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Foraging and pollination activities of *Apis mellifera adansonii* Latreille (Apidae) on *Syzygium guineense* var. *guineense* (Myrtaceae) flowers at Ngaoundéré (Cameroon)

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1 SUMMARY

To estimate the apicultural value and evaluate the impact of *Apis mellifera adansonii* (Hymenoptera: Apidae) on the fruit yield of *Syzygium guineense* var. *guineense* (Myrtaceae), bee foraging and pollination activities on flowers were observed in Ngaoundéré, in the gallery forests of Tchabal-Bambi and Béka, for two seasons (February - March, 2006 and 2007). One hundred and twenty and 200 flower clusters subdivided in two lots based on the presence or absence of protection of flower clusters from insects using gauze bags. The seasonal rhythm of bee visits, the daily activity of workers, the abundance of foragers on 1000 flowers, the fruiting index of labelled flower clusters were also evaluated. Results indicate that *A. m. adansonii* visited *S. g.* var. *guineense* the whole day and during all the flowering period. Each year, foragers harvested nectar permanently and intensively. The rhythm of the bee's visits was positively correlated with the flowering rhythm of the Myrtaceae. The greatest mean number of workers foraging simultaneously was 256 per 1000 flowers. Data obtained suggest that *S. g.* var. *guineense* is a highly nectariferous apicultural plant. The fructification index of the unprotected flower clusters was significantly higher than that of flower clusters protected from insects. *A. m. adansonii* foraging resulted to a significant increment of the fruiting by 50% in 2006 and 32.9% in 2007. Installation of honeybee colonies close to the population of *S. g.* var. *guineense* is recommended to improve fruit and honey production in the region.

2 INTRODUCTION

The honey bee *Apis mellifera* eats mainly nectar and pollen that workers harvests on the flowers (Crane & Walker, 1984; Weidenmüller & Tautz, 2002). This bee produces the highest quantities of honey in the world (Pesson & Louveaux, 1984; Tchuenguem Fohouo et al., 2008). The productivity of the honey bee colonies is proportional both to the abundance and attractiveness of the nectariferous and polliniferous plants present in the environment of the apiary (Williams & Carreck, 1994; Van't Leven et al., 2005).

Not much data on the relationship between honey bees and plants growing in Cameroon exists (Tchuenguem Fohouo, 2005; Tchuenguem Fohouo et al., 2008). Yet, it is known that anthophilous insects in general and particularly the honey bees *A. mellifera* increase

the outputs in fruits and seeds of several plant species, via flower pollination during their foraging activities (Philippe, 1991; Tchuenguem Fohouo et al., 2004, 2007, 2008, 2009a and 2009b; Tchuenguem Fohouo, 2005; Fluri & Frick, 2005; Sabbahi et al., 2005; Fomekong et al., 2008).

To our knowledge, the results published after deepened studies on the relationship between *Syzygium guineense* var. *guineense* and *A. m. adansonii* in Cameroon are those made at Dang (village of Ngaoundéré) by Tchuenguem Fohouo et al. (2008). These studies reveal that: a) the Myrtaceae is greatly nectariferous and can permit to increase honey production; b) *A. m. adansonii* increases the possibilities of plant pollination during foraging via numerous contacts with anthers and stigmas. These studies don't treat the impact of the pollination by these bees on the outputs of *S. g.* var. *guineense* fruits (figure 1) which are scarce and highly consumed by human populations of its area of distribution and provide them with additional incomes via the sale. Besides, the apicultural value of a plant species can vary with the localities (Segeren et al., 1996).

The objective of this research is to contribute to the mastery of the relationship between *S. g.* var. *guineense* and honey bees for their optimal management.

The specific objectives was: (a) the registration of *A. m. adansonii* foraging activities on flowers of *S. g.* var. *guineense*; (b) the evaluation of the apicultural value of this plant; (c) the assessment of the effects of the pollination by *A. m. adansonii* on fruit yields of *S. g.* var. *guineense*.

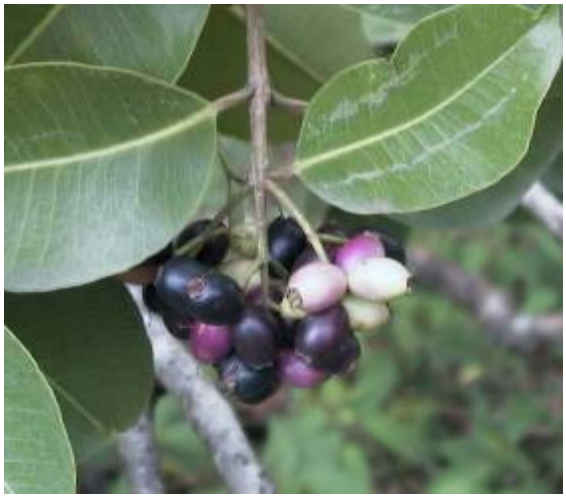

Figure 1: Fruiting stage of *Syzygium guineense* var. *guineense*.

