International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 4, No. 6, p. 62-74, 2014

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Foraging and pollination behavior of *Apis mellifera adansonii* Latreille (Hymenoptera, Apidae) on *Brachiari brizantha* (Hochst. Ex A. Rich.) Stapf. 1919 flowers at Dang (Ngaoundere-Cameroon)

Moïse Adamou*, Fernand-Nestor Tchuenguem Fohouo

Department of Biological Sciences, Faculty of Science, University of Ngaoundere

Article published on June 16, 2014

Key words: *Brachiaria brizantha*, *Apis mellifera adansonii*, flowers, pollen, pollination, yield.

Abstract

To evaluate the *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) impact on fruit and seed yields of *Brachiaria brizantha* H. (1919) (Poaceae), *A. m. adansonii* workers foraging and pollinating activities were studied in Ngaoundéré. From September to October 2010 and from September to October 2011, the experiments were carried out on 240 and 440 inflorescences divided in three lots: two lots differentiated according to the presence or absence of protection regarding *A. m. adansonii* and other insects visits; the third protected and uncovered when flowers were open, to allow insect visits. Worker's seasonal rhythm of activity, its foraging behavior on flowers, its pollination efficiency, the fructification rate and the percentage of normal seeds were evaluated. Results show that *A. m. adansonii* foraged on *B. Brizantha* flowers throughout the whole blooming period. This bee intensely and preferably harvested pollen. The greatest mean number of individuals foraging simultaneously on 1000 flowers was 10 in 2010 and 625 in 2011. The mean duration of a visit per spikelet was 5.77 ± 5.08 sec in 2010 and 4.94 ± 3.44 sec in 2011. The mean foraging speed was 4.55 flowers/min in 2010 and 6.86 flowers/min in 2011. The fructification rate and the percentage of normal seeds of unprotected inflorescences were significantly higher than those of inflorescences protected from insects. Through its pollination efficiency, *A. m. adansonii* provoked a significant increment of the fructification rate by 37.70 % in 2010 and 34.75 % in 2011, as well as the percentage of normal seeds by 3.39 % in 2010 and 6.82 % % in 2011. The installation or conservation of *A. m. adansonii* nests close to *B. brizantha* fields could be recommended to increase seeds and fruits production in the region.

* **Corresponding Author:** Moïse Adamou ✉ adamou.moise@yahoo.fr

Introduction

Brachiaria brizantha is a genus of grasses originating from savannas of eastern Africa. These grasses are widely used as livestock forage. This genus includes 97 species, which can be found in tropical and subtropical climates, mostly in Africa and America. These grasses are monocots in the family *Poaceae* (John *et al.*, 1988; Miles *et al.*, 1996; Peters *et al.*, 2003). *B. brizantha* is the most widely used tropical grass in Central and South America, about 40 million ha in Brazil alone (Boddey *et al.*, 2004). *Brachiaria* are annual or perennial grasses, most lacking rhizomes (Watson and Dallwitz, 2008).

B. brizantha is the single most important foraging grass for pastures in the tropics (Sun and Geoff, 1996; Dias-Filho and Moacyr, 2002). *B. brizantha* have impacted the economy of various countries found in the tropics because of its ability to grow in infertile soil with high acidity (Dias-Filho and Moacyr, 2002; Burke *et al.*, 2003). One of the best attributes to *Brachiaria* is that it can grow so well in low-fertility acid soils and still be able to produce highly nutritious forage for many ruminants. In the past 25-30 years, *Brachiaria* cultivation and export have become a major component of sown pastures (Watson and Dallwitz, 2008). In the America's, Brazil represents the leading user and producer of *Brachiaria* seeds (Boddey *et al.*, 2004).

Lightly grazed, *B. brizantha* provides good ground cover and weed control. Under light grazing, many twining legumes will persist in the sward. Creeping legumes such as *Arachis* spp. and *Desmodium heterocarpon* subsp. *ovalifolium* will combine well under more intense grazing. There has also been research done showing that *Brachiaria* could inhibit nitrification of soils (Dias-Filho and Moacyr, 2002; Burke *et al.*, 2003). This could be an amazing find since this it's the most widely grown grass in South America on the same land as cattle. The cattle can eat this highly nutritious grass and it helps to keep down nitrous oxide levels in the atmosphere (Thomas and Grof, 1986; Dias-Filho and Moacyr, 2002).

Before this study, literature is scant on the relationships between the honey bee and many plant species in Cameroon. Nevertheless, in this country, owing to increasing demand for hive products such as honey and pollen, beekeeping needs to be developed. Highest quantities of pollen marketed in Cameroon came from the Adamawa region which has a climate particularly favourable to the proliferation of bees (Inades, 2000a). Despite this attribute, the region is equally concerned by the problem of low beekeeping production (Inades, 2000b).

Bees in particular usually increase the fruit and seed yields of many plants species, through pollinisation of flowers during foraging (Keller and Waller, 2002; Fluri and Frick, 2005; Sabbahi *et al.*, 2005; Klein *et al.*, 2007; Tchuenguem Fohouo *et al.*, 2009; Kingha, 2012).

The main objective of this research undertaken in Ngaoundere in 2010 and 2011 was to contribute to the knowledge of the relationships between honey bees and *B. brizantha*. This knowledge is essential for an efficient management of these plants. For each plant species, specific objectives were: (1) the registration of the activity of *Apis. mellifera. adansonii* on *B. brizantha* flowers; (2) the evaluation of the apicole value of this plant; (3) the evaluation of the impact of flowering insects on pollination, on fruits and seeds yields of this Poaceae, and (4) the estimation of the pollination efficiency of *A. m. adansonii* on *B. brizantha*.

Materials and methods

Study site and biological material

The experiment was carried out twice, from September to October 2010 and from September to October 2010, and then, from September to October 2011 and from September to October 2011 at Dang, a village of Ngoundere in the Adamawa Region of Cameroon. This Region belongs to the high altitude guinean savannah agro-ecological zone. The climate is characterized by two seasons: a rainy season (April-October) and a dry season (November - March). The annual rain fall is about 1500 mm. The mean annual temperature Is 22°C, while the mean annual relative humidity is 70%. Plants chosen for observations were located at three km away in diameter, centered on a Kenyan top-bar hive inhabited by an *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae). This hive is located at 7°24.949'N, 13°32.870'E and 1093 m above sea level. The number of honeybee colonies located in this area varied from 51 in September 2010 to 64 in October 2011. The vegetation was represented by ornamental hedge and native plants of the savannah and gallery forests.

