and fruit quality in ca. 30% of the crops [3]. Furthermore, the decline of pollinating species can lead to a parallel decline of plant species [3].

Around 25,000 species of bees have been described worldwide [3]. Bees are mainly diversified and distributed in hot, arid or semi-arid areas. Unfortunately, degradation of ecosystems, depletion of plant species, habitat fragmentation, pesticides and global warming are supposed to negatively impact their diversity and range distribution [4]. This is likely to increase the risk of future pollination deficits in areas requiring high, and increasing, pollination demands [5-6].

Only few studies on bees were carried out in West Africa [5], where the main source of livelihood is based on rain-fed agriculture. In this African region in general and in Burkina Faso specifically, bee species are not well known. However, this country has been viewed as the potential breadbasket of the African continent under climate change [7]. Especially in developing countries, human population is growing fast, while many of the rural inhabitants are poor, undernourished, and live in conditions where the environment is either degraded or being degraded. [8-10]. Hence, ecosystem services enhanced through biodiversity (such as biotic pollination) can create mutually beneficial environmental and food-supply scenarios [11-13], improving the livelihoods of smallholders through higher and more stable crop yields, fast minimizing negative environmental impacts [9], [14].

Since there hardly exist any current data on the bee species in West Africa, the study aimed to investigate the bee pollinator communities of a Sudanese agro-ecological system in Burkina Faso serving as a first assessment of the bee pollinator diversity in this area. Furthermore, we aimed to reveal if the diversity and abundance of bees differs (i) in near-natura-savannah habitats and in nearby fields of the main cash crops of this area (cotton, sesame) and (ii) in the dry and rainy season, since ectothermal insects are highly sensitive to microclimatic variations.

MATERIALS AND METHODS

2.1. Study area and study sites

The study was carried out from October 2014 to September 2015 at three locations in the South of Burkina Faso: Dano (11°08'56.566"N - 003°03'36.446"W), Bontioli (10°48'26.393"N - 003°04'39.564"W) in the South-West and Nazinga (11°06'34.998"N - 001°29'07.181"W) in South-Central Burkina Faso (Figure 1). These areas are expected to react especially sensitive to the effects of climate variability. Among these sites, Bontioli and Nazinga are partly protected areas with small villages nearby, Dano is a small city with agricultural land in the suburban surroundings.
These three areas belong to the south-sudanese climatic zone. The averages rainfall are 750 mm, 1075 mm and 900 mm in Dano, Bontioli and Nazinga, respectively. The averages annual temperature are 27°C , 26.5°C and 31°C in Dano, Bontioli and Nazinga, respectively.

There are two pronounced seasons, a dry season from November to May and a rainy season from June to October. Agriculture (industrial and food crops) is the main activity from the populations in these study areas.