3 MATERIALS AND METHODS

3.1 Site and biological material: This study was conducted from February to March, of 2006 and 2007, in the gallery forests situated between Tchabal-Bambi and Béka, villages of Ngaoundéré in the Adamawa region in Cameroon. This region belongs to the high altitude Guinean savannah agro-ecological zone (Tchuenguem Fohouo et al., 2007). The climate is characterized by two seasons: a rainy season (April to October) and a dry season (November to March). The annual rainfall is about 1500 mm. The mean annual temperature is 22 °C. The mean relative humidity is 70% (Tchuenguem Fohouo et al., 2007). The plants chosen for observation were located on an area of 3000 m in diameter centred on a cylindrical traditional hive with two openings inhabited by *A. m. adansonii*. The hive is located at the latitude 7°31.557'N, the longitude 13°33.645'E and the altitude 1258 masl. The number of *A. m. adansonii* colonies located in this area was 73 in February 2006, 94 in March 2006, 47 in February 2007 and 52 in March 2007. Vegetation was represented by the native plants

species of the savannah and the gallery forests. The number of plants of *S. g.* var. *guineense* blooming was 217 in 2006 and 323 in 2007.

3.2 Methods

3.2.1 *Determination of the reproduction system of S. g. var. guineense:* Before this study, no data on this parameter existed in the literature. In 2006, February 1st, 120 flower clusters of *S. g.* var. *guineense* which the flowers were to the bud stage were marked and two lots were constituted: - lot 1 made of 60 free flower clusters; - lot 2 made of 60 flower clusters protected from insects using gauze bags. In 2007, February 9th, 200 flower clusters to the bud stage were marked and two lots were constituted: - lot 3 made of 100 flower clusters; - lot 4 made of 100 flower clusters protected from insects using gauze bags. Each season, ten days after the last flower faded, the number of fruits formed by each marked flower cluster was counted and the capacity of trees to bear fruits estimated using the fraction [number of fruits formed/number of viable flowers initially set].

This fraction, which corresponds to the fruiting index (I_{fr}) (Tchuenguem Fohouo et al., 2001) and which was calculated for each flower cluster, was use for the comparison of fruit yields of different lots.

The allogamy rate (TC) was calculated using the formula: $TC = \{[(I_{fr}X - I^{fr}Y) / I_{fr}X] \times 100\}$, where $I_{fr}X$ and $I_{fr}Y$ are the mean fruiting indexes of the free lot and the protected lot respectively (Demarly, 1977). The autogamy rate (TA) was calculated by the formula: $TA = \{100 - TC\}$.

In 2006, two more lots were added: - lot 5: 10 flower clusters which the number of flower buds was reduced to four, then emasculated and bagged; - lot 6: 10 flower clusters which the number of flower buds was reduced to four, then emasculated and pollinated manually was before being bagged. In 2007, two supplementary lots were added: - lot 7: 10 flower clusters which the number of flower buds was reduced to four, then emasculates and bagged; - lot 8: 10 flower buds which the number of flower buds was reduced to four, then emasculated and pollinated manually before being bagged. Each season, 17 days after the emasculation, the number of fruits formed by each flower cluster was counted and the fruiting index was calculated. The comparison of fruit yields of these last four lots permitted to evaluate the impact of pollination on fruiting of the Myrtaceae.

3.2.2 *Study of the foraging activity of A. m. adansonii on the S. g. var. guineense flowers*: The observations were done on the 150 flower clusters of lots 1 and 3, from the opening of the first flower bud (2nd February 2006 and 10th February 2007) to the fading of the last flower (28th February 2006 and 2nd March 2007), during at least five days per week. This was done in six hourly periods: 6 - 7 h, 8 - 9 h, 10 - 11 h, 12 - 13 h, 14 - 15 h and 16 - 17 h. The identity of all insects that visited *S. g.* var. *guineense* flowers was recorded. Specimens of all insect taxa were caught with an insect net on unlabelled flower clusters and conserved 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 *S. g.* var. *guineense* (Tchuenguem Fohouo, 2005).

