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Full Length Research Paper

Bee plant potentials and characteristics in the Ngaoundal subdivision, Adamawa – Cameroon

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Abstract

Selection of suitable site for apiaries mainly depends on the availability of bee plants. In the Adamawa region of Cameroon, bee plants are not yet well known. Studies were carried out from September 2015 to August 2016 in the Ngaoundal subdivision with the main objective to survey bee plants in order to improve the apiarian productivity in Cameroon. 80 bee plants grouped into 31 families were identified. Asteraceae and Poaceae were highly represented. Herbs were dominant. Bee actively foraged within the radius of 1 km from the apiary. White color flowers frequently foraged. More than half of the bee plants bloomed in the rainy season. The flower size has the influence on the forager activities and the moderate size flowers were the most represented. Bees frequently foraged actinomorphic flowers. Inflorescences of plants were preferred than solitary flowers. Nutrients were available to bees all the year around apiaries. The study site was favourable and indicated for the practice of intensive bee keeping, precisely during the rainy season with the majority efflorescence of beeplants, bees foraged pollen while in the dry season, nectar was preferred.

Keys words: Bee plants, characteristics, foraging distance, nectar, pollen.

Introduction

Bee plants are those plants whose flowers produce natural substances notably nectar, pollen and resin that can be collected by honey bees to feed themselves and/or to breed various products (Dongock *et al.,* 2004; Tashev *et al.,* 2011; Adebayo *et al.,* 2012). Many flowering plants can not be harvested by honey bees, because of their physiognomy (body size and shape, the length of proboscis, etc.) (Adebayo *et al.,* 2012). It has been observed that the quantity and quality of beehive products are reflected by the nature of plants foraged (Laflèche 1981). The knowledge of plants visited by honeybees is important in guiding prospective beekeepers in the choice of suitable sites for sitting apiaries. It is also essential in the identification of crops that may benefit from pollination by honey bees (Dukku 2013). This knowledge provides basis for objective evaluation of honey bees' productivity in the different regions; morever, it can provide a rational conception of the agro-forestry systems which favor essentially the honey bees activities (Dongock *et al.,* 2004). Several types of research were already done on the identification of bee plants in Africa : Akosim *et al.* (2007), Mbah *et al.* (2009), Dukku (2013), Ezeabara *et al.* (2013), Adebayo *et al.* (2012) in Nigeria, Hadda *et al.* (2011) in Algeria, Abou-shaara (2015) in Egypt, Abdelmajid *et al.* (2013) in Morocco, Yédomonhan *et al.* (2009, 2012) and Akoegninou *et al.* (2010) in Benin, Iritie *et al.* (2014) and Siendou *et al.* (2013) in Ivory Coast, Koudegnan *et al.* (2014) in Togo, Abebe *et al.* (2014) in Ethiopia, Bakenga *et al.* (2000) in Democratic Republic of Congo and Gadbin (1980), Dongock *et al.* (2016 ; 2017) in Chad.

Beekeeping has become an important socio-economic activity in Cameroon (Ingram 2011). The large amount of honey consumed or marketed in Cameroon comes mainly from the Adamawa region. The climate of this region is particularly conducive to the proliferation of honeybees (INADES, 2000). Following the increasing demand for hive products worldwide, the development of beekeeping is essential in this country. Indeed, sustainable and efficient beekeeping in a given region requires the knowledge, the conservation and the optimal management of local bees' flora. (Bakenga *et* *al*., 2000; El-Nebir *et al.,* 2013). Researches on bee plants in Cameroon concern notably those of Dongock *et al.* (2004; 2007; 2011) in the west region, Ingram (2011), Tchuenguem *et al.* (1997; 2001; 2005; 2008; 2009; 2010), Youmbi *et al.* (2011), Fameni *et al.* (2012), Mazi *et al.* (2013) and Djonwangwe *et al.* (2011a; 2011b) in the Adamawa Region. Nevertheless, Ingram *et al.* (2011) observed that studies based on the identification of plants foraged by honeybees have not been performed in Djerem Division, where beekeeping is highly practiced with an average of 68 % households involved. The main objective of the present study is to identify bee plants in the Djerem Division in order to improve the beekeeping productivity in this part of the country.

Methods

Study area

The investigations were carried at Massim-coopérative village around apiaries (Alt: 892 m, LN : 6°19, LE : 13°16) during twelve months from September 2015 to August 2016 (figure 1). The site covers about 62000 km^2 (Letouzey 1968; Djoufack *et al.,* 2012). The native human population is made up of the Mboum, Dii, Gbaya, Tikar, Mambila, Kaka, Babouté, Haoussa, Mbororo, Péré, and Peulh (MINEF 1994).

