Journal of Research in Biology

An International Scientific Research Journal

Original Research

Foraging and pollination behavior of *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) on *Glycine max* L. (Fabaceae) flowers at Maroua

Authors:
Fernand-Nestor Tchuenguem Fohouo[1] and Dounia[1-2]*.

Institution:
1. Laboratory of Zoology, Faculty of Science, University of Ngaoundéré, Ngaoundéré, Cameroon.

2. Laboratory of Zoology, Higher Teacher Training College, University of Yaoundé I, Yaoundé, Cameroon.

Corresponding author:
Dounia.

Email Id:
Dounia.nat@gmail.com

Web Address:
http://jresearchbiology.com/documents/RA0415.pdf.

ABSTRACT:

To assess the impact of *Apis mellifera adansonii* on pod and seed yields of *Glycine max,* its foraging and pollinating activities were studied in Maroua, during the two season seasons (August-September 2010 and 2011). Observations were made on 51 to 17866 flowers per treatment. Treatment 1 represented by free flowers; treatment 2 bagged flowers and treatment 3 flowers visited only by *A. m. adansonii*. In addition, all flower visitors were recorded. The abundance of bee, duration of visits, impact of activity of *A. m. adansonii* on fruiting percentage, the influence of this bee on formation of pods, number of seeds in each pods and average of normal seeds (well developed) were recorded. Individuals from 28 species of insects were recorded on the flowers of *G. max*, after two years of observations. *Apis mellifera adansonii* with 23.18% of 954 visits was the most frequent, followed by *Polyrachis* sp. 1 (14.77%), *Macronomia vulpina* (14.22%), *Lipotriches collaris* (11.07%). This honey bee intensely and exclusively foraged for nectar. The mean foraging speed was 12.56 ± 5.79 flowers per minute. Flowers visited by insects had higher fruiting rate compared with the others while those bagged had the lowest. *Apis mellifera adansonii* foraging resulted to a significant increment in fruiting rate by 14.14 and 11.98%, as well as the number of seeds per pod by 36.95 and 35.65%, and the percentage of normal seeds by 32.61 and 29.26% respectively in 2010 and 2011. The installation of *A. m. adansonii* colonies in *G. max* plantations is recommended to improve pod and seeds production of this species.

Keywords:

Apis mellifera adansonii, *Glycine max*, flower, visit, nectar, pollination.

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

Dates:
Received: 15 Jan 2014 **Accepted:** 04 Feb 2014 **Published:** 11 April 2014

This article is governed by the Creative Commons Attribution License (http://creativecommons.org/licenses/by/2.0), which gives permission for unrestricted use, non-commercial, distribution and reproduction in all medium, provided the original work is properly cited.

Journal of Research in Biology

INTRODUCTION

Glycine max is an annual plant originated from Northern and Central regions of China (Hymowitz, 1970). The plant is an annual, herbaceous, erect, and can reach a height of 1.5m; there are cultivars of soybean indeterminate, determinate and semi-determinate growth (Gallais and Bannerot, 1992). The first leaves are simple, opposite and swallowed, while the following are trifoliate and alternate; the pod is straight or slightly curved, with a length of two to seven cm; the seed is generally oval, but may vary depending on the cultivar, almost spherical, elongated and flattened (Hymowitz and Harlan, 1983). Flowers are grouped by two to eight on a short racemes inserted on the stem axile sheets and are purple or white (Boyeldieu, 1991). Each flower has a tubular calyx of five sepals, a corolla of five petals, a single carpel and ten stamens, nine of which being welded and the tenth is free (Hymowitz and Harlan, 1983). Each flowers Produce nectar and pollen which attract insects (Milfont *et al.*, 2013). The reproduction system is autogam/allogam (Ibarra-Perez *et al.*, 1999). Soybean is grown primarily for its seeds, which have many uses in the food and industrial sectors (USDA, 2002). It is a major edible oil and vegetable sources of protein (38-40%) for the feed of men and other animals (Boyeldieu, 1991; Tien *et al.*, 2002; USDA, 2002). Currently the production of *G. max* in Cameroon is low whereas the demand for seeds is high (MINADER, 2010). Therefore, it is important to investigate on the possibilities of increasing the production of this plant in the country. This can be done if flowering insects of *G. max* in each region are well known and exploited (Milfont *et al.,* 2013). Unfortunately no research has been reported on the relationships between *G. max* and its anthophilous insects in Cameroon. In Maroua *A. m. adansonii* visit flowers of *G. Max* (unpublished data), and this study is carried out to assess the effects of foraging activities of *A. m. adansonii* on yields of *G. max.*