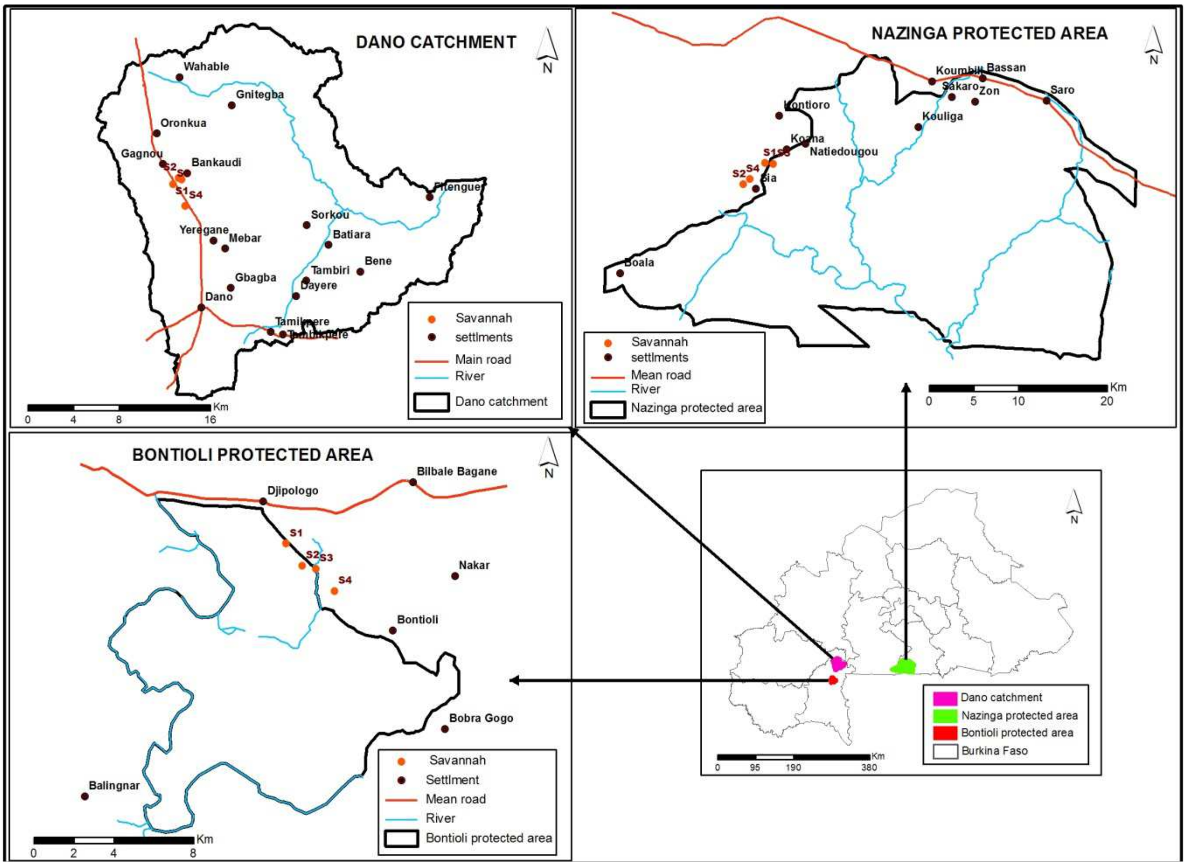

Figure 1: Study sites in Burkina Faso and localization of the sampling plots

2.2. Study design and bee sampling

Four sampling plots of each 5400 m^2 (60m x 90m) were chosen in near-natural savannah habitats and in nearby fields of the main cash crops of this area (cotton, sesame) at each study site (Figure 2), resulting in a total number 36 sampling plots.

Each sampling plot comprised four sampling blocks (15m x 30m) spaced to 30 m. In each block six traps were installed in a distance of 15 m. In total, we set up 864 traps (24 traps per sampling plot; 288 traps per site). Cotton and sesame fields chosen to capture bees in were located at a maximum distance of 2km from the near-natural savanna sites. (Figure 2).

Pantraps were used to sample honey bees and wild bees. UV-bright yellow, white and blue 500ml plastic bowls were placed in the height of ca. 1m above the ground in the savanna sites and fields; filled with salt (NaCl) saturated water and a small drop of detergent (liquid soap) were left out for 72h during each sampling round. Bees were sampled once each month in the savanna plots and every 2 weeks in the fields due to the shorter flowering period of the crops. Specimens of bees were collected, stored in alcohol, and thereafter pinned and identified to genus or species (voucher specimens are held at the Royal Belgian Institute of Natural Sciences, Brussels).

2.3. Statistical analysis

Data were analyzed using statistica software version 7.1. Data sets were tested for normality distribution. To analyze if bee species number and abundances vary between sites Analysis of Variance (ANOVA) and post-hoc Duncan tests were carried out. The significance level was $p < 0.05$.

Diversity can be defined as the degree of heterogeneity within a population [15]. The diversity of bees on our sites was assessed by calculating the following diversity indices:

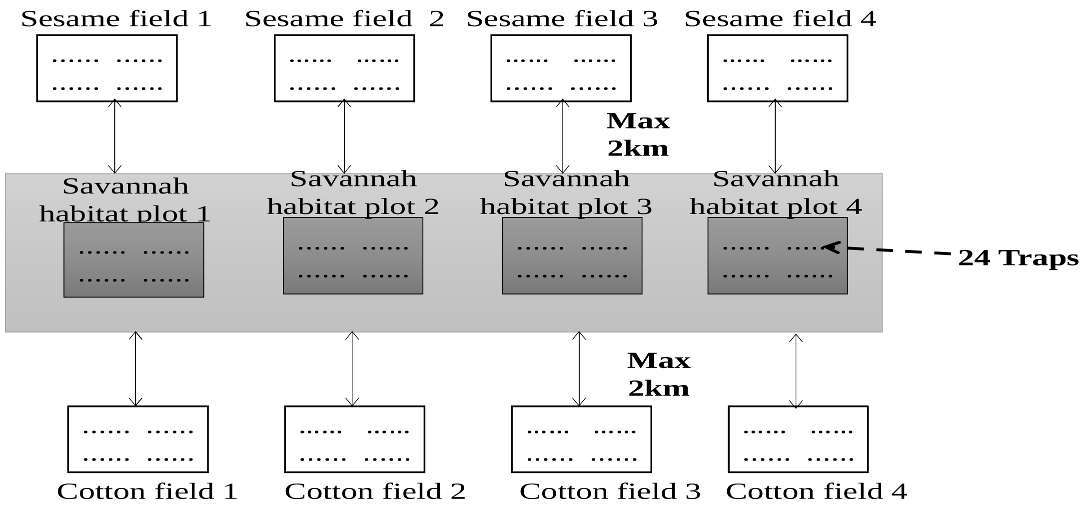

Figure 2: Sampling design for each site showing the 4 near-natural savanna plots and each 4 nearby cotton and sesame fields in a maximum distance of 2 km. Each sampling plot comprised 24 pantraps.

- Index of Shannon [16]
The Shannon index compares the alpha-diversity of different sites. It is expressed by the following formula:

$$H' = -\Sigma\ ((Ni / N) * \log2\ (Ni / N))$$

Where Ni is the number of individuals of a given species, i ranging from 1 to S (total number of species); N is the total number of individuals.

The maximum diversity (H'max) is calculated using the following formula:

$$H'max = \text{Log2}\ S$$

S represents the total species richness [17].

- Index of equitability [17]
This index assesses the equal distribution of abundance among species. The equal distribution is the ratio of the diversity observed at the maximum diversity. It varies between 0 and 1. The higher, this index tends to 1, more the population is flat, more it tends to 0, more this population is contrasted (quantitative representation of varied species in the sample). It is given by the following formula:

$$E = H' / H'max$$

- Jaccard index [18].
This index is a test of similarity between two habitats.

$$J = \frac{a}{(a+b+c)}$$

Where a represents the number of common species between habitats; b represents the number of unique species for habitat 1 and c represents the number of unique species for habitat 2.

- Sorensen similarity coefficient (Ks), [19].
This index is a complement of the Jaccard index. The Sorensen similarity coefficient (Ks) was used to express the existence or not of similarity between sites or between habitat types.

Sorensen coefficient is calculated from the formula:

$$Ks = \frac{2a}{(2a+b+c)}$$

Where a is the number of species common to both sites; b the number of species own to the site 1 and c the number of species own to the site 2.

- Abundance (Ab)
The abundance of a species is the total number of the species or the number of species per area unit.

$$\textbf{Ab = Number of species}$$

RESULTS

3.1. Diversity and distribution of bees

a) Diversity

In this study, the identification of bees captured on all sites (near natural and agricultural sites included) revealed 105 species of bees distributed in 4 families (Apidae, Halictidae, Megachilidae and Colletidae) and 32 genera. By analyzing the bees for each site, we obtained 62; 66 and 77 species of bees in Dano, Bontioli and Nazinga, respectively (Table 1). The most diverse family of bees was Halictidae with 41 species (39.04% from all species identified). This latter was followed by Apidae (31 species; 29.53%), Megachilidae (31 species; 29.53%) and Colletidae (2 species; 1.90 %).

Table 1: Number of families, genera and species of bees identified on each study site

	Study sites		
Number	Dano	Bontioli	Nazinga
families	3	4	4
genera	24	28	31
species	62	66	77