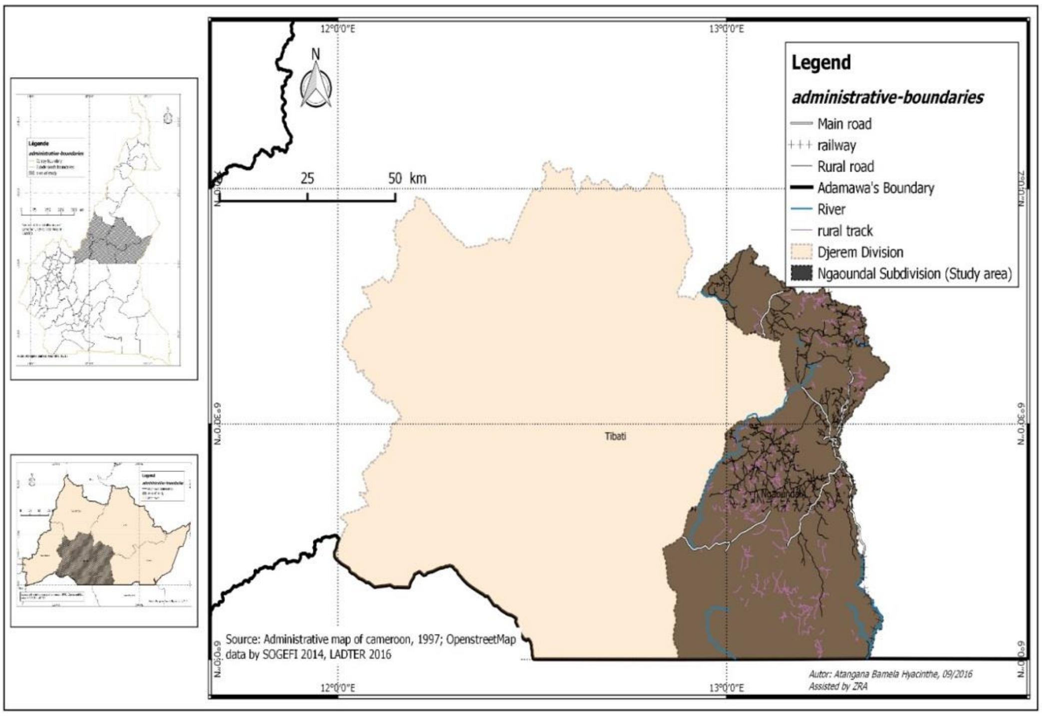

Figure 1 : Map of Ngaoundal Subdivision showing the study area

The climate is characterized by two seasons: a rainy season (April - October) and a dry season (November - March). The annual rainfall varies from 1227.9 to 1675.8 mm; the annual insulation duration varies from 2321.1 h to 2557.9 h (Djoufack *et al.,* 2012). The mean annual temperature is between 22.08 °C and 22.93 °C, while the mean annual relative humidity varies from 64.1 % to 67.6 % (Tchuenguem et al., 2010). Precipitations are particularly important between July and September (Mapongmetsem *et al.,* 2000). Adamawa is a transition zone between forest South and Savannah North (Mope, 1997). The vegetation is represented by crops, ornamental plants, hedge plants and native plants (Letouzey, 1968; Djoufack *et al.* 2012). It is a savannah shrub or trees, made of *Daniellia oliveri* and *Lophira lanceolata* (Letouzey, 1968). In some areas, meadows and gallery forests are present. Development of natural resources is mainly through agriculture, cattle breeding, beekeeping and fishing (MINEF 1994; Djoufack *et al.*, 2012).

Experimental design

The sites were chosen based on the presence of two types of apiaries: a modern apiary with 39 Kenyan beehives and a traditional one with about 10 beehives. Direct observations were carried out bi-monthly around these apiaries. The observation of the honeybees' activities on flowers was done within the radius of 2km (Ca-R40) around apiaries. So, to increase the probability to convert the maximum of bee plants in the site, within each perimeter, forty circles were formed, each circle represented a transect. The distance between the centre of the apiary (Ca) and the first radius (R_1) was 25m. However, 50m separated one radius from another ($R_2+R_3+…R_{39}$ = 1950m). R_{40} was situated at 25m from R_{39}. Following the walking azimuth, a band of 50m wide, 25m to the left and 25 to the right.

Data collection

The data was collected during a one year period from September 2015 to August 2016.

Identification of bee plants

The identification of a given plant species as a bee plants was done through direct observation of honeybee workers on its flowers. All plants that flowers were foraged by the honey bees were considered as bee plants. Unknown species were identified in the laboratory of Biodiversity and sustainable management of the University of Ngaoundere (Cameroon) and completed by the systematic documents of Arbonnier (2010), Merlier and Montegut (1982) and Le Bourgeois and Merlier (1995).

Floristic richness of bee plants in radius

The diversity of the bee plants and evenness measures were evaluated within three radii (0-1, 1-1.5 and 1.5-2 km) using the Shannon and Wiever (1963) index and Pielou's (1966) evenness.

Botanical characteristics

Biological types

The identified bee plants were grouped into four biological types (trees, shrubs, small trees and herbs) according to the Vidal and Derrière (2004), Beaudoin et al. (2014) and Bouxin's (2005) classification.