MATERIALS AND METHODS

Study site, experimental plot and biological material

The experimental is carried, from June to October, in 2010 and 2011 at Mayel-Ibbé (Latitude 10° 62' N, Longitude 14°33' E and altitude 400 m), Maroua, Far North Region of Cameroon. This Region belongs to the Savanna zone, with unimodal rainfall (Letouzey, 1985). It has a Sahel-Sudanian climate type, characterized by two seasons: a more extended dry season (November to May) and a brief rainy season (June to October) (Kuete *et al.*, 1993). The maximum rainfall and temperature are 1100mm and 38°C respectively (Kuete *et al.*, 1993). The experimental plot was 28m x 5m. The biological material was represented by *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae), and others insects present in the environment. Seed of *G. max* was provided by the Institute of Agricultural Research for Development (IARD).

Sowing and weeding

On the June 12, 2010 and June 15, 2011, the experimental plot was cleaned and divided into 24 subplots, each measuring 1m × 1m. Sowing and weeding was done as described by Douka and Tchuenguem (2013).

Determination of the reproduction system of *Glycine max*

On July 22, 2010, eight subplots carrying 106 plants with 34395 flowers at the bud stage were labeled. Four subplots carrying 80 plants with 17187 flowers were left to be open pollinated (treatment 1) (figure 1) and four subplots carrying 17208 flowers were protected with gauze mesh prevent to insect or other pollinating animals visits (treatment 2) (figure 2). On July 28, 2011, the experiment was repeated, for treatment 1 four subplots carrying 80 plants with 17866 flowers and four treatment 2 four subplots carrying 80 plants with 15875 flowers.

Twenty days after shading of the last flower, the number of pods was assessed in each treatment.

Figure 1. *Glycine max* plot showing unprotected plants in bloom.

Figure 2. *Glycine max* plot showing isolated plants in bloom.

The podding index (P_i) was then calculated as described by Tchuenguem *et al.,* (2004): $P_i = F_2/F_1$, where F_2 is the number of pods formed and F_1 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 1 (unprotected flowers) and treatment 2 (bagged flowers) as follows (Demarly, 1977):

$Alr = [(P_{i1} - P_{i2}) / P_{i1}] \times 100,$ Where P_{i1} and P_{i2} are respectively the podding average indexes of treatments I and II. Atr = *100 – Alr.*

Study of the foraging activity of *Apis mellifera adansonii* on *Glycine max* flowers

The frequency of *A. m. adansonii* in the flowers of *G. max* was determined based observations on flowers of treatments 1 in 2010 and 2011. Experience were made on 17187 individual opened pollinated flowers (treatment 1) each day, from July 26 to August 20, 2010 and from August 2, to August 24, 2011 at 7 – 8 h, 9 – 10 h, 11 – 12 h, 13 – 14 h, 15 – 16 h and 17 – 18 h. Capture and determination of insects that visited *G. max* flowers was realize as described by Borror and White (1991).

The determination of the relative frequency of all insects visit the *G. max* flowers was calculated (Tchuenguem, 2005).

During the same time that *A. m. adansonii* encountered on flowers were registered, the types of floral products collected by this bee were noted. This parameter was measured to determine if *A. m. adansonii* is strictly a pollenivore, nectarivore or pollenivore and nectarivore. This could give an idea on its implication as a cross pollinator of *G. max*.

In the morning of each day, the number of opened flowers was counted. The determination of frequency of visits, the duration of *A. m. adansonii* on the flower of *G. max* was recorded according to Tchuenguem (2005). The number of pollinated visits, the abundance of foragers, the number of flowers visited by *A. m. adansonii* per minute was recording every day of observation. The method of observation was followed as given by Tchuenguem *et al.,* (2004).

The foraging speed was calculated according to Jacob – Renacle (1989) by this formula: Vb = (*Fi/di*) x 60 where *di* is the time (s) given by a stopwatch and *Fi* is the number of flowers visited during *di.* The interaction between *A. m. adansonii* and the competitors and the attractiveness exerted by the flower of other plant species around the experimental plot on *A. m. adansonii* were recorded (Tchuenguem *et al.,* 2004). The climatic factor (temperature and humidity) was registered as described by Douka and Tchuenguem (2013).