Methods

Determination of the of Brachiaria brizantha mating system

October 9th, 2010, 240 *B. brizantha* flowers at bud stage were labeled among which 120 were left unattended (treatment 1) and 120 were protected using gauze bags net to prevent insect visitors (Roubik, 1995) (treatment 2). October 12th, 2011, 240 flowers of *B. brizantha* with flowers at bud stage were labelled among which 120 were left unattended (treatment 3) and 120 were protected using gauze bags (treatment 4).

In both years, ten days after shading of the last labelled flowers, the number of fruits was assessed in each treatment. The podding index was then calculated as described by Tchuenguem Fohouo *et al.* (2001): Pi = F2/F1 Where F2 is the number of fruits formed and F1 the number of viable flowers initially set.

The allogamy rate (Alr) from which derives the autogamy rate (Atr) was expressed as the difference in podding indexes between treatment X (unprotected flowers) and treatment Y (protected flowers) (Demarly, 1977).

Alr = [(PiX – PiY) / PiX] x 100 Where PiX and PiY are respectively the podding average indexes of treatment X and treatment Y. Atr = 100 – Alr

Estimation of the frequency of Apis. mellifera. adansonii visiting flowers of Brachiaria brizantha

From 2nd to 3rd September 2010, 60 quadrats of 1 m² of flowering *B. brizantha* were made. Out of these plants, 440 inflorescences with flowers at the bud stage were labelled among which 120 were left unattended (treatment 1) and 120 bagged (treatment 2) to prevent visitors. On September 3rd 2011, 440 inflorescences of *B. brizantha* with flowers at the bud stage were labelled among which 200 were left for unlimited visits (treatment 3). The frequency of *A. m. adansonii* in the flowers of *B. brizantha* was determined based on observations on inflorescences of treatment 1 and treatment 3, every day, from September 4th to October 4th 2010 and from September 4th to October 4th 2011, at 6 – 7h, 7 – 8h, 8 – 9h, 9 – 10h. In a transect walks along all labelled inflorescences treatment 1 and treatment 3, the identity of all insects visiting *B. brizantha* was recorded. Specimens of all insect taxa were caught with insect net and conserved in 70% ethanol for subsequent taxonomy determination. All insects encountered on flowers were registered and the cumulated results expressed in number of visits to determine the relative frequency of *A. m. adansonii* in the anthophilous entomofauna of *B. brizantha.*

In addition to the determination of the floral insects' frequency, direct observations of the foraging activity on flowers were made on insect pollinator fauna in the experimental field. The floral products (pollen) harvested by *A. m. adansonii* during each floral visit were recorded based on its foraging behavior. Pollen gatherers scratched the anthers with their mandibles or legs. In the morning of each sampling day, the number of opened flowers carried by each labelled inflorescence was counted.

During the same days, as for the frequency of visits, the duration of individual flower visits was recorded (using a stopwatch) for the following time frames: 6 – 7h, 7 – 8h, 8 – 9h, 9 – 10h.

Moreover, the number of pollinating visits during which the bee came into contact with the stigma, the abundance of foragers or the highest number of individuals foraging simultaneously on a flower or on 1000 flowers: Tchuenguem *et al.* (2004) and the foraging speed as the number of flower visited by a bee per min as described by Jacob-Remacle (1989); Tchuenguem (2005) were measured. The disruption of the activity of foragers by competitors or predators and the attractiveness exerted by other plant species on *A. m. adansonii* were also assessed.

During each daily investigations period, a mobile thermo-hygrometer was used to register the temperature and the relative humidity in the experimental site.

Evaluation of the effect of Apis. mellifera. adansonii and other insects on Brachiaria brizantha yields

This evaluation was based on the impact of flowering insects on pollination, the impact of pollination on fructification of *B. brizantha*, and the comparison of yields (fructification rate, mean number of seed per fruit and percentage of normal seeds) of treatment X (unlimited Inflorescences) and treatment Y (bagged inflorescences). The fructification rate due to the influence of foraging insects (Fri) was calculated by the formula: $Fri = \{[(FrX - FrY) / FrX] \times 100\}$ where FrX and FrY were the fructification rate in treatment X and treatment Y. The fructification rate of a treatment (Fr) is $Fr = [(F2/F1) \times 100]$, where $F2$ is the number of fruits formed and $F1$ the number of viable flowers initially set. At maturity, fruits were harvested from each treatment and the number of seeds counted. The mean number of seeds per fruit and the percentage of normal seeds per fruit were then calculated for each treatment. The impact of flowering insects on seed yields was evaluated using the same method as mentioned above for fructification rate (Tchuenguem *et al.*, 2004).

Assessment of the pollination efficiency of Apis. mellifera. adansonii on Brachiaria brizantha

Parallel to the constitution of treatments 1 and 2, 100 inflorescences were isolated (treatment 5) as those of treatment 2. Parallel to the constitution of treatments 3 and 4, 100 inflorescences were isolated (treatment 6) as those of treatment 4. Between 7 am and 9 am of each observation date, the gauze bag was delicately removed from each inflorescence carrying new opened flowers, the inflorescence were observed for up to 20 minutes and then protected again.

The contribution (Frx) of *A. m. adansonii* in the fructification was calculated by the formula: $Frx = \{[(FrZ - FrY) / FrZ] \times 100\}$, where FrZ and FrY are the fructification rate in treatment Z (bagged inflorescences and flowers visited exclusively by *A. m. adansonii*) and treatment Y (bagged inflorescences). At maturity, fruits were harvested from treatment 5 and treatment 6 and the number of seeds per fruit counted. The mean number of seeds per fruit and the percentage of normal seeds were then calculated for each treatment. The impact of *A. m. adansonii* on seed yields was also evaluated using the same method as mentioned above for fructification rate (Tchuenguem *et al.*, 2004).