Status of bee plants

The bee plants were classified into two categories according to their uses: cultivated and spontaneous plants. All vegetal species used in agriculture for food were considered as cultivated plants, while the non-cultivated plants were classified among spontaneous plants.

Life cycle

The life cycle of each species was determined into two groups: annuals and perennials.

Characteristics of flowers

The characteristics of flowers dwelt on were the color, type, size, and symmetry. The flower colors of plants foraged by honeybees were considered. The flower type of each bee plant was identified by using Botanic systematic documents. Flowers were distinguished in two types: inflorescence and solitary flower. The size of each flower was noted using a graduated ruler. Indeed, the diameter of petals was considered. For the bee plants without petals, the diameters of capitulum and glomeruli were recorded. Furthermore, the sizes of spike were recorded for the flowers with spike inflorescences. Bee plants were classified into three groups according to the sizes of their flowers: small size flowers (< 6 mm), moderate size flowers (6 to 50 mm) and high size flowers (>50 mm). The symmetry of flowers was noted: the actinomorphic and zygomorphic flowers (Arbonnier, 2010).

Nutrients harvested by honeybees

The nutrients harvested by the honey bees on the plant flowers were recorded. When the honeybee was active at the anther level and left with pollen on the hind legs, it was considered that the honeybee has harvested pollen. Nevertheless, if honey bee foraged deeply inside the corolla, it was deduced that he has harvested nectar (Dongock *et al.,* 2004). Honeybees with their activities of extending their proboscis into the flowers and also collecting pollen on their hind legs were considered as collecting nectar and pollen (Bista *et al.,* 2009).

Flowering period

The flowering period of bee plants was noted and grouped into two types: those of the rainy and dry season. Thus, considering the months, three classes of bee plants were distinguished according to Yédomonan *et al.* (2009) : class I groups the bee plants that flower during one month ; class II group the bee plants whose flowering time cover two months continuously ; class III group the bee plants whose flowering time is more than two months.

Statistical analysis

Data were analysed using descriptive statistics (mean, standard deviation and percentage). The Chi - square ($\chi 2$) tests were used for comparison of percentages and ANOVA for the comparison of means of more than two samples. In addition, we used three software, Microsoft Excel 2013, R commander and SLStat 2016.

Results

Spectrum of bee plants

A total of 80 species of plant, grouped into 31 families, were identified as bee plants (Table 1). Three categories of families were registered according to the number of species (figure 2): highly represented families with 07.50 to 10.00 % of the 80 bee plants studied; it concerns Asteraceae and Poaceae with 10 % each, Euphorbiaceae and Rubiaceae with 07.50 % each. Average represented families (05.00 to 7.25%) contain Fabaceae (06.25%), Combretaceae (05.00%) and Mimosaceae (05.00%). The other families were less represented (≤ 04 % of the bee plants recorded).

Table 1: Distribution of bee plants in function of families, biological types (BT), degree of domestication (DD), life cycle (LC), flower's colours (FC), flower's size (FS), flower's symmetry (FSy) floral types (FT), flowering period (FP) and harvested nutrients (HN)