Evaluation of the impact of *Apis mellifera adansonii* and other insects on *Glycine max* yields

This evaluation was based on the impact of visiting flowers on pollination, the impact of pollination on fructification of *G. max*, and the comparison of yields [fruiting rate, mean number of seeds per pod and percentage of normal (well developed) seeds] of treatments 1 and 2. The fruiting rate due to the activity of insects (Fr_i) was calculated as follows by Tchuenguem *et al.,* (2004): $Fr_i = \{[(Fr_1 – Fr_2) / Fr_1] \times 100\}$

Where Fr_1 and Fr_2 are the fruiting rate in treatments 1 and 2.

The fruiting rate (Fr) is: $Fr = [(F_2/F_1) \times 100]$

Where F_2 is the number of pods formed and F_1 the number of flowers initially set.

At maturity, pods were harvested from each treatment. The mean number of seeds per pod and the percentage of normal seeds were then calculated for each treatment.

Evaluation of the pollination efficiency of *Apis mellifera adansonii* on *Glycine max*

In 2010, along with the development of treatment 1 and 2, 11 plants belonging to four subplots and carrying 47 flowers were protected using gauze mesh (treatment 3). In 2011 the same experience was repeated but on 16 plants carrying 51 flowers. Between 7 and 9am, of each observation date, the evaluation or the efficiency pollination of *A. m. adansonii* on *G. max* was realized as according of Douka and Tchuenguem (2013). The impact (Fr_x) of *A. m. adansonii* to fruiting rate was calculated as follows by Tchuenguem *et al.,* (2004) the formula:

$$Fr_x = \{[(Fr_3 – Fr_2) / Fr_3] \text{ x } 100\}$$

Where Fr_3 and Fr_2 are the fruiting rates in treatment 3 (protected flowers visited exclusively by *A. m. adansonii*) and treatment 2 (protected flowers). The number of seeds per pod, the percentage of normal seeds (well developed) was then calculated for each treatment 3.

Data analysis

Data were analyzed using descriptive statistics, student's *t*-test for the comparison of means of the two samples, correlation coefficient (*r*) for the study of the association between two variables, chi-square ($\chi2$) for the comparison of two percentages using SPSS statistical software and Microsoft Excel.

RESULTS

Reproduction system of *Glycine max*

According to table 2 : the allogamy rate was 6.59% and 5.38% respectively in 2010 and 2011 and autogamy rate was 93.41% and 94.62% respectively in 2010 and 2011. *Glycine max* (used in our experiments) has a mixed reproduction system autogamous - allogamous, with the predominance of autogamy.

Frequency of *A. m. adansonii* in the floral entomofauna of *Glycine max*

Among the 532 and 422 visits of 24 and 24 insect species counted on *G. max* flower in 2010 and 2011, respectively, *A. m. adansonii* was the most represented insect with 132 visits (24.81 %) and 91 visits (21.56 %), in 2010 and 2011, respectively. The difference between these two percentages is not significant ($\chi2$ = 1.39, df = 1, p > 0.05) (Table 1). In 2010, the highest mean number of *A. m. adansonii* simultaneously in activity was one per flower (n = 50; s = 0) and 2.88 per 1000 flowers (n = 60; s = 3.53; *maxi* = 19). In 2011, the corresponding figures were one per flower (n = 50; s = 0) and 1.97 per 1000 flowers (n = 60; s = 2.59; *maxi* = 12). The difference between the mean number of foragers per 1000 flowers in 2010 and 2011 was highly significant (t = 9.19; df = 118, p < 0.001).

Activity of *Apis mellifera adansonii* on *Glycine max*

Floral reward harvested

During each of the two flowering periods, *A. m.*

Figure 3. ***Apis mellifera adansonii*** **collecting nectar in a flower of** ***Glycine max***

adansonii was found to collect nectar intensively and exclusively (Figure 3).

Relationship between visits and flowering stages

Visits were most numerous when the number of open flowers was highest (Figure 4) Furthermore a positive and significant correlation was found between the number of *G. max* opened flowers and the number of *A. m. adansonii* visits in 2010, as well as 2011 (r_{2010} = 0.90; df = 8; $p < 0.05$; r_{2011} = 0.85; df = 8; $p <$ 0.05). *Apis mellifera adansonii* foraged on *G. max* flowers throughout the blooming period, with a peak of activity situated between 10 and 11am (Figure 5).