Data analysis

Data were analyzed using descriptive statistics, student's *t*-test for the comparison of means between two samples, correlation coefficient (r) for the study of the association between two variables, chi-square (X^2) for the comparison of percentages using *SPSS* statistical software and Microsoft Excel programs.

Results

Brachiaria brizantha mating system

120 flowers were studied in each of the treatments 1 respectively in 2010 and 2011. In 2010, the podding index was 0.60 for treatment 1 and 0.35 for treatment 2 while in 2011, it was instead 0.55 for treatment 1 and 0.37 for treatment 2. Hence, the allogamy rate (Alr) and the autogamy rate (Atr) were respectively 41.67% and 58.33% in 2010 against 32.73% and was 67.27% in 2011. **(Table1)** It appears from those results that *B. brizantha* variety used for our experiment had a mixed mating system: allogamous and autogamous, with the predominance of autogamy over allogamy.

Table 1. *Brachiaria brizantha* yields in different Treatments.

Studied	Treatments	Nfs	Npf	Fr	Nsf	Nns	Pns
2010	1(Ff)	3163	1899	60.04	1899	1868	98.36
	2(Pf)	2929	1035	35.34	1035	933	90.14
2011	3(Ff)	2684	1469	54.73	1469	1422	96.80
	4(Pf)	2838	1037	36.54	1037	952	91.80
2010	5(Fv *A. m. adansonii)*	3519	1906	54.16	1906	1844	96.74
2011	6(Fv *A. m. adansonii*)	3659	1887	51.57	1887	1835	97.24

Ff: free flower, Pf: protected flowers, Fvx: flowers visited exclusively by *A. m. adansonii*, Nfs: number of flowers studied, Npf: number of fruit formed, Fr: fructification rate, Nsf: number of seeds formed, Nns: number of normal seeds, Pns: percentage of normal seeds.

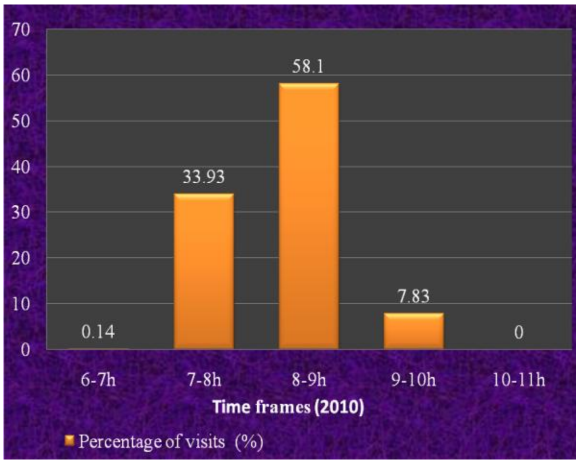
Frequency of Apis. mellifera. adansonii in the floral entomofauna of Brachiaria brizantha

In table 2, showing the 3647 and 3692 visits of 3 and 4 insect species recorded on runner bean flower, respectively in 2010 and 2011, *A. m. adansonii* was the most represented insect with 3490 visits (95.69%) and 3462 visits (93.78%), respectively in 2010 and 2011. The difference between these two percentages is highly significant (X^2 = 13.61; P < 0.001). **(Table 2)** *A. m. adansonii was active on B. brizantha* flowers from 6 am and 10 am, with a peak of visits between 8 am and 9 am in 2010 as well as in 2011 **(Fig. 1A and B).**

Table 2. Diversity of floral insects on *Brachiaria brizantha* inflorescences in 2010 and 2011, number and percentage of visits of different insects.

Insects			2010		2011	
Order	**Family**	**Genus, species, sub-species**	**n1**	**p1 (%)**	**n2**	**p2 (%)**
Hymenoptera	Apidae	*Apis mellifera adansonii*	3490	95,69	3462	93,78
	Halictidae	*Lasioglossum* sp.	100	2,74	80	2,2
		Lipotriches notabilis	57	1,57	106	2,9
Coleoptera	Lagridae	*Lagria villosa*	-	-	41	1,12
Total		2010/2011: 3 species / 4 species	3647	100%	**3692**	**100%**

n_1: number **of** visits on 120 inflorescences in 30 days, n_2: number of visits on 120 inflorescences in 30 days, p_1 and p_2: percentages of visits, p_1 = (n_1 / 2677) ×100, p_2 = (n_2 / 3647) ×100; comparison of percentages of *A. m. adansonii* visits for two years: X^2 = 51.43; p < 0.001



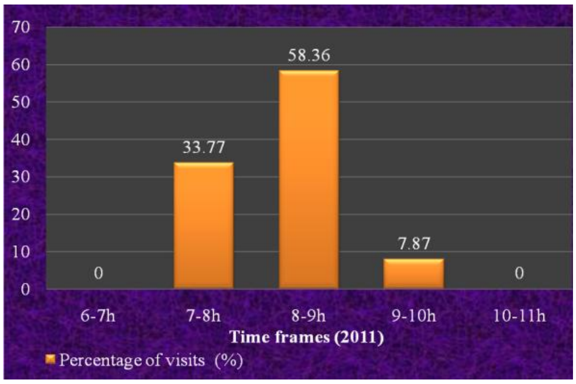


Fig. 1. Daily distribution of *A. m. adansonii* visits on 120 *Brachiaria brizantha* flowers over 30 days in 2010 (A) and in 2011 (B).