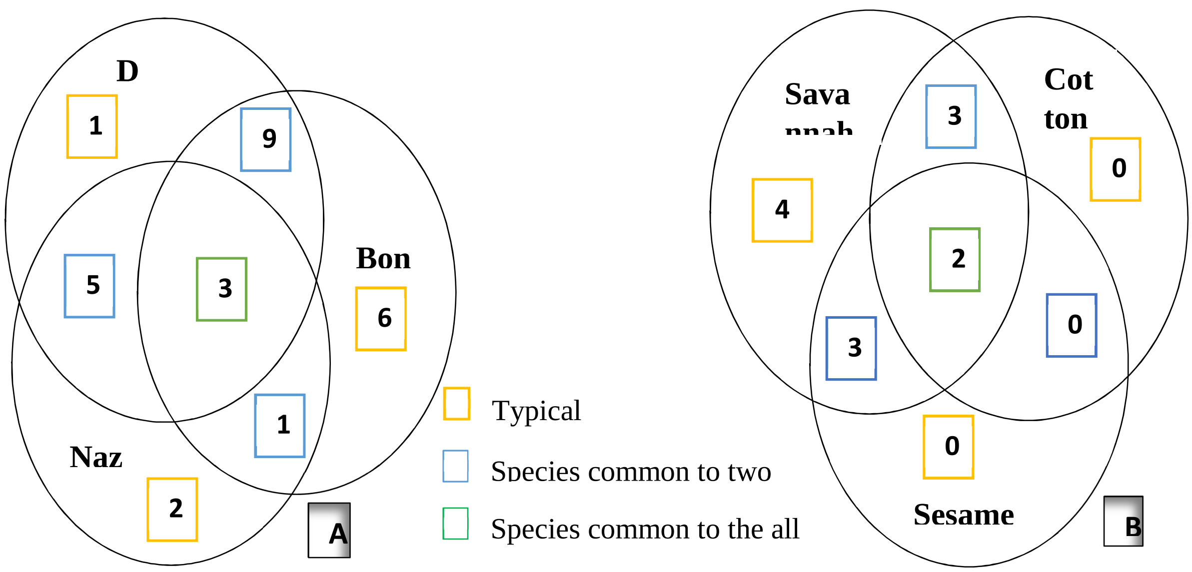

Figure 3: Distribution of bee species in three study sites (A) and in near-natural savannah habitats and in nearby fields (B)

Among all bees captured, 33 species of bees were recorded at all three study sites. However, some species were only identified for each of the sites. We identified 15, 6 and 21 species of bees only occurring at one of the three study sites for Dano, Bontioli and Nazinga, respectively. By comparing the study sites according to their species richness, we noticed that some species were common to them. Dano and Bontioli had 9 bee species in common; Dano and Nazinga (5 species); Bontioli and Nazinga (18 species). The results exhibited that Bontioli and Nazinga had the highest number of species in common (Figure 3A). Each of 105 bee species identified has been found at least once in the savannah habitats but not always in the fields. Among the 105 species of bees, only 54 species were identified in the cotton fields and 23 species in the sesame fields. Thirty four (34) species were recorded in savannah habitats and cotton fields while 3 species were found as well in savannah habitats as sesame fields. Furthermore, 20 species were common to the three habitats (Figure 3B). There were no species strictly common to cotton and sesame fields. The Shannon index showed that Nazinga (H' = 2.73) was the most diverse site compared to Bontioli (H' = 1.45) and Dano (H' = 1.41). The maximum diversity was also greater in Nazinga (H'max = 6.27) compared to Bontioli (H'max = 6.04) and Dano (H'max = 5.95). However, the calculation of the equitability index showed that there was a more equitable distribution of bee species in Bontioli (E = 0.24) and Dano (E = 0.24) compared to Nazinga (E = 0.44).

The indices of Jaccard and Sorensen (Table 2) indicate similar results. The aim was to find the similarity in species by crossing two different habitats. We received the following results:

By crossing Bontioli and Nazinga, we obtained the strongest similarity index (J = 0.11 and Ks = 0.20). The lowest indices were obtained by crossing Dano and Nazinga. Bontioli and Nazinga showed a higher similarity and had more bee species in common.

Taking Jaccard index, we noticed that in all crossing, this index did not exceed 25% of similarity. This suggests that environmental conditions were relatively distinct between habitats.

Table 2: Calculation of Jaccard index (J) and Sorensen coefficient (Ks) to compare the similarity between the study sites

Study sites	Jaccard indices		
	Dano	Bontioli	Nazinga
Nazinga	0.03	**0.11**	1
Bontioli	0.07	1	-
Dano	1	-	-

Study sites	Sorensen coefficients		
	Dano	Bontioli	Nazinga
Nazinga	0.07	**0.20**	1
Bontioli	0.12	1	-
Dano	1	-	-

b) Abundance

In this study, the calculation of abundance of bees according to the sites, revealed that bees were more abundant in Bontioli (10593 ± 530.33) compared to Dano (6381 ± 494.98) and Nazinga (2047 ± 388.91) (Figure 4). Apidae family was the most abundant (17607 ± 141.42) compared to the other families according to statistical analysis (Table 3).