Duration of visits per flower

In 2010 and 2011, the mean duration of *A. m. adansonii* visit is 2.50 sec (n = 132; s = 1.34; *maxi* = 6 sec) and 2.61 sec (n = 91; s = 1.40; *maxi* = 6 sec) respectively. The difference between the duration of the visit in 2010 and 2011 is higher significant (t = 22.25; df = 221, $p < 0.001$). For the two cumulated years, the mean duration of a flower visit were 2.55 sec.

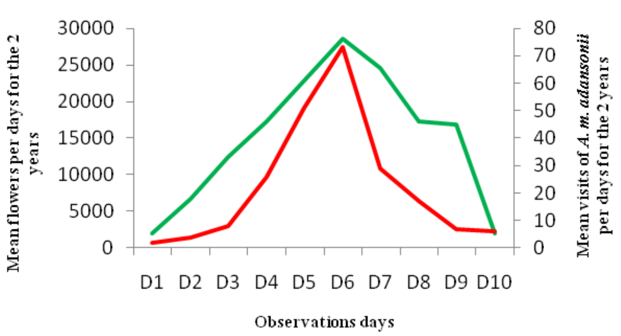

Figure 4: Variation of number of flowers and number of visits of ***Apis mellifera adansonii*** **on the flowers of** ***Glycine max*** **in 2010 and 2011.**

Foraging speed of ***Apis mellifera adansonii*** **on** ***Glycine max*** **flowers**

On the pot of *G. max*, *A. m. adansonii* visited between 4 and 24 flowers/min in 2010 and between five and 25 flowers/min in 2011. The mean foraging speed was 11.65 flowers/min (n = 50; s = 5.77) in 2010 and 13.48 flowers/min (n = 50; s = 5.82) in 2011. The difference between these means is highly significant (t = - 7.95; df = 98, $p < 0.001$). For the two cumulated years, the mean foraging speed was 12.56 flowers /min.

Effect of climate on foraging activity of ***Apis mellifera adansonii*** **on** ***Glycine max*** **flowers**

Climatic condition seem not to influence the activity of *A. m. adansonii*. The correlation was negative and not significant (r_{2010} = - 0.34; df = 11; p > 0.05 and r_{2011} = 0.28; df = 11; $p > 0.05$) between the number of *A. m. adansonii* visits on *G. max* flowers and the temperature. It was positive and not significant (r_{2010}= 0.48; df = 11; $p > 0.05$ and r_{2011}= 0.07; df = 11; $p > 0.05$) between the number of *A. m. adansonii* visits and relative humidity (Figure 6).

Impact of anthophilous insects on pod formation and seed yields of ***Glycine max***

During nectar harvest on *G. max,* foraging insects always shook flowers and are regularly in contact

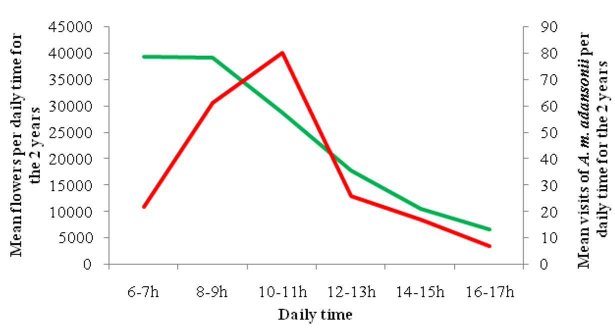

Figure 5. Variation of number of flowers and visits of ***Apis mellifera adansonii*** **on the flowers of** ***Glycine max*** **according to daily time in 2010, 2011.**

with the anthers and stigma (Figure 3), increasing cross pollination possibility of *G. max* fruiting rate, number of seeds per pod and percentage of normal seeds in different treatments (Table 2).

a - The difference observed was highly significant between fruiting rate of free opened flowers (treatment 1) and that of bagged flowers (treatment 2), the first year ($\chi2$ = 248.73, *df* = 1, $p < 0.001$) and the second year ($\chi2$ = 299.84, *df* = 1, $p < 0.001$). The fruiting rate of treatment 1 (unprotected flowers) was higher than treatment 2 (protected flowers) in 2010 and in 2011. The fruiting rate due to the action of insects was 5.92 and 5.81% in 2010 and 2011 respectively. For the two cumulated years, the fructification rate due to the influence of insects was 5.86%.

b - For the mean number of seeds per pod, there was a highly significant difference between treatments 1 and 2 (t_{2010} = 4315.78; *df* = 30462; $p < 0.001$; t_{2011} = 5958.33; *df* = 30670; $p < 0.001$). Consequently, a high mean number of seeds per pod in treatment 1 (opened flowers) were noticed compared to treatments 2 (bagged flowers). The number of seeds per pod attributed to the activity of insects was 26.11% in 2010 and 36.47% in 2011, giving an overall mean of 31.29%.