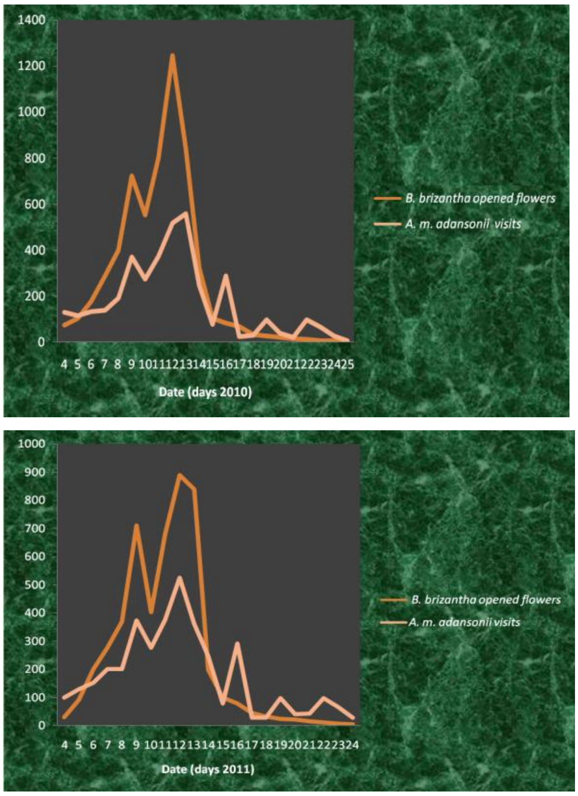
Activity of Apis. mellifera. adansonii on Brachiaria brizantha flowers

Floral products harvested: From our field observations, *A. m. adansonii* workers were found to collect pollen on *B. brizantha* flowers. Pollen collection was intensive and regular. From 3490 visits recorded in 2010, 3490 (100.00%) were devoted to exclusive pollen harvest; whereas in 2011, from 3716 visits recorded, 3716 (100.00%) were devoted to exclusive pollen harvest. (**Fig. 2**) Pollen was harvested all scheduled time frame long.

Fig. 2. Flower of *B. brizantha* plant showing *A. m. adansonii* collecting pollen on opened flowers

Rhythm of visits according to the flowering stages

Visit was most numerous on the experiment plot when the number of inflorescences carrying opened flowers was highest **(Figs. 3 C and D).** Furthermore, a positive and very highly significant correlation was found between the number of *B. brizantha* opened flowers and the number of *A. m. adansonii* visits in 2010 (r = 0.89; df = 20; P < 0.001) as well as in 2011 (r = 0.84; df = 19; P < 0.001).



Figs. 3. Seasonal distribution of the number of *Brachiaria brizantha* opened flowers and the number of *A. m. adansonii* visits in 2010 (C) and 2011 (D).

Daily rhythm of visits

A. m. adansonii foraged on *B. brizantha* flowers throughout the whole daily blooming period, with a peak of activity situated between 8 and 9 am (table 4). Climatic conditions influenced the activity of *A. m. adansonii* in the field of *B. brizantha* (table 4). In 2010, the correlation was positive and not significant (r = 0.41; ddl = 3; P < 0.05) between the number of *A. m. adansonii* visits on *B. brizantha* flowers and the temperature, while it was positive and not significant (r = 0.30; ddl = 3; P < 0.05) between the number of visits and relative humidity. In 2011, the correlation was negative and not significant (r = -0.03; ddl = 3; P < 0.05) between the number of *A. m. adansonii* visits on *B. brizantha* flowers and the temperature, while it was positive and not significant (r = 0.10; ddl = 3; P < 0.05) between the number of visits and relative humidity **(Figs. 4 E and F).**

Table 3. Seasonal distribution of the number of *Brachiaria brizantha* opened flowers (f) and the number of *A. m. adansonii* visits (v) in 2010 and 2011.

2010	**Day**	**4 sp**	**5 sp**	**6 sp**	**7 sp**	**8 sp**	**9 sp**	**10 sp**	**11 sp**	**12 sp**	**13 sp**	**14sp**
	f	74	102	176	287	399	722	522	803	1245	840	324
	v	129	116	133	139	191	372	274	373	518	559	247
2011	Day	4 sp	5 sp	6 sp	7 sp	8 sp	9 sp	10 sp	11 sp	12 sp	13 sp	14sp
	f	30	90	200	277	370	710	402	680	890	840	198
	v	100	129	153	202	202	374	277	365	525	362	248

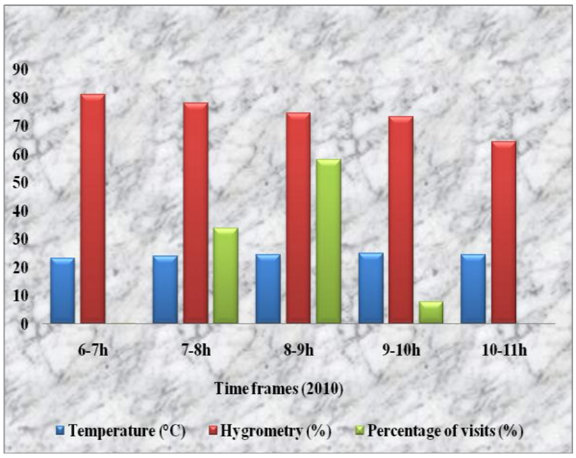
2010	**Day**	**15 sp**	**16 sp**	**17 sp**	**18 sp**	**19 sp**	**20 sp**	**21 sp**	**22 sp**	**23 sp**	**24 sp**	**25 sp**
	f	324	104	81	68	32	27	20	16	11	5	3
	v	247	78	290	26	30	97	40	22	98	29	7
2011	Day	15 sp	16 sp	17 sp	18 sp	19 sp	20 sp	21 sp	22 sp	23 sp	24 sp	25 sp
	f	99	77	44	32	23	20	14	11	7	4	
	v	79	292	29	30	98	41	44	98	66	29	

sp: septembre; statistical analysis: For 2010: $r = 0.89$ ($df = 20$; $p < 0.001$); for 2011: $r = 0.84$ ($df = 19$; $p < 0.001$)

Table 4. Daily distribution of *A. m. adansonii* visits on *Brachiaria brizantha* inflorescences over 30 days in 2010 and 30 days 2011 respectively, mean temperature and mean humidity of the study site.