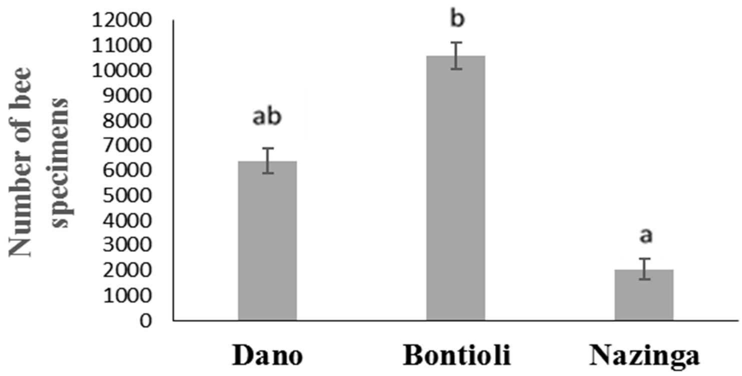

Figure 4: Abundance of bees by study sites:

The values with the different letters are significantly different at $P < 0.05$ (Duncan test).

Table 3: Abundance of bees by family

The values with the different letters on the same line are significantly different at $P < 0.05$ (Duncan test).

Study sites	Number of bee specimens			
	Apidae	Halictidae	Megachilidae	Colletidae
Dano	5921 ± 120.21^{c}	408 ± 76.37^{b}	52 ± 22.63^{a}	0^{a}
Bontioli	9821 ± 138.59^{c}	710 ± 91.92^{b}	60 ± 16.97^{a}	2 ± 1.41^{a}
Nazinga	1865 ± 108.89^{b}	134 ± 57.98^{a}	44 ± 12.73^{a}	4 ± 1.41^{a}
Total	17607 ± 141.42^{c}	1252 ± 108.89^{b}	156 ± 45.26^{a}	6 ± 1.41^{a}

In this study, *Hypotrigona gribodoi* was the most abundant species followed by *Seladonia jucunda*, *Pseudapis interstitinervis, Apis mellifera, Braunsapis spA.* The other species identified (100 species) were rare (Table 4).

Table 4: Abundance of bee species

Bee species	Abundant species n > 10000	Lest abundant species 500 < n < 10000	Rare species n < 500
Hypotrigona gribodoi	x		
Seladonia jucunda		x	
Pseudapis interstitinervis		x	
Apis mellifera		x	
Braunsapis spA		x	
Other species			x

n: number of bee specimens; *x: presence of the bee species*

3.2. Comparison near natural to agricultural site

a) Diversity

The index of Jaccard and Sorensen (Table 5) indicate similar results. By crossing natural habitats and cotton fields we obtained the strongest similarity indices (J = 0.18 and Ks = 0.30). The lowest indices were obtained by crossing natural habitats and sesame fields. Furthermore, there was no similarity between the cotton fields and the sesame fields (J = 0 and Ks = 0).

Table 5: Calculation of Jaccard index (J) and Sorensen coefficient (Ks) to compare the similarity between the habitat types

Habitat type	Natural habitats	Cotton fields	Sesame fields
Sesame fields	0.02	0	1
Cotton fields	0.18	1	-
Savannah habitat	1	-	-

Habitat type	Natural habitats	Cotton fields	Sesame fields
Sesame fields	0.04	0	1
Cotton fields	0.30	1	-
Savannah habitat	1	-	-

b) Abundance

The calculation of abundance of bees according the habitat types, showed that bees were more abundant in the natural habitats (13667 ± 79.20) than in the fields (5354 ± 65.06) (Table 6).

Table 6: Comparison of abundance of bees between natural habitats and fields

The values with the different letters on the same line are significantly different at P < 0.05 (Duncan tes

Study sites	Number of bee specimens: Natural habitats	Number of bee specimens: Fields (Cotton, Sesame)
Dano	4997 ± 82.02[b]	1384 ± 35.36[a]
Bontioli	7055 ± 77.78[b]	3538 ± 53.74[a]
Nazinga	1615 ± 28.28[b]	432 ± 14.14[a]
Total	13667 ± 79.20[b]	5354 ± 65.06[a]

Table 7: Diversity of bee species by season

The values with the different letters on the same line are significantly different at P < 0.05 (Duncan test).