c - There was a highly significant difference between the percentage of normal seed of treatment 1 and that of treatment 2 in the first year ($\chi2$ = 4329.98; *df* = 1; $p < 0.0001$) as well as the second year ($\chi2$ = 6094.38; *df* = 1; $p < 0.0001$). Thus, the percentage of normal seeds in opened flowers was higher than that of protected flowers in 2010 and 2011. The percentage of the normal seeds due to the action of insects was 24.81% in 2010 and 20.90% in 2011. For all the flowers studied, the percentage of the normal seeds due to flowering insects was 22.85%.

Pollination efficiency of *Apis mellifera adansonii* on *Glycine max*

Apis mellifera adansonii foragers were always in contact with the stigma and the anthers of *G. max* (contacts with anthers and stigma was 100% for all visits). Consequently this bee increased possibilities of the pollination of *G. max* flowers.

a - the difference observed between the fruiting rate of treatments 2 and that of treatment 3 was highly significant in 2010 ($\chi2$ = 7.73; *df* = 1; $p < 0.001$) as well as 2011 ($\chi2$ = 6.93; *df* = 1; $p < 0.001$). The fruiting rate of flowers exclusively visited by *A. m. adansonii* (treatment 3) was higher than those of bagged flowers (treatment 2). The fruiting rate due to *A. m. adansonii* activity was 14.14% and 11.98% respectively in 2010 and 2011. The percentage of the fruiting rate due to *A. m. adansonii* activity was 13.06 %

b - There was a highly significant difference between treatments 2 and 3 (t = 64.76; *df* = 14821; $p < 0.001$) the first year and the second year (t = 49.28; *df* = 14023; $p < 0.001$). High mean number of seeds per pod of flowers of treatment 3 was noticed compared to flowers of treatment 2. The augmentation of the number of seeds per pod due to *A. m. adansonii* was 36.95% and

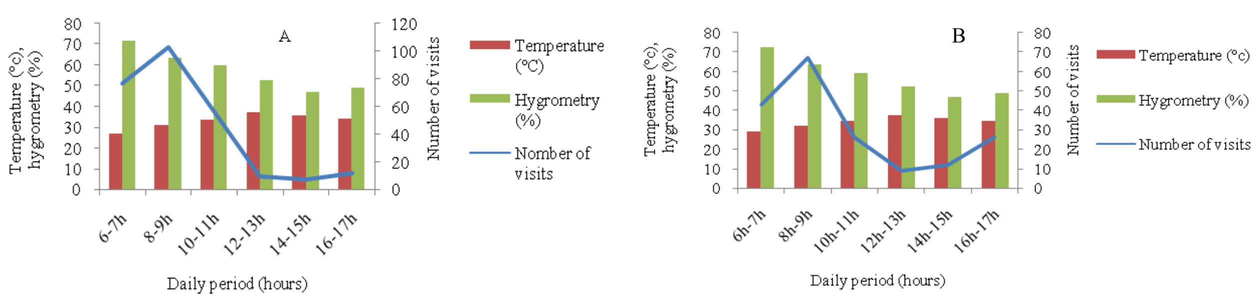

Figure 6. Daily distribution of *A. m. adansonii* visits on 17187 and 17866 *G. max* flowers over 10 days in 2010 (A) and 10 days in 2011 (B) respectively, mean temperature and mean humidity of the study site.

Table 1. Diversity of floral insects on *Glycine max* in 2010 and 2011, number and percentage of visits of different insects