Families	Scientifics names	BT	DD	LC	FC	FS (mm)	FSy	FT	FP	HN
Acanthaceae	*Monechma ciliatum* (Jacq.) Miln.Redh	h	sp	An	w	5.23 ± 1.21	ZF	I	RS	N
Amaranthaceae	*Amaranthus hybridus* L.	h	sp	An	g	80.47 ± 12.18	ZF	I	RS	P
	Amaranthus spinosus L.	h	sp	An	gh	120 ± 24.62	ZF	I	RS	P
Anacardiaceae	*Anacardium occidentale* L.	sh	c	p	gh-ph	7.02 ± 1.29	ZF	I	DS	NP
	Lannea schimperi (Hochst. ex A. Rich.) Engl.	Tr	sp	p	yh	5.23 ± 0.95	AF	I	DS	N
	Mangifera indica L.	Tr	c	p	yh-r	3.02 ± 0.98	AF	I	DS	NP
Astaraceae	*Ageratum conyzoïdes* L.	h	sp	An	v	7.41 ± 1.66	AF	I	RS	P
	Aspilia kotscyi (Schultz-Bipontinus ex Hochstetter) Oliver.	h	sp	An	r-pu	25.13 ± 6.94	AF	SF	RS	P
	Bidens pilosa L.	h	sp	An	w	12.16 ±3.60	AF	I	RS	P
	Chromolaena odorata L.	St	sp	An	v	9.26 ± 2.68	AF	I	RS	P
	Laggera pterodonta (de Candolle) Schultz Bipontinus	St	sp	An	v	12.83 ± 2.18	AF	I	DS	NP
	Synedrella nodiflora Gaertn	h	sp	An	y	5.15 ± 1.01	AF	I	RS	P
	Tithonia diversifolia (hemsl.)	St	sp	An	y	100 ± 21.73	AF	I	RS	NP
	Vernonia tenoreana Oliv.	St	sp	An	w	34.21 ± 7.69	AF	SF	DS	NP
Balanitaceae	*Balanites aegyptiaca* (L.) Del.	sh	sp	p	y-gh	11.60 ± 1.86	AF	I	DS	NP
Caesalpiniaceae	*Cassia mimosoides* L.	h	sp	An	y	20.03 ± 3.86	AF	SF	RS	NP
	Daniellia oliveri (Rofle) Hutch. et Dalz.	Tr	sp	p	w	29.18 ± 5.67	AF	I	DS	N
	Piliostigma thonningii (Schumach.) Milne-Redh.	sh	sp	p	w	20.06 ± 3.60	ZF	I	RS	N
Clusiaceae	*Harungana madagascariensis* Lam. ex Poir.	sh	sp	p	w	7.04 ± 1.14	AF	I	RS	P
Combretaceae	*Combretum collinum* Fresen.	sh	sp	p	y-gh	10.3 ± 2.13	AF	I	DS	NP
	Combretum molle R. Br. ex G. Don	sh	sp	p	gh	10.24 ± 1.92	AF	I	DS	NP
	Terminalia glaucescens Planch. ex Benth.	Tr	sp	p	b	10.17 ± 1.99	AF	I	DS	NP
	Terminalia macroptera Guill. & Perr.	Tr	sp	p	w-yh	7.72 ± 1	AF	I	RS	NP
Commelinaceae	*Commelina benghalensis* L.	h	sp	An	bl	4.61 ± 0.93	ZF	SF	RS	P
	Commelina spL.	h	sp	An	y	5 ± 0.86	ZF	SF	RS	N
Convolvulaceae	*Ipomoea batatas* (L.) Lam	h	c	An	v	47.16 ± 15.02	AF	SF	DS	N
Cyperaceae	*Cyperus esculentus* L.	h	sp	An	yh	60.23 ± 13.90	ZF	I	RS	P
	Kyllinga tenuifolia Steudel	h	sp	An	g	20.02 ± 4.78	ZF	I	RS	P
	Mariscus cylindristachyus Steudel	h	sp	An	g	15.02 ± 2.92	ZF	I	RS	P
Euphorbiaceae	*Alchornea cordifolia* (Schumach. & Thonn.) Müll. Arg.	sh	sp	p	g	10.37 ± 1.47	AF	I	DS	P

	Antidesma venosum Tul.	sh	sp	p	g	80.30 ± 11.46	ZF	I	RS	P
	Euphorbia heterophylla L.	h	sp	An	g	4.07 ± 0.82	ZF	I	RS	P
	Jatropha curcas L.	sh	sp	p	y-gh	6.02 ± 0.89	AF	I	RS	N
	Manihot esculenta Crantz.	St	c	p	gh	20.02 ± 4.05	AF	I	RS	N
	Margaritaria discoidea (Baill.)	sh	sp	p	g	5.25 ± 0.81	AF	I	DS	NP
Fabaceae	*Dalbergia boehmii* Taub.	sh	sp	p	w	6 ± 1.23	ZF	I	DS	P
	Desmodium dichotomum (Willdenow) de Candolle	h	sp	An	bl	5.37 ± 1.02	ZF	SF	RS	P
	Erythrina sigmoidea Hua.	sh	sp	p	r	30.02 ± 4.11	ZF	I	DS	P
	Sesbania pachycarpa de Candolle.	h	sp	An	y-br	5.05 ± 0.95	ZF	I	RS	P
	Stylosanthes guianensis (Aubl.) Sw.	h	sp	An	y	6.02 ± 1.01	ZF	SF	RS	N
Ficoidaceae	*Trianthema portulacastrum* L.	h	sp	An	w	4.08 ± 0.82	AF	I	RS	N
Hymenocardiaceae	*Hymenocardia acida* Tul.	sh	sp	p	pu	73.12 ± 6.64	ZF	I	DS	NP
Lamiaceae	*Ocinum canum* Sims.	h	sp	An	bl	3.32 ± 0.8	ZF	I	RS	P
Lauraceae	*Persea americana* Mill.	Tr	c	p	w	7 ± 1.35	AF	I	RS	N
Malvaceae	*Sida corymbosa* RE Fries.	h	sp	An	y	12.02 ± 1.36	AF	SF	RS	N
	Sida rhombifolia L.	h	sp	An	y	12.02 ± 1.38	AF	SF	DS	N
	Urena lobata L.	St	sp	An	pi	44 ± 7.68	AF	SF	RS	P
Mimosaceae	*Albizia coriaria* Welw. ex Oliv.	Tr	sp	p	w	40 ± 5.42	AF	I	DS	P
	Entada africana Guill. & Perr.	sh	sp	p	yh	73.23 ± 3.87	AF	I	DS	NP
	Mimosa invisa C. Wright ex Sauvalle	sh	sp	An	w	20.05 ± 2.02	ZF	I	RS	P
	Mimosa pudica L.	h	sp	An	pi	25.09 ± 3.14	ZF	I	RS	P
Myrtaceae	*Psidium guajava* L.	sh	sp	p	w	25.06 ± 4.04	AF	I	DS	P
	Syzygium guineense var. *macrocarpum* (Engl.) F.	sh	sp	p	w	4.31 ± 0.77	AF	I	DS	P
Ochnaceae	*Lophira lanceolata* Van Tiegn Ex Keay	Tr	sp	p	w	27.18 ± 3.51	AF	I	DS	N
Olacaceae	*Ximenia americana* L.	sh	sp	p	w	7 ± 0.84	AF	I	DS	N
	Digitaria argillacea (Hitchcock et Chase) Fernald	h	sp	An	g	40.33 ± 3.38	ZF	I	RS	P
	Eleusine indica (L.) Gaertner	h	sp	An	g	50 ± 5.89	ZF	I	RS	P
	Eragrostis pilosa (L) P. Beauv.	h	sp	An	v	300.17 ±58.85	ZF	I	RS	P
Poaceae	*Hyparrhenia rufa* (Nees) Stapf subsp.	h	sp	An	b	200.28 ± 37.23	ZF	I	RS	P
	Pennisetum pedicellatum Linn.	h	sp	An	r	97 ± 12.90	AF	I	RS	P
	Setaria barbata (Lam.) Kunth	h	sp	An	g-yh	20 ± 4.07	AF	I	RS	P
	Sporobolus pyramidalis Palisot de Beauvois.	h	sp	An	v	15.06 ± 2.59	AF	I	RS	P