Bee families	Number of bee species: Dry season	Number of bee species: Rainy season
Apidae	25 ± 2.83[a]	26 ± 1.41[a]
Halictidae	28 ± 2.83[a]	40 ± 7.07[a]
Megachilidae	27 ± 7.07[a]	10 ± 2.83[a]
Colletidae	2 ± 1.41[a]	1 ± 1.41[a]
Total	82 ± 12.73[a]	77 ± 9.90[a]

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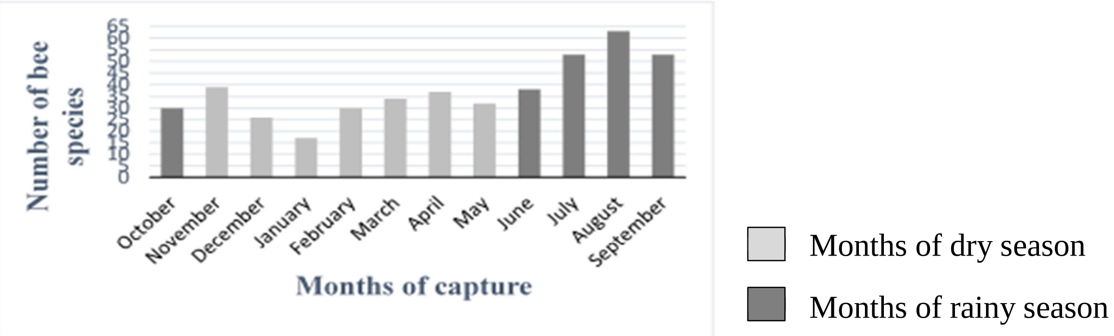

Figure 5: Diversity of bee species by month

3.3. Seasonal variation of bee species diversity and abundance

a) Diversity

The results of bee diversity according to the seasons can be interpreted in two ways:

- By counting the number of bee species identified by season, we noticed that the highest number of species of bees was observed in dry season (Table 7) but, the results are not statistically significantly.

- By analyzing separately the bees identified by month of capture, we noticed that the highest values of diversity were observed in July, August and September which correspond to the period of intense rains (Figure 5).

b) Abundance

The results of abundance of bees according to the seasons can be also interpreted in two ways:

- By counting the number of bee specimens by season, we noticed that the greatest number of bees was harvested during the dry season (11053 ± 124.45) (Table 8).

- By analyzing the number of bee specimens by month, we noticed the peak of abundance in July (period of intense rains) (Figure 6).

Table 8: Abundance of bee species by season

The values with the different letters on the same line are significantly different at P < 0.05 (Duncan test).

Bee families	Number of bee specimens	
	Dry season	Rainy season
Apidae	9719 ± 134.35[b]	7047 ± 120.21[a]
Halictidae	1178 ± 63.64[b]	884 ± 46.67[a]
Megachilidae	150 ± 16.97[b]	37 ± 9,90[a]
Colletidae	6 ± 1.41[a]	1 ± 1.41[a]
Total	11053 ± 124.45[b]	7969 ± 91.92[a]