Insects			2010		2011	
Order	Family	Genus, species, sub-species	n_1	p_1%	n_2	p_2%
Hymenoptera	Apidae	*Apis mellifera adansonii* [n]	132	24.81	91	21.56
		Amegilla sp. 1 [n]	4	0.75	0	0
		Xylocopa sp. 1 [n]	3	0.56	1	0.24
	Halictidae	*Macronomia vulpina* [n]	87	16.35	51	12.09
		Lipotriches collaris [n]	56	10.53	49	11.61
	Megachilidae	*Chalicodoma* sp.1 [n]	13	2.44	2	0.47
		Megachile sp. 1 [n]	3	0.56	1	0.24
		Megachile sp. 2 [n]	0	0	4	0.95
	Formicidae	*Polyrachis* sp. 1 [sh]	79	14.85	62	14,69
	Vespidae	*Synagris cornuta* [n]	11	2.07	4	0.95
		(1 sp.) [n]	1	0.19	0	0
	Sphecidae	*Philanthus triangulum* [pr]	6	1.13	2	0.47
		(1 sp.) [pr]	1	0.19	0	0
Lepidoptera	Pieridae	*Catopsilia florella* [n]	28	5.26	29	6.87
		(sp. 1) [n]	17	3.20	8	1.90
		(sp. 2) [n]	12	2.26	3	0.71
	Nymphalidae	(1 sp.) [n]	19	3.57	23	5.45
	Acraeidae	*Acraea acerata* [n]	13	2.44	17	4.03
Diptera	Muscidae	*Musca domestica* [n]	26	4.89	49	11.61
	Drosophilidae	*Drosophila* sp. 1 [n]	12	2.26	8	1.90
	Syrphidae	(1 sp.) [n]	2	0.38	3	0.71
	Calliphoridae	(1.sp.) [n]	3	0.56	0	0
Hemiptera	Coreidae	*Anoplocnemis curvipes* [n]	1	0.19	1	0.24
	Pyrrhocoridae	*Dysdercus voelkeri* [n]	1	0.19	2	0.47
Orthroptera		(sp.1) [lv]	0	0	5	1.18
		(sp.2) [lv]	0	0	2	0.47
Nevroptera		(sp.1) [pr]	2	0.38	1	0.24
		(sp.2) [pr]	0	0	4	0.95
Total		28 species	532	100	422	100

Comparison of percentages of *Apis mellifera adansonii* visits for two years: $\chi 2 = 1.39$ ([$df = 1$; $P > 0.05$]).
n_1: number of visits on 17187 flowers in 10 days.
n_2: number of visits on 17866 flowers in 10 days.
p_1 and p_2: percentages of visits.
$p_1 = (n_1 / 532) \times 100$.
$p_2 = (n_2 / 422) \times 100$.
n: Visitor collected nectar.
lv: Visitor eating leaves.
sh: visitor shelter
pr: Predation.
sp.: Undetermined species.

35.65% respectively in 2010 in 2011. The percentage of the mean number of seeds per pod attributed to the activity of *A. m. adansonii* was 36.30%.

c - There was highly significant difference between the percentage of normal seed of treatment 3 and that of treatment 2 in first year ($\chi 2$ = 67.76; df = 1; p < 0.001) as well as the second year ($\chi 2$ = 58.58; df = 1; p < 0.001). The percentage of normal seeds in treatment 3 was higher than in treatment 2. The percentage of the normal seeds due to *A. m. adansonii* was 32.61% in 2010 and 29.26% in 2011. The percentage of the number of seeds per pod attributed to the activity of *A. m. adansonii* was 30.93%.

DISCUSSION

Honey bee was the main floral visitor of *G. max* during the observation period. This bee has been reported as the main floral visitor of this Fabaceae in USA (Rortais *et al*., 2005) and Brazil (Milfont *et al*., 2013). *Apis mellifera adansonii* was also shown to be the most abundant floral visitors of other Fabaceae members such as *Phaseolus coccineus* in Yaoundé, Cameroon (Pando *et al*., 2011a), and *Phaseolus vulgaris* in Ngaoundéré, Cameroon (Kingha *et al*., 2012) and in Maroua by Douka and Tchuenguem (2013). The significant difference between the percentages of *A. m. adansonii* visits for the two studied years could be attributed to the variation of the number of colonies of this honey bee around the experimental site. The peak of activity of *A. m. adansonii* on *G. max* flowers was at between 10 and 11am, which correlated to the period of highest availability of nectar on *G. max* flowers. The positive and highly significant correlation between the number of *G. max* flowers and the number of *A. m. adansonii* visits indicates the attractiveness of *G. max* nectar with respect to this bee. The significant difference observed between the duration of visits in 2010 and 2011 could be attributed to the availability of nectar, the floral morphology of this crop or the variation in the diversity of flowering insects from one year to another. At Maroua in 2010 and 2011 (in the rainy season), *A. m. adansonii* intensely and regularly harvested nectar on the flowers of *G. max* during flowering periods. This could be attributed to the needs of colonies during the flowering period. During our investigations, the interruption of visits by other insects or the same honey bee reduced the duration of *A. m. adansonii* visits. Similar results were found in Cameroun by Tchuenguem *et al.,* (2009b) and Douka and Tchuenguem (2013) on flowers of *Vigna unguiculata* (L.) (Fabaceae) and *Phaseolus vulgaris* (Fabaceae) respectively. It indicates that *A. m. adansonii* can increased the possibility of pollination of *G. max* flowers. During the collection of

Table 2. *Glycine max* yields under pollination treatments.