Year	**Parameter registered**	**Daily period (hours)**				
		6 - 7	**7 - 8**	**8 - 9**	**9 - 10**	**10 - 11**
2010	Number of visits	5	1274	2181	294	0
	Percentage of visits (%)	0.14	33.93	58.10	7.83	0
	Temperature (°C)	23.26	24.10	24.64	25.0	24.60
	Hygrometry (%)	81.33	78.17	74.73	73.40	64.50
2011	Number of visits	0	1255	2169	292	0
	Percentage of visits (%)	0	33.77	58.36	7.87	0
	Temperature (°C)	22.55	23.85	26.15	28.7	28.85
	Hygrometry (%)	82.92	79.32	76.63	73.4	69.67

2010 for temperature and hygrometry, each figure represents the means of 34 observations. 2011: for temperature and hygrometry, each figure represents the means of 40 observations.



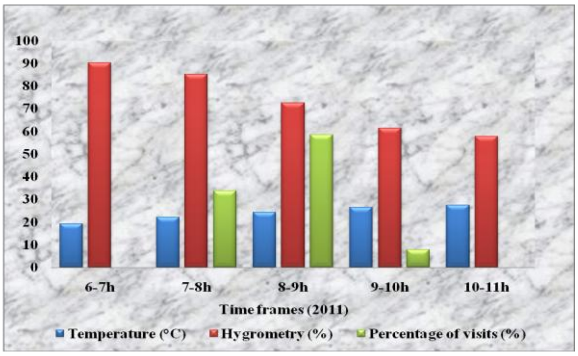


Fig. 4. Daily distribution of *A. m. adansonii* visits on 120 *Brachiaria brizantha* flowers over 30 days in 2010 (E) and in 2011 (F), mean temperature and mean humidity of the study site.

Abundance of Apis. mellifera. adansonii

In 2010, the highest mean number of *A. m. adansonii* simultaneous in activity was 1 per flower (n = 1655; s = 0) and 96.69 per 1000 flowers (*n* = 354; *s* = 80.23; maxi = 625). In 2011, the corresponding numbers were 1 (*n* = 1632; *s* = 0) and 98 (*n* = 341; *s* = 81.39; maxi = 444.4). The difference between the mean number of foragers per 1000 flowers in 2010 and 2011 is highly significant (t = 4.68; P < 0.001).

Duration of visits per flower

In 2010, the mean duration of a visit was 4.94 seconds (*n* = 3754; *s* = 3.44), with a maximum of 36 sec for pollen collection. In 2011, the corresponding numbers were 5.00 sec (*n* = 3716; *s* = 3.45) with a maximum of 36 sec for pollen harvest. The difference between the duration of the visit to harvest pollen in 2010 and 2011 is highly significant (t = 63.84; $P < 10^{-9}$).

Foraging speed of Apis. mellifera. adansonii on Brachiaria brizantha flowers

On the experimental plot of *B. brizantha*, *A. m. adansonii* visited between 2 and 22 flowers/min in 2010 and between 2 and 22 flowers/min in 2011. The mean foraging speed was 6.86 flowers/min (*n* = 196; *s* = 3.03) in 2010 and 7.00 flowers/min (*n* = 178; *s* = 3.03) in 2011. The difference between these two means is highly significant (t = 2.85; P < 0.001).

Influence of neighboring flora

During the observation period, flowers of many others plant species growing near *B. brizantha* were visited by *A. m. adansonii*, for nectar (ne) and/or pollen (po). Amongst these plants were *Mimosa pudica* (Fabaceae; po), *Senna javanica* (Fabaceae; ne and po), *Ctenium newtonii* (Poaceae, po); *Psidium guajava* (Myrtaceae; po); *Tithonia d iversifolia* (Asteraceae; ne and po); *Mimosa invisa* (Mimosaceae; po) and *Callistemon rigidus* (Myrtaceae; ne and po). During one foraging trip, an individual bee foraging on *B. brizantha* was not observed moving from *B. brizantha* to the neighboring plant and vice versa.

During *B. brizantha* flowering periods, a well elaborated activity of *A. m. adansonii* as well as other bee species was registered on its flowers. In particular, there was a high density of bee workers on that plant, very good pollen harvest and workers faithfulness to its flowers. These data point out the very good attractiveness of *B. brizantha* floral products to *A. m. adansonii*. It appears from those data that our studied plant species could be classified in one category of apicole plants: highly polleniferous plant species.

Impact of Apis. mellifera. adansonii and others anthophilous insects' activity on pollination and on the fruit and seed yields of Brachiaria brizantha

During pollen harvest on *B. brizantha*, foraging insect always check flowers and regularly contacted anthers and stigma. The flowering insect increased the pollination possibility of *B. brizantha*. The comparison of the fructification rate **(Table 1)** shown that the differences observed are highly significant between treatments 1 and 2 (X^2 = 125.28; df = 1; P < 0.001) and treatments 3 and 4 (X^2 = 113.87; df = 1; P < 0.001). The difference between the treatments 1 and 3 was not significant (X^2 = 0.93; df = 1; P > 0.05).

Consequently, in 2010, the fructification rate of unprotected inflorescences (treatment 1) was higher than that for protected inflorescences (treatment 2); whereas in 2011, the fructification rate of the unprotected inflorescences (treatment 3) was higher than that of protected inflorescences (treatment 4).

The comparison of the percentage of normal seeds **(Table 1)** showed that the observed differences was highly significant between treatments 1 and 2 (X^2 = 36.84; df = 1; P < 0.001) and treatments 3 and 4 (X^2 = 10.37; df = 1; P < 0.01). The difference between treatments 1 and 2 was not significant (X^2 = 2.88; df = 1; P > 0.05).

Hence, in 2010, the percentage of normal seeds of exposed inflorescences (treatment 1) was higher than that of protected inflorescences (treatment 2); similarly, in 2011, the percentage of normal seeds of exposed inflorescences (treatment 3) was higher than that of protected inflorescences (treatment 4).

The percentage of the fructification rate due to the action of flowering insects were 41.15 % in 2010 and 33.24 % in 2011. For all of the inflorescences studied, the percentage of the fructification rate attributed to the influence of insects was 37.20 %.

The percentages of the number seeds production due to the action of insects were 8.35 % in 2010 and 5.17 % in 2011. For all of the inflorescences studied, the percentage of the normal seeds attributable to influence of insects was 6.76 %.