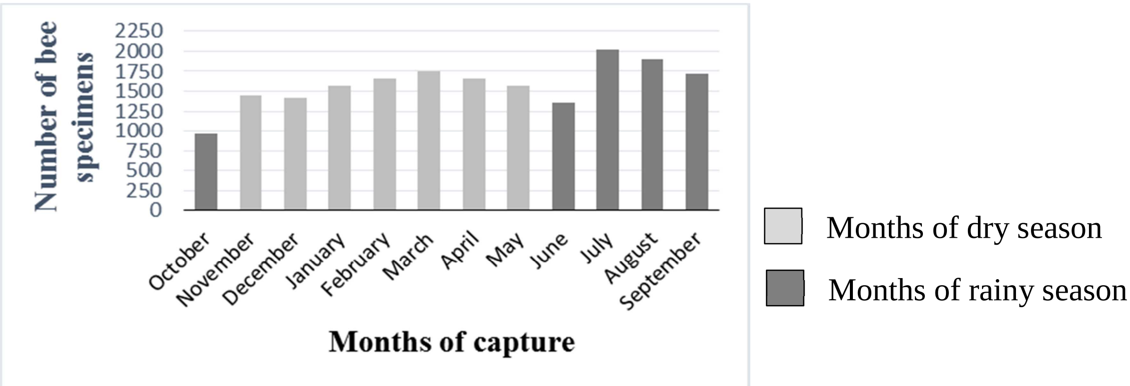

Figure 6: Abundance of bee species by month

Diversity and abundance of bees

The comparison of the bee species diversity between the sites showed that Nazinga was the area with most diversity. This great diversity of bees in Nazinga could be explained by the presence of a mosaic of mixed habitats dominated by more or less well protected forest (woodland savanna and gallery forests along rivers) compared to other sites which are dominated by agricultural land and high human activities. Indeed, the species of bees have a preference for the flowers to gather nectar and pollen, even if for most of time, they are polylectic (we consider that a pollinator is polylectic when he gathers a wide variety of contemporally flowering plants). The multiplicity of plants in the forest increases the chances to find several types of flowers and consequently several species of bees. These observations are in accordance with those made by Meurgey [20]. According to the author, *Apis mellifera* (Honey bees) were observed during his studies on 70 different plant species, thus bees from this hive could be seen as opportunistic, whereas other species of the Megachile genus were apparently strictly enfeoffed to a single plant family (Fabaceae). The great diversity of bees observed in Nazinga could also be explained by the large size of this reserve. Due to its size and divers natural vegetation formations, Nazinga seems to be able to house more species of plants and hence more potential habitats for different types of bees.

At the protected area of Bontioli the highest number of specimens was recorded followed by Dano. This abundance is due in part to the high number of honeybees (*Apis mellifera*) in Bontioli and Dano because of many traditional hives inside of these areas. Hence, the differences in abundances might be explained by land use intensity and managed honey bee populations. In addition, we noticed that farmers used more pesticides in Nazinga compared to Dano and Bontioli. The intensive use of pesticides in an area may reduce the abundance of bees. Pesticides used for crop protection pose a potential risk to non-target beneficial insects, with foragers coming into contact with residues in the environment [21], [22].

Several species of bees were common at all three sites. This came as no surpise as the study plots layed in the same phytogeographical zone. However, due to the fact that density and floristic richness were different from one site to another, each site houses some typical species of bees. Dano and Nazinga turned out to have more typical species of bees compared to Bontioli. This could be explained by the fact that there are bee species typical to forest areas (like Nazinga) and others to disturbed areas (like Dano). However, the similarity between Bontioli and Nazinga is greater because of their status of forest.

Our study is the first to assess the bee species diversity in south Burkina Faso. It contributes to the monitoring of biodiversity in this area which underlies strong land use pressures due to population growth and intensified agriculture and at the same time high demand of pollination services provided by bees to maintain natural vegetation as well as to secure crop yields. Despite clear bee species diversity patterns being different from site to site, probably due to many factors such as land use intensity one has to be cautious when drawing general conclusions regarding the abundances of the different families or species of bees, since they might greatly differ between years. Some bee species will be present during the entire year, others will most probably have a much shorter period of activity. There is specialization also in regard to preferred temperatures, honey bees are not active at very high temperatures, this might be to the advantage of those bee species who are outcompeted as soon as air temperatures allows honey bees resuming their very effective mode of harvesting pollen and nectar.

In this study, Halictidae was the most diverse family but, Apidae was the most abundant family. Our result concerning the wide diversity of Halictidae was in accordance with one of the very rare studies available for West-Africa carried out by Pauly et al. [23], which stated that the family of Halictidae was the most diverse in Sub-Saharan Africa. Apidae represented by the tribe of Meliponini and by the honeybee (*Apis mellifera*) are very polytrophic; Halictidae, overall have a rather more choice for the plants; Megachilidae are limited in their choice by the accessibility of the stamens to the movements of their ventral brush; Colletidae are represented by only two genera, they are most common during the dry season (*Hylaeus* devoid of Scopa, collect pollen by mouth) [24]. Halictidae, Megachilidae and Colletidae include all solitary species, although some of them display some degree of socialization. But, Apidae family includes solitary species, social and highly social [25]. This social character of Apidae explains their abundance in a given environment.