	Zea mays L.	h	c	An	r-y	180.06 ± 6.48	ZF	I	RS	P
Rubiaceae	*Crossopteryx febrifuga* (Afzel. ex G. Don) Benth.	sh	sp	p	w	7.02 ± 1.04	AF	I	DS	NP
	Mitracarpus villosus (Sw.) DC.	h	sp	An	y-ph	4.18 ± 0.65	AF	SF	RS	N
	Pavetta cinereifolia Berhaut	sh	sp	p	W	10.17 ± 1.31	ZF	I	DS	N
	Pavetta corymbosa (DC.) F. N. Williams	sh	sp	p	w	15.04 ± 3.35	AF	I	DS	N
	Spermacoce stachydae de Candolle	h	sp	An	w	5.02 ± 0.68	AF	I	RS	NP
	Psychotria psychotrioides (DC.) Roberty	sh	sp	P	gh	4.21 ± 0.75	AF	I	DS	N
Rutaceae	*Citrus aurantifolia* (Christm.) Swingle	sh	c	p	w	25 ± 2.12	AF	I	DS	NP
Sapindaceae	*Allophylus africanus* P. Beauv.	sh	sp	p	w	5 ± 0.94	AF	I	RS	P
	Paullinia pinnata L.	sh	sp	p	w-y	8.07 ± 0.82	AF	I	DS	P
Scrofulariaceae	*Scoparia dulcis* L.	h	sp	An	Bh	4.23 ± 0.85	AF	SF	RS	P
Tilliaceae	*Grewia flavescens* Juss.	sh	sp	p	w-y	12 ± 1.25	AF	I	RS	P
	Triumfetta pentandra A. Rich.	h	sp	An	y-o	7.02 ± 0.92	AF	I	RS	P
Verbenaceae	*Clerodendrum inerme* L.	h	sp	An	w	18 ± 3.21	ZF	I	DS	P
	Stachytarpheita angustifolia (Miller) Vahl	St	sp	An	w-b	7.23 ± 1.10	ZF	I	DS	N
	Vitex madiensis Oliv.	sh	sp	p	w-ph	8.04 ± 0.76	ZF	I	DS	N

Legend: Tr : trees ; St : small trees ; sh : shrubs h : herbs ; sp : spontaneous ; c : cultivated ; An : annuals ; p : perennials ; P : pollen ; RS : rainy season ; DS : dry season ; AF : actinomorphic flower ; ZF : zygomorphic flower ; SF : solitary flower ; N : nectar ; P : pollen ; NP : nectar and pollen ; MA : modern apiary ; I : inflorescence ; gh-ph : greenish-purplish ; yh-r : yellowish- red ; v : violet ; w : white ; w-bl : white blue ; w-ph: white purplish ; y : yellow ; yh : yellowish ; y-gh : yellow-greenish ; y-ph : yellow-purplish ; b : beige ; pu : purple ; g : green ; gh : greenish ; gyh : green yellowish ; w-y : white-yellow ; w-yh : white yellowish ; r : red; pi : pink ; bh : bluish ; bl : blue ; r-pu : red-purple ; y-o : yellow-orange ; r-y : red-yellow ; y-br : yellow-brown ; s : second.