Pollination efficiency of Apis. mellifera. adansonii on Brachiaria brizantha

On all visited flowers, *A. m. adansonii* contacted anthers and carried pollen. With this pollen, worker bees flew frequently from flower to flowers. *A. m. adansonii* came into contact with visited flowers during 100% of visits. Thus this bee highly increased the pollination possibilities of *B. brizantha* flowers.

The comparison of the fructification rate **(Table 1)** showed that the differences observed were highly significant between the treatments 2 and 5 (X^2 = 22.36; $df = 1$; $P < 0.001$) and treatments 4 and 6 (X^2 = 246.51; $df = 1$; $P < 0.001$). The difference between the treatments 5 and 6 was significant (X^2 = 7.35; $df = 1$; $P < 0.05$).

Therefore, in 2010, the fructification rate of flowers protected and visited exclusively by *A. m. adansonii* (treatment 5) was higher than that of flowers protected during their opening period (treatment 2); similarly, in 2011, the fructification rate of flowers protected and visited exclusively by *A. m. adansonii* (treatment 6) was higher than that of flowers protected during their opening period (treatment 4).

The comparison of the percentages of normal seeds **(Table 1)** has shown that the differences were highly significant between treatments 2 and 5 (X^2 = 1600.13; $df = 1$; $P < 0.001$) and treatments 4 and 6 (X^2 = 7.47; $df = 1$; $P < 0.001$). The difference between treatments 5 and 6 was not significant (X^2 = 0.71; $df = 1$; $P > 0.05$).

Consequently, in 2010, the percentage of normal seeds of flowers protected and visited exclusively by *A. m. adansonii* (treatment 5) was higher than that flowers protected during their opening period (treatment 2); in 2011, the percentage of normal seeds of flowers protected and visited exclusively by *A. m. adansonii* (treatment 6) was higher than that of flowers protected during their opening period (treatment 4).

The percentage of the fructification rate due to *A. m. adansonii* activity was 30.92% in 2010 and 29.15% in 2011. For all the flowers studied, the percentage of fructification rate attributed to the influence of *A. m. adansonii* was 30.04 %.

The percentage of the normal seeds due to *A. m. adansonii* was 6.82 % in 2010 and 5.60% in 2011. For all the flowers studied, the percentage of the number of seeds per pod attributable to influence of *A. m. adansonii* was 6.21%.

In short, the influence of *A. m. adansonii* on fruit and seeds yields was positive and higher significant.

Discussion

Activity of Apis. mellifera. adansonii on Brachiaria brizantha flowers

Results obtained from these studies indicated that bee *A. m. adansonii* was the main floral insect frequent on *B. brizantha.* during the observation periods. The significant difference between the visit frequencies of *A. m. adansonii* and those of other insects can be explained by the strategies adopted by this bee that consist of the recruiting of a great number of workers for the exploitation of an interesting nutritional source (von Frisch, 1969; Louveaux, 1984; Schneider and Hall, 1997; Goodman, 2003; Kajobe, 2006). Consequently, there may be a limitation of the number of visits of other insect species due to the occupation of the majority of open flowers by *A. m. adansonii* workers.

The significant difference between the percentages of *A. m. adansonii* visit for the two years of study could be explained by the presence of the nest of this insect near the experimental plot in 2011.

An activity peak of *A. m. adansonii* has been observed on *B. brizantha* inflorescences in the morning. This peak could be linked of the period to highest availability of the pollen on *B. brizantha* flowers

The high abundance of *A. m. adansonii* foragers on 1000 flowers and the positive and significant correlation between the number of *B. brizantha* flowers bloom and number of *A. m. adansonii* visits, underscore the attractiveness of *B. brizantha* pollen with respect to this bee. The attractiveness for *B. brizantha* pollen could be partially explained by its high production compared to range of 15 - 75 % in which fail most of the plant species (Proctor *et al.*, 1996).

The significant difference observed between the duration of pollen harvest visits could be explained by the accessibility of each of these floral products. Pollen is produced by the anthers, which are situated on the top of the stamen and are thus easily accessible to *A. m. adansonii* (Heslop-Harrisson and Heslop-Harrisson, 1983).

The fact that an individual bee exploiting *B. brizantha* plot was not observed visiting another plant species indicates that *A. m. adansonii* shows flowers constancy for the flowers of this plant species.

Impact of Apis. mellifera. adansonii activity on the pollination and yields of Brachiaria brizantha

During the collection of pollen on each flower, *A. m. adansonii* workers regularly come into contact with the stigma. They could thus provoke auto-pollination by applying pollen of one flower on its own stigma.

The same results were found in southwestern Brazil on *Couepia uiti* flowers (Paulino-Neto, 2007), in Dang-Ngaoundéré *Anona senegalensis*, *Croton macrostachyus*, *Psorospermum febrifugum* and *Syzygium guineense var. guineense* flowers (Tchuenguem *et al.*, 2008), *Phaseolus vulgaris* (Kingha *et al.*, 2012), *Callistemon rigidus* (Fameni Tope *et al.*, 2012), in South Africa on *Cyrtanthus breviflorus* flowers (Glenda *et al.*, 2010); in Ngaoundéré on *Ximenia americana* flowers (Djonwangwe *et al.*, 2011), in Yaoundé on *Phaseolus coccineus* flowers (Pando *et al.*, 2011) and in Maroua (Dounia and Fohouo, 2014; Douka and Fohouo, 2014; Tchuenguem and Dounia, 2014).

Apis mellifera adansonii foragers were also able to carry pollen with their furs, legs and mouth accessories. They could consequently carry the pollen from a flower of one plant to stigma of another flower of the same plant (geitonogamie) or to that of another plant (xénogamie). This last form of pollination is as probable as allogamy exist in *B. brizantha* (Williams and Free, 1975; Kendal and Smith, 1976; Koltowski, 2004; present study).

The intervention of *A. m. adansonii* in the pollination of *B. brizantha* is seemingly more real than its density per 1000 flowers and its foraging visits are high. Moreover, its daily period of intense activity which is situated in the morning hours coincides with the optimal receptive period of the stigma of *B. brizantha* (William and Free, 1975).