The abundance of *Hypotrigona gribodoi* could be explained by the multiplicity of its nesting sites. *Hypotrigona gribodoi* use various structures in the nature for nesting. These social bees nest both in the soils and in wooden materials [26], [27]. Its ability to proliferate in different locations is supposed to allow it to be very present anywhere. Because of their small size, *Hypotrigona gribodoi* also nest in colonies of hundreds of individuals in wall cavities or residential roofs, which explains their abundance in rural areas. They are also "generalists" in the choice of pollinated plants, which explains their abundance both in the dry and rainy season. Furthermore their colonies are perennial unlike other bees which produce one or more generations in the year and the seasons. *Hypotrigona* are well distributed within the tropics and can be found in various specific habitats (land-uses) such as grasslands, natural forests, wetlands, marshlands, protected areas, farmlands, woodlands, woodlots (forest plantations) and riparian forest areas [28]. *Hypotrigona* belong to the tribe Meliponini (stingless bees) which along with the honey bee (which belong to the tribe Apini) constitute the two highly eusocial bee groups. Bees that live in large colonies of individuals in which there is a division of labour including reproductive queens and sterile workers. Although these insects are well known to farmers they are generally not recognised as bees, as the name bee is generally thought only to apply to honey bees. *Hypotrigona* are vital pollinators within tropical ecosystems [29] and vary widely in both individual and colony size.

Comparison of near natural and agricultural sites

The diversity and abundance of bees was different in near-natural savannah habitats and in nearby fields of the main cash crops of this area (cotton, sesame). All species of bees identified in the fields were also identified in savannah habitats. On the contrary, some savannah species were not found in the fields. This means that there is a movement of certain bee species from savannah habitats to the fields. This movement is supposed to be beneficial for crops due to the potential pollination service provided by the bees. For example, native and/or wild pollinators are more efficient at pollinating certain plant species than honeybees [30-36], and that long-tongued wild pollinators can effectively pollinate plants that may not be accessible for short tongued pollinators such as honeybees [37].

Seasonality

The diversity and abundance of bees can differ also from one season to another. In our study, by counting the number of species and the number of specimens identified during each season, we noticed that there were more bee species and bee specimens during the dry season. This could be explained by the fact that the dry season is longer than the rainy season. We benefitted from many months of capture in the dry season compared to the rainy season. Another reason was the fact that the flowering of many plants occurs during the dry season and bees roam enough flowers. Indeed, as reported by the work of Pauly [38] and Tchuenguem and al. [39], the stage of flowering attracts many insects. Another hypothesis for the diversity in the dry season is that (1) the Apoidea are animals that prefer zones with dry climate rather than the humid climate zones [40], so some species , not all, prefer the dry season, especially because the nesting conditions are more favorable (fewer mold problems in the nests), (2) most species of trees of the savannah bloom in the dry season and are good floral resources for these bees, for example, for the Megachilidae subservient to Fabaceae and Mimosaceae, (3) on the contrary, the herbaceous bloom in rainy season and attract other bee species, such as the Halictidae of Lipotriches genus which forage the Poaceae.

However, in our study, by separately analyzing the bees identified for each month of the year, we noticed that the highest values of diversity and abundance were observed in rainy season. This could be explained by the fact that during the rainy season, in addition to some plant species in blossom, there were also crop plants which produced flowers. This situation created a large diversity of flowers that attracted several species of bees.

CONCLUSION

Our study showed that the diversity and abundance of bees differs not only, in near-natural savannah habitats and in nearby fields of the main cash crops (cotton, sesame) but also, in the dry and rainy season. Thus it gains importance on several levels our study take place at several levels:
- The evaluation of bees diversity and abundance, allowed us to have a first list of bee species in Sudanian zone of Burkina Faso. This list could be used in subsequent studies as in the case of identification of true pollinators of cotton and sesame.
- The flow of bees from savannah habitats to the fields, reveal the importance of plant species and the natural habitats of bees located near the fields.
- The study of bees diversity and abundance according to the seasons is an important scientific basis which may contribute to the establishment of an appropriate strategy for the management of species within agroecosystems in the perspective of an approach to the use of pollinators.

This study is the first of its kind, it will contribute to the establishment of a reference collection of bees not only for the study area but especially for the entire region. It will also constitute an important scientific basis for new studies. In the future, the study should be expanded to all areas of Sudanian savannah of West Africa in order to get a fairly complete list of bee species. The habitat requirements, food resources of the bee species should be studied towards their conservation. A study of phenology of bee species identified in this study would be necessary to deepen the specific knowledge on each bee.

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