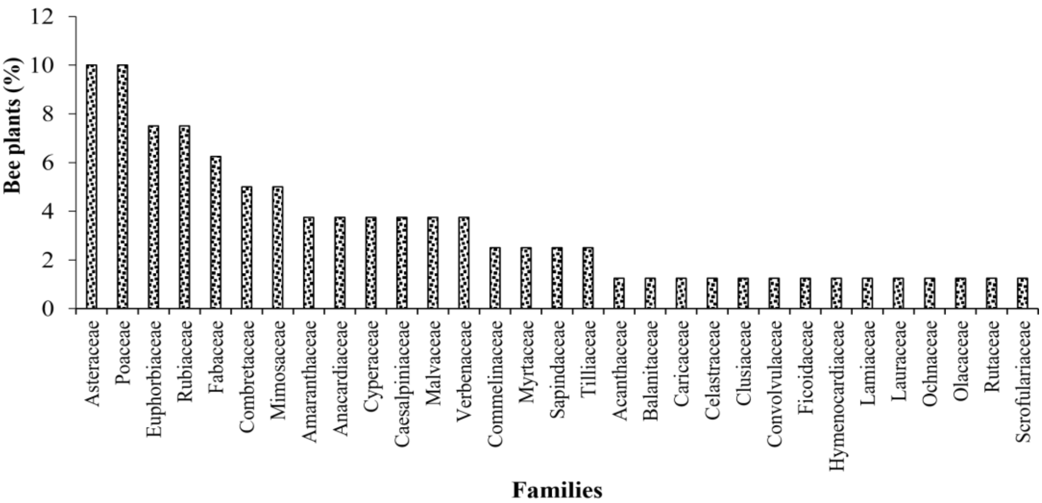

Figure 2: Distribution of bee plants in function of families

Foraging radius

The Shannon's diversity index was above 4 between 0 and 1 km around the both apiaries: H' = 4.65 for first and H' = 4.04 for the second apiary, it was explained that bee plants were highly diversified within this radius of 1 km. Nonetheless, the diversity of bee plants was average between 1 and 1.5 km around the both apiaries (H' = 3.55 for the first and H' = 3.64 for the second apiary) and low between 1.5 and 2 km (H' = 1.29 and H' = 1.90 respectively for the first and second apiary). The high diversity of bee plants within the radius of 1 km justified the high activities of bees on flower in this space. The Pielou's measures of evenness were the same (J = 0.33) for the both apiaries between 0 and 1 km. Nevertheless, between 1 and 1.5 km, it was 0.28 for the first apiary and 0.31 for the second. Thus, J = 0.13 and 0.20 respectively for the first and second apiary between 1.5 and 2 km. The Pielou's measures of evenness were low (< 0.6) around the apiaries. The Shannon's diversity index and Pielou's measures of evenness were low between 1.5 and 2 km around the both apiaries. It means that the vegetation was homogeneous.

Botanical characteristics of bee plants

Biological types

The recorded bee plants were unevenly distributed according to their biological types. Herbs were the most represented (45 %) followed by shrubs (36.25 %), the differences was very highly significant (χ^2 = 43.33; *df* = 3; P < 0.001). The trees and small trees were less represented.

Status of bee plant

Studies have revealed the importance of the spontaneous plants (88.75%) as the bee plants compared to cultivated plants with the very highly significant (χ^2 = 96.10; *df* = 1; P < 0.001). Considering the cultivated plants, fruit trees such as *Mangifera indica, Persea americana, Carica papaya, Psidium guajava, Citrus aurantifolia* and *Anacardium occidentale* were the most represented (66.66%), followed by tubers (*Ipomoea batatas* and *Manihot esculenta*) with 22.22% and a single cereal *Zea mays* (11.11%). The main spontaneous bee plants found everywhere in the study area were *Daniellia oliveri, Lophira lanceolata, Chromolaena odorata* and *Thitonia diversifolia*. The annual species were the most represented but not significant with 53.75% (χ^2 = 0.90; *df* = 1; P < 0.05) compared to the perennial species.

Flower's colours

The distribution of bee plants according to their flowers (figure 3 and 4) showed high diversity of colours between and within the families. A total of 25 colours were registered. The white flowers were significantly (χ^2 =189.90; *df* = 25; P < 0.001) the most represented (30.00%) followed by the green, yellow and violet with 11.25, 08.75 and 07.50% respectively. The others colours were less represented. The flower diversity is in relation with the floristic diversity and the preference of the honeybees to the flower's colour.

Figure 3: *Apis mellifera adansonii* collecting nectar in the flowers of some plants

Figure 4: *Apis mellifera adansonii* collecting pollen in the flowers of some plant

Nutrients harvested by honeybees

The nutrients harvested by honeybees vary between and within families (table 1). A half of the recorded bee plants were visited for their pollens (Fig 4), followed by nectar plants (28.75%) (Figure 3), and nectar/pollen plants (21.25%). The differences between the type of nutrient harvested by bees were very highly significant (χ^2 = 16.01; *df* = 2; P < 0.001). In the rainy season, pollen (70.58%) were more collected compare to nectar (29.41%), the differences were very highly significant (χ^2 =180.90; *df* = 23; P < 0.001). However, in the dry season, nectar (55.55%) were well privileged than pollen (44.44%). The type of nutrients collected by bees varies with the season.