Treatment	Year	Flowers	Pods	Fruiting rate	Seeds / Pod		Total seeds	Normal seed	% normal seed
					Mean	sd			
Unlimited visits	2010	17187	15688	91.28%	3.14	1.42	48853	42609	87.22
Protected plot	2010	17208	14776	85.87%	2.32	1.01	34162	22415	65.61
Protected plot	2011	17866	16697	93.46%	3.92	2.06	66020	57137	86.54
Bagged flowers	2011	15875	13974	88.03%	2.49	1.52	63176	43250	68.46
A. m. adansonii	2010	47	47	100.00%	3.68	1.84	152	148	97.37
A. m. adansonii	2011	51	51	100.00%	3.87	1.88	217	201	92.63

nectar, *A. m. adansonii* foragers regularly come into contact with the stigma and carry the pollen to the anthers for stigma. The weight of *A. m. adansonii* shoot the flowers of *G. max* during nectar collection and this movement played a positive role in liberation of pollen by anthers for the optimal occupation of the stigma. This phenomenon was also reported by Ahrent and Caviness (1994) and Rortais *et al.,* (2005) on *G. max.* Thus in addition to their direct pollination role, *A. m. adansonii* foragers also indirectly effected self-pollination and cross-pollination of *G. max* flowers. The positive and significant contribution of *A. m. adansonii* in pods, seed yields and percentage of normal seeds of *G. max* is justified by the action of this bee on pollination. The similar have been obtain in Britain (Kendall and Smith, 1976) on *Phaseolus coccineus* (Fabaceae), USA (Ibarra-Perez *et al.*, 1999) on *Phaseolus coccineus* (Fabaceae), Ngaoundéré (Cameroon) (Kingha *et al.*, 2012) on *Phaseolus vulgaris* (Fabaceae), Maroua (Cameroon) (Douka and Tchuenguem, 2013) on *Phaseolus vulgaris* (Fabaceae) and Brazil (Milfont *et al.*, 2013) on *G. max* who showed that these plants species produce fewer seeds per pod in the absence of efficient pollinators. The higher percentage of pods, seeds and normal seeds in the treatment with unlimited visits or treatment visiting exclusively by *A. m. adansonii* compared to treatment with protected, showing that insect visits were effective in increasing cross-pollination or self- pollination. Our results confirmed those of Caviness (1970), Ahrent and Caviness (1994), Rortais *et al.,* (2005) and Milfont *et al.,* (2013) who revealed that *G. max* flowers set little pods in the absence of insect pollinators. Similar experiments on crop species realized in England (Free, 1966) and in Brazil (Free, 1993) have shown that pollination by insects was not always needed. Woodworth (1922) showed that self-pollination of *G. max* flowers produced as many pods and seeds as exposed plants. Thus, pollination requirements may differ between plant varieties and /or region.

CONCLUSION

This study reveals that the variety of *G. max* studied is a nectariferous bee plant that obtained benefits from the pollination by insects among which *A. m. adansonii* is the must important. The comparison of pods and seeds set of unprotected flowers with that of flowers visited exclusively by *A. m. adansonii* underscores the value of this bee in increasing pods and seed yields as well as seed quality. The installation of *A. m. adansonii* colonies to *G. max* fields should be recommended for the increase of pod and seeds yields of this valuable crop.

REFERENCES

Ahrent DK, Caviness CE. 1994. Natural cross-pollination of twelve soybean cultivars in Arkansas. Crop. Sci. 34 (2): 376-378.

Borror DJ, White RE. 1991. Les insectes de l'Amérique du Nord (au nord du Mexique). Broquet (ed.), Laprairie. p. 408.

Boyeldieu J. 1991. Produire des grains oléagineux et protéagineux. Ed. Tec et Doc/Lavoisier Col. Agriculture d'aujourd'hui. 115 - 152

Caviness CE. 1970. Cross-pollination in the soybean. In : The indispensable pollinators, Ark. Agr. Ext. Serv. Misc. Pub. 127: 33-36.

Demarly Y. 1977. Genetic and amelioration of plants. Masson, Paris. p. 577.

Douka C, Tchuenguem FF-N. 2013. Foraging and pollination behavior of *Apis mellifera adansonii* L. (Hymenoptera, Apidae) on *Phaseolus vulgaris* (Fabaceae) flowers at Maroua (Cameroon). International Research Journal of Plant Science 4(2): 45-54.