The positive and significant contribution of *A. m. adansonii* in the fruit and seeds yields of *B. brizantha* is justified by the action of this worker bee on pollination. Our results agreed with those obtained in Great Britain (Kendall and Smith, 1976) and United State of America (Ibarra-Perez *et al.*, 1999) which showed that *Phaseolus coccineus* flowers produce less seeds per pod in the absence of insect pollinators.

The numeric contribution of *A. m. adansonii* to the yields of *B. brizantha* through its pollination efficiency was significantly higher than that of all insects on the exposed flowers. This shows on one hand that *A. m. adansonii* is one of the principal insect pollinators of *B. brizantha* and on the other hand that many insect that visit *B. brizantha* flowers benefits from this Poaceae, but did not have any influence on pollination and yields of the plant species. This result confirmed other findings reported by Pando *et al.*, 2011, Fameni *et al.*, 2012; Kingha *et al.*, 2012; Dounia and Tchuenguem, 2014 and Mazi *et al.*, 2013, 2014) with *A. m. adansonii* bee specie. The weight of *A. m. adansonii* played a positive role: when collecting pollen, *A. m. adansonii* shacked flowers; this movement could facilitate the liberation of pollen by anthers, for the optimal occupation of the stigma.

Conclusion

Apis mellifera adansonii is the most important pollinator of *B. brizantha* at Dang (Ngaoundere), providing yield benefits to this host plant. The comparison of fruits and seeds set of unprotected inflorescences with that of inflorescences visited exclusively by *A. m. adansonii* underscores the value of this bee in increasing fruit and seed yields as well as seed quality. The study thus shows investment management of *A. m. adansonii* interms of nest provision at proximity of *B. brizantha* field is worthy while for growers.

Acknowledgements

We would like to be grateful to the University of Ngaoundere for providing us the experimental field within the campus. We thank P. M. Mapongmetsem for the identification of plant species.

References

Boddey RM, Macedo R, Tarré RM, Ferreira E, de Oliveira OC, Rezende C de P, Cantarutti RB, Pereira JM, Alves BJR, Urquiaga S. 2004. Nitrogen cycling in Brachiaria pastures: the key to understanding the process of pasture decline. Agriculture, Ecosystems & Environment **103**, 389-403

Burke IC, Thomas WE, Spears JF, Wilcut JW. 2003. Influence of environmental factors on broadleaf signalgrass (*Brachiaria platypylla*) germination. Weed Science **51**, 683-689.

Demarly. 1977**.** Génétique et amélioration des plantes. Masson, Paris. 577 p.

Dias-Filho, Moacyr B. 2002. Photosynthetic light response of the C4 grasses *Brachiaria brizantha* and *Brachiaria humidicola* under shade. Sci. agric. (Piracicaba, Braz.). vol.59, n.1, pp. 65-68. ISSN 0103-9016.

Djonwangwe D, Tchuenguem Fohouo FN, Messi J. 2011. Foraging and pollination activities of *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) on *Ximenia americana* (Oleaceae) flowers at Ngaoundéré (Cameroon). International research Journal of Plant Science **2**(6), 170-178.

Douka C, Tchuenguem Fohouo FN. 2014. Foraging and pollination activity of *Musca domestica* L. (Diptera: Muscidae) on flowers of *Ricinus communis* L. (Euphorbiaceae) at Maroua, Cameroon. Journal of Biodiversity and Environmental Sciences **4**(3), 63-76.

Dounia, Tchuenguem Fohouo FN. 2014. Foraging and pollination activity of Macronomia vulpine (Gerstaecker, 1857) (Hymenoptera: Halictidae) on Gossypium hirsutum L. (Malvaceae) flowers at Maroua, Cameroon. International Journal of Agronomy and Agricultural Research 2225-3610 (Online).

Fluri P, Frick R 2005. L'apiculture en Suisse: état et perspectives. Rev. Suisse. Agr. **37**(2), 81-86.

Glenda V, Ramsey M, Johnson, SD. 2010. Pollinator and late-acting self-incompatibility in *Cyrtanthus breviflorus* (Amaryllidaceae): implications for seed production. Annals of Botany **106**, 547-555

Goodman L. 2003 Form and Function in the Honey Bee .IBRA, Cardiff. 22 pp.

Heslop-Harrison J, Heslop-Harrison Y. 1983. Stigma organisation and the control of fertilisation in *Phaseolus*. *In: Eucarpia* meeting on *Phaseolus* beans Breeding, Hamburg, 19-21 July 1983, 88-96.

Ibarra-Perrez FJ, Barnhart D, Ehdaie B, Knio KM, Waines JG. 1999. Effects of insect tripping on seed yield of common bean: Published in crop science **39**, 425-433.

Jacob-Remacle A. 1989. Comportement de butinage de l'abeille domestique et des abeilles sauvages dans des vergers de pommiers en Belgique. Apidol. **20**, 271-285.

John T. McGregor Jr, Roy J, Smith Jr, Ronald E. 1988. Broadleaf Signalgrass (*Brachiaria platyphylla*) Duration of Interference in Rice (*Oryza sativa*). Talbert Weed Science Vol. **36**, No. 6, pp. 747-750.

Kajobe R. 2006 Pollen foraging by *Apis mellifera* and stingless bees *Meliponula bocandei* and *Meliponulane bulata* in Bwindi Impenetrable National Park, Uganda. African Journal of Ecology **45,** 265 – 274.

Keller LF, Waller DM. 2002. Inbreeding effects in wild populations. Trends Ecol. Evol. **17**, 230–241.

Kendal DA, Smith BD. 1976. The pollinating efficiency of honey bee and Bumblebee visits to flowers of runner bean *Phaseolus coccineus*. J. Appl Ecol. **13**(3), 749-752.

Klein AM, Vaissière BE, Cane JH, Steffan-Dewenter I, Cunnigham SA, Kremen C, Tscharntke T. 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society **274**, 303–313.