Floral size, symmetry and types of flowers

The floral characteristics were summarized in Table 1. The bee plant flowers showed a high diversity of sizes (Figure 3 and 4). The moderate size flowers was the most represented (60.50%) followed by the small size flowers (27.50%) and high size flowers (12.50%). The difference between the averages of flower sizes was highly significant (P < 0.001). These results show that bees preferred flower with moderate size, which was more indicated for their morphologies and foraging activities.

The flower's symmetry of the recorded bee plants varies within and between families. The actinomorphic flowers (62.5%) were highly significantly (χ^2 = 10.00; *df* = 1; P < 0.001) foraged than the zygomorphic ones (37.5%). The activities of foragers seem to depend on the flower symmetry, actinomorphic flowers seem most accessible by foragers.

The flower types differ from one family to another and from one species to another. Inflorescences were highly (83.75 %) represented for bee plants than solitary flowers (16.25 %) with very highly statistical significance (χ^2 = 72.10; *df* = 1; P > 0.001). In the study zone, the foraging behaviour appears to depend on the floral morphology.

Flowering period

The blooming times of bee plants present variations between and within families (table 1). The bee plants that flower in the rainy season (58.75%) represent significantly (χ^2 = 4.90; *df* = 1; P > 0.05) more than half of the total identified bee plants. The differences were Herbs were the most represented (70.21%) during the rainy season. Shrubs, small trees and trees are lowly represented with 17.02, 8.51 and 4.25 % respectively. However, during the dry season, shrubs are highly represented (63.63%) followed by trees (18.18%). Herbs and small trees are less represented with 09.09% each. There was no any period during which bee plant was not flowering in our study area.

Regarding the flowering period, plants whose blooming for one month (class I) grouped almost significantly (χ^2 = 8.36; *df* = 2; P > 0.05) the half of bee plants identified. It was followed respectively by those of class III (31.25%) and class II (23.75%). The flowering times of the bee plants were not the same, however, there were plants with flowers all the years.

Discussion

Foraging activity of bee is high in the radius of 1km in the study zone. This result was also noted by Lecomte (1960) that the radius of the foraging activities was limited; marked bees does not exceed one kilometre and the high quantities of bees foraged in the radius of 0.6 km. According to Couvillon *et al.* (2014), the foraging distance does not depend on the food type collected by a bee, but on a strong correlation between average monthly nectar foraging distance and average monthly pollen foraging distance. **This result were contrary to those of** Abou-Shaara (2014) who noted that the mean foraging distance for *Apis mellifera carnica* was 1526.1 m, for small colony of *Apis mellifera* was 670 m and for large colonies was 620 m in July, while the values were 1430 m for small colonies and 2850 m for large colonies in August. Hagler *et al.* (2011) found that the foraging range of honey bees ranged from 45 m to 5983 m. Under desert conditions, water foragers can fly up to 2 km from their colonies to collect water (Visscher *et al.,* 1996). It seems that the foraging distance for colonies in the same region is impacted by race, colony strength, food resource, month and the time of the day (Abou-Shaara, 2014).

Bee plants of the study zone were diversified, Asteraceae and Poaceae were the most represented families. These results are in agreement with those of Dongock *et al.* (2004) who have identified Asteraceae's family as the most foraged in the Western Highland Sudano-Guinean zone of Cameroon. More than 1/3 of the bee plants recorded in our study area (*Anacardium occidentale, Mangifera indica, Ageratum conyzoides, Bidens pilosa, Tithonia diversifolia, Carica papaya, Harugana madagascarriensis, Terminalia macroptera, Combretum molle, Commelina benghalensis, Ipomoea batatas, Alchornea cordifolia, Jatropha curcas, Manihot esculenta, Sesbania pachycarpa, Persea americana, Daniellia oliveri, Urena lobata, Mimosa invisa, Psidium guajava, Lophira lanceolata, Zea mays, Paulinia pinnata, Piliostigma thonningii, Hymenocardia acida, Erythrina sigmoidea, Entada africana, Syzygium guineens var. macrocarpum, Ximenia americana, Vitex madiensis*) were also identified in other zones of Cameroon such as the Western Highland Sudano-Guinean (Dongock *et al.,* 2004), the mountain range stretching from Mt Oku in the North-West and South-West regions (Ingram, 2011), at Dang - Ngaoundere (Tchuenguen *et al.*, 2005; 2007; 2008; 2009 and 2010) and the Guera zone of Chad (Dongock *et al.,* 2016).

Herbs are found to be the dominant biological type in the study area. These results are in agreement with those of Dongock *et al.* (2004) in Western Highlands Sudano-Guinean zone of Cameroon where herbs were the most represented followed by trees, shrubs and small trees. Nevertheless, our results are not similar to those of Dukku (2013) in the Sudan savannah zone of North eastern Nigeria and Dongock *et al.* (2016) in Southern Chad where trees were highly visited by bee plants. However, Yédomonhan *et al.* (2009) in Manigri Subdivision in Benin have revealed that the bee plants were dominated by shrubs followed by trees and herbs. The predominance of the biological types of bee plants can be influenced by the anthropic activities (agriculture) around the apiaries.