Free JB. 1966. The pollination of the beans *Phaseolus multiflorus* and *Phaseolus vulgaris* by honeybees. J. Apicult. Res. 5: 87-91.

Free JB. 1993. Insect pollination of crops. Academic Press. p. 544

Freitas BM. 1997. Number and distribution of cashew (*Anacardium occidentale*) pollen grains on the bodies of its pollinators, *Apis mellifera* and *Centris tarsata*. J. Apicul. Res. 36 (1): 15-22.

Gallais A, Bannerot H. 1992. Amélioration des espèces végétales cultivées. INRA, Paris.p.768.

Hymowitz T. 1970. On the domestication of the soybean. Econ. Bot. 24 (4): 408-421.

Hymowitz T, Harlan JR. 1983. Introduction of soybean to North America by Samuel Bowen in 1765. Econ. Bot. 37 (4): 371-379.

Ibarra-Perez FJ, Barnhart D, Ehdaie B, Knio KM, Waines JG. 1999. Effects of insect tripping on seed yield of common bean. Crop Sci. 39 (2): 428-433.

Jacob-Remacle A. 1989. Comportement de butinage de l'abeille domestique et des abeilles sauvages dans des vergers de pommiers en Belgique. Apidologie. 20 (4): 271-285.

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

Kuete M, Melingui A, Mounkam J, Nofiele D. 1993. Nouvelle géographie du Cameroun. EDICEF, Paris. p. 207.

Kingha BMT, Tchuenguem FF-N, Ngakou A, Brückner D. 2012. Foraging and pollination activities of *Xylocopa olivacea* (Hymenoptera, Apidae) on *Phaseolus vulgaris* (Fabaceae) flowers at Dang (Ngaoundere-Cameroon) J. Agric. Extension and Rural Development. 4 (10): 330-339.

Letouzey R. 1985. Notice de la carte phytogéographique du Cameroun au 1/500000. Inst. Carto. Intern. Végétation, Toulouse et Inst. Rech. Agron., Yaoundé.

Milfont MO, Rocha EEM, Lima AON, Freitas BM. 2013. Higher soybean production using honeybee and wild pollinators, a sustainable alternative to pesticides and autopollination. *Environ. Chem. Lett.* 11(4) :335-341. Doi 10.1007/s10311-013-0312 .8.

Minader. 2010. Annuaire des Statistiques du Secteur Agricole, Campagnes 2007 & 2008. Direction des Enquêtes et des Statistiques, Agricoles. AGRI-STAT Cameroun n° 16, p.98.

Pando JB, Tchuenguem FF-N, Tamesse JL. 2011a. Foraging and pollination behaviour of *Xylocopa calens* Lepeletier (Hymenoptera: Apidae) on *Phaseolus coccineus* L. (Fabaceae) flowers at Yaoundé (Cameroon). Entomol. Res. 41(5): 185-193.

Rortais[a] A, Arnold[a] G, Halm[b] MP, Touffet-Briens[b] F. 2005. Modes of honeybees exposure to systemic insecticides: estimated amounts of contaminated pollen and nectar consumed by different categories of bees. Apidologie., 36 (1): 71-83).

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

Tchuenguem FF-N, Ngakou A, Kengni BS. 2009b. Pollination and yield responses of cowpea (*Vigna unguiculata* L. Walp.) to the foraging activity of *Apis* *mellifera adansonii* (Hymenoptera: Apidae) at Ngaoundéré (Cameroon). Afr. J. Biotechnol. 8 (9): 1988-1996.

Tien HH, Hien TM, Son MT, Herridge D. 2002. Rhizobial Inoculation and N_2 fixation of soybean and mungbean in the Eastern region of South Vietnam. In" inoculants and nitrogen Fixation of legumes in Vietnam". Edited by D. Herridge. ACIAR proceedings 109[e].

USDA. 2002. Oilseeds : World markets and trade. Foreign Agricultural Service. Circular series FOP.

Woodworth CM. 1922. The extent of natural cross-pollination in soybeans. Jour. Amer. Soc. Agron. 14: 278-283.

Submit your articles online at www.jresearchbiology.com

Advantages

- Easy online submission
- Complete Peer review
- Affordable Charges
- Quick processing
- Extensive indexing
- You retain your copyright

submit@jresearchbiology.com

www.jresearchbiology.com/Submit.php.