Koltowski Z. 2004. Flowering biology, nectar secretion and insect foraging of runner bean (*Phaseolus coccineus* L.). J. Apicult. Sci. **48**(2), 53-60

Louveaux J. 1984. L'abeille domestique relations avec les plantes cultivées. In : ''Pollinisation et productions végétales'', Pesson P. & Louveaux J. (eds), INRA, Paris, 527-555 p

Mazi S, Tchuenguem Fohouo FN, Dorothea B. 2013. Foraging and Pollination Behaviour of *Apis mellifera adansonii* Latreille (Hymenoptera, Apidae) on *Gossypium hirsutum* (Malvaceae) Flowers at Dang (Ngaoundéré, Cameroon). Journal of Agricultural Science and Technology **3**, 267-280.

Mazi S, Tchuenguem Fohouo FN, Dorothea B. 2014. Foraging and pollination behaviour of Chalicodoma rufipes L. (Hymenoptera: Megachilidae) on Cajanus cajan L. Mill sp. (Fabaceae) flowers at Dang (Ngaoundéré, Cameroon). International Journal of Agronomy and Agricultural Research.**4**(4), 77-88.

Miles JW, Maass BL. 1996. *Brachiaria*: Biology, Agronomy and Improvement. Joint publication by CIAT, do Valle C.B. (eds) Cali, Colombia and Embrapa/CNPGC, Campo Grande, MS, Brazil.

Pando JB, Tchuenguem Fohouo FN, Tamesse JL. 2011. Foraging and pollination behaviour of *Xylocopa calens* Lepeletier (Hymenoptera: Apidae) on *Phaseolus coccineus* L. (Fabaceae) flowers at Yaoundé (Cameroon). Entomological Research **41**, 185-193.

Peters M, Franco LH, Schmidt A, Hincapié B. 2003. Especies forrajeras multipropÓsito: Opciones para productores de Centroamérica. *CIAT Publication No. 333* . CIAT, Cali, Colombia.

Proctor M, Yeo P, Lack A. 1996. The natural history of pollination. Corbet SA, Walters SM, Richard W, Streeter D, Ractliffe DA (eds), Harper Collins, p. 462.

Roubik DW. 2000. Pollination system stability in Tropical America. Conserv. Biol. **14**(5), 1235-1236.

Sabbahi R, De Oliveira D, Marceau J. 2005. Influence of honey bee (Hymenoptera: Apidae) density on the production of canola (Crucifera : Brassicacae). J. Econ. Entomol. **98**(2), 367-372.

Schneider SS, Hall HG. 1997. Diet selection and foraging distances of African and European-African hybrid honey bee colonies in Costa Rica. Insectes sociaux **44**, 171-187.

Sun D, Geoff R. 1996. The competition effect of *Brachiaria decumbens* on the early growth of direct-seeded trees of *Alphitonia petrei* in tropical North Australia. Biotropica **28**, 272-276.

Fameni TS, Tchuenguem Fohouo FN, Dorothea B. 2012. Pollination efficiency of Apis mellifera adansonii (Hymenoptera: Apidae) on Callistemon rigidus (Myrtaceae) flowers at Dang (Ngaoundere, Cameroon). International Journal of Tropical Insect Science **32**(1), 2–11.

Tchuenguem Fohouo FN, Messi J Pauly A. 2001. Activité de *Meliponula erythra* sur les fleurs des *Dacryodes edulis* et son impact sur la fructification. Fruits **56**(3), 179-188.

Tchuenguem Fohouo FN, Messi J, Brückner D, Bouba B, Mbofung G, Hentchoya Hemo J. 2004. Foraging and pollination behaviour of the African honey bee (*Apis mellifera adansonii*) on *Callistemon rigidus* flowers at Ngaoundéré (Cameroon). J. Cam. Acad. Sci. **4**(2), 133-140.

Tchuenguem Fohouo FN. 2005. Activité de butinage et de pollinisation d'*Apis mellifera adansonii* Latreille (Hymenoptera: Apidae, Apinae) sur les fleurs de trois plantes à Ngaoundéré (Cameroun): *Callistemon rigidus* (Myrtaceae), *Sygygium guineense var. macrocarpum* (Myrtaceae) et *Voacanga africana* (Apocynaceae). Thèse du Doctorat d'Etat, Université de Yaoundé I, 103 p.

Tchuenguem Fohouo FN, Djonwangwé D Brückner D. 2008. Foraging behaviour of the african honey bee (*Apis mellifera adansonii)* on *Annona senegalensis*, *Croton macrostachyus, Psoropermum febrifugum* and *Syzygium guinense* var. *guineense* at Ngaoundéré (Cameroon). Pak. J. Biol. Sci. **11**(5), 719-725.

Tchuenguem Fohouo FN, Djonwangwé D, Messi J. Brückner D. 2009. Activité de butinage et de pollinisation de *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) sur les fleurs de *Helianthus annus* (Asteraceae) à Ngaoundéré (Cameroun). Cam. J. Exp. Biol. **5**(1), 1-9.

Tchuenguem Fohouo FN, Dounia. 2014; Foraging and pollination behavior of *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) on *Glycine max* L. (Fabaceae) flowers at Maroua. Journal of Research in Biology **4**(1), 1209-1219

Tekombo Kingha BM, Tchuenguem Fohouo FN, Ngakou A, Brückner D. 2012. Foraging and pollination activities of *Xylocopa olivacea* (Hymenoptera, Apidae) on Phaseolus vulgaris (Fabaceae) flowers at Dang (Ngaoundere-Cameroon). Journal of Agricultural Extension and Rural Development **4**(6), 330-339.

Thomas D, Grof B. 1986. Some pasture species for the tropical savannas of South America. III. *Andropogon gayanus* , *Brachiaria* species and *Panicum maximum* . *Herbage Abstracts*, **56**, 557–565.

von Frisch K. 1969. Vie et moeurs des abeilles (edited by A. Michel). Paris. 556 pp.

Watson L, Dallwitz MJ. 2008. The grass genera of the world: descriptions, illustrations, identification, and information retrieval; including synonyms, morphology, anatomy, physiology, phytochemistry, cytology, classification, pathogens, world and local distribution, and references. The Grass Genera of the World. Retrieved 2011-11-07.

Williams IH, Free JB. 1975. The pollination and set of the early flowers of runner bean (*Phaseolus multiflorus* L.). J. Hortic. Sci. **50**, 405-413