The predominance of wild plants are in discordance with the results obtain by Dongock et al. (2004) in Western Highlands Sudano-Guinean zone of Cameroon, Iritie *et al.* (2014) in Ivory Coast, these authors have shown that the cultivated bee plants were most represented. The life cycle of the bee plants influences the activities of foragers by providing foods. They are in opposition with those of Dongock *et al.* (2011) in the Western Sudano-Guinean zone of Cameroon who has declared that perennial plants are highly represented compared to annual species.

Bee plant was highly diversified in terms of flowers colours, the white one shown the high attraction for bees. The diversity of colours is in agreement with the work of Dongock et al. (2004) in Western Highlands Sudano-Guinean zone of Cameroon and of Dongock *et al.* (2016) in the southern Chad within which white colour was also the most frequent. Nevertheless, in the Democratic Republic of Congo, precisely in Bukavu (Bakenga *et al.,* 2000) were the blue, beige and yellow colours characterised the bee plant of their site. The difference was in relation with the floristic diversity or the preference of the honeybees to flowers. The flower shape often provides a landing platform for bees, they are especially attracted by flowers of white, blue and yellow colours. As noted by Roubik (1992), the most attractive colours to bees are those seen by humans as white, yellow, blue and violet.

During the studies, bees highly collected pollen compared to nectar. The availability of sufficient food to sustain honeybee colonies was made artificial feeding unnecessary (Dukku, 2013). These results are similar to those of Dongock *et al.* (2004) in Western Highlands Sudano-Guinean zone of Cameroon and Dongock *et al.* (2016) in Southern Chad who noted that polliniferous bee plants were highly represented compared to nectariferous plants. In opposition to our results, Iritie *et al.* (2014) in the agroforestry zone of Yamoussoukro (Ivory Coast) have shown that the plants foraged by the honeybees simultaneously for their nectar and pollen were the most represented, bee plants visited for nectar and pollen were lowly represented. Bakenga *et al.* (2000) in the Democratic Republic of Congo has shown that 2/3 of species were foraged for nectar, while, plants visited for nectar and pollen were less represented.

Bee plants with moderate size flowers were the most visited by the foragers. It was noted by Lobreau-Callen and Damblon (1994) that in a tropical region, bees select attractive plants species with small and relative big flowers in their foraging activities, however in the south Saharan dry region bees exploited flower with big size. *Apis mellifera Adansonii* exploited indifferently all flowers, small or big, flat or deep in function of the site.

It was noted by Möller (1995) and Giurfa *et al.* (1999) that that symmetrical flower might signal a high quality and/or quantity of nectar or pollen to pollinators that, in turn, might exert strong selection pressure on symmetric features. Giurfa *et al.* (1999) noted that floral symmetry is a conspicuous cue, it has a particular signal value that is evidently perceived by insect pollinators. That can explain why flowers visited by bumblebees were larger and more symmetrical than the nearest neighbouring flower. In the transition Sudano-Guinean zone of Tropicale West Africa and Mediterranean, the foraging behaviour depends on the floral morphology and all inflorescence were thus generally exploited Lobreau-

Callen and Damblon (1994). It can be concluded that the degree of selectivity of bees is influenced principally by floral morphology and phenology.

The proportion of bee plants flowering during the rainy season is higher compared to those flowering during the dry season. However, there was no any period during which bee plant was not flowering in our study area. This implies that food was available to honeybees all the year. The peak of efflorescence was in rainy season; it corresponds to the honeyed period. Bee plants whose blooming period extend during one month were frequent. Our results are similar to those of Yédomonhan *et al.* (2009) in Benin who have indicated that bee plants which flowering during one month and more than two months were the most represented. The flowerings times of the bee plants vary from species to another's and depend on the type of vegetation.

Conclusion

From our works, at the study site where traditional and modern beekeeping is practised, the bee plants are very diverse in terms of species. Asteraceae, Poaceae, Euphorbiaceae and Rubiaceae were the most represented families. The predominance of herbs and shrubs reminds that it is a savannah vegetation, made of *Daniellia oliveri* and *Lophira lanceolata*. The vegetation is less anthropized and justified the predominance of the spontaneous bee plants. Flowers colour was diversity. Flowers with moderate size were the most represented. Actinomorphic flowers were dominant. Bee plants with inflorescences were frequent. Due to the fact that the precipitations are particularly important between July and September, most of the identified bee plants were flowered in the rainy season. Bee plants with only one month of flowering were highly represented. Half of the recorded bee plants foraged for their pollens. The diversity of bee plants and their characteristics showed that the study site was favourable for the practice of intensive apiculture preferably within the radius of 1 km.

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