The floral products (nectar or pollen) harvested by this bee during each floral visit were registered based on its foraging behaviour, during the same dates and the same daily periods as for the counting of insects. The duration of floral visits, the foraging speed (number of flowers visited per minute: Jacob-Remacle, 1989) and the abundance of workers per 1000 flowers (greatest number of individuals foraging simultaneously on 1000 opened flowers) were recorded on the same dates and during each of the following daily periods: 7 - 8 h, 9 - 10 h, 11 - 12 h, 13 - 14 h and 15 - 16 h. Abundance per flower and per plant was recorded following the direct counting, during the same dates and daily periods as for the registration of the duration of visits. For the abundance per 1000 flowers (A_{1000}) some workers were counted on a known number of flowers. A_{1000} was then calculated by the formula: $A_{1000} = [(A_x / F_x) \times 1000]$, where F_x and A_x are the number of opened flowers and the number of workers effectively counted on these flowers at time x (Tchuenguem Fohouo et al., 2004).

3.2.3 *Evaluation of the total sugars concentration in the nectar of S. g. var. Guineense*: This parameter was recorded using a portable refractometer (0 - 90° Brix) and a thermometer that gave the ambient temperature. Since the nectar of *S. g.* var. *guineense* is not directly accessible to the investigator, *A. m. adansonii* workers in full activity of nectar harvest were captured on the flowers of this Myrtaceae. The thus

harvested individuals were anesthetized by introduction in a small bottle containing cotton moistened with chloroform. Then, by experienced pressures on the bee abdomen placed between the thumb and the forefinger of the experimenter, the nectar of the crop was expelled and its concentration in total sugars (in dry matter g/100g) measured. The collected values were corrected according to the ambient temperature. The data was recorded every day, from the 13th to the 19th February 2006, then from the 20th to the 26th of February 2007, during the same daily periods as for the registration of the abundance of foragers. Ten to 30 values were registered for each daily period, according to the bee's rhythm of activity.

3.2.4 ***Evaluation of the apicultural value of S. g. var. Guineense***: Like for other plants species (Guerriat, 1996; Tchuenguem Fohouo et al., 2004, 2007 and 2008), the apicultural value was evaluated using data on the flowering intensity of *S. g.* var. *guineense* and the attractiveness of *A. m. adansonii* workers with respect to nectar and pollen.

3.2.5 ***Assessment of the impact of the anthophilous insects on S. g. var. guineense yields***: The percentage of the fruiting index due to the influence of the foraging insects (F_i) was calculated by the formula: $\% F_i = \{[(m_x - m_y) / m_x] \times 100\}$, where m_x and m_y are the mean fruiting indexes in lot x (flower clusters without protection) and lot y (flower clusters protected). The contribution of *A. m. adansonii* in the fruiting (F_a) was quantified by the formula: $F_a = [Pi \times (Va/100)]$, where Va is the percentage of *A. m. adansonii* visits on free flower clusters of lot 1 or lot 3.

3.3 Data analysis: Data were analysed using descriptive statistics, Student's *t*-test for the comparison of means of two samples, Correlation coefficient (r), Chi - Square (χ^2), and Microsoft Excel.

4 RESULTS

4.1 ***Reproduction system of S. g. var. guineense***: The mean fruiting index was: 0.58 (s = 0.23; n = 60) for lot 1; 0.25 (s = 0.15; n = 60) for the lot 2, 0.50 (s = 0.22; n = 100) for lot 3 and 0.24 (s = 0.21; n = 100) for lot 4. Thus, for the year 2006, *TC* = 58.04% and *TA* = 41.96%; for 2007, *TC* = 52.74% and *TA* = 47.26%. For the two accumulated years, *TC* = 55.39% and *TA* = 44.61%. Consequently *S. g.* var. *guineense* has a mixed reproduction regime, allogamous - autogamous, with the predominance of allogamy.

The mean fruiting indexes were 0.00 (s = 0; n = 10) for lot 5, 0.55 (s = 0.20; n = 10) for lot 6, 0.00 (s = 0; n = 10) for lot 7 and 0.53 (s = 0.30; n = 10) for lot 8. Thus, pollination is indispensable for the fruiting of *S. g.* var. *guineense*.

4.2 ***Activity of A. m. adansonii on S. g. var. guineense flowers***

4.2.1 ***Seasonal and daily visits***: During 32 and 27 days of the flowering periods in 2006 and 2007, 5106 and 7813 visits of 24 and 21 insects' species were counted on 60 and 100 free flower clusters of *S. g.* var. *guineense* respectively. *A. m. adansonii*, with 4378 and 5305 visits on 32 and 27 days, that is 85.74% and 67.90% of the total number of visits counted respectively in 2006 and 2007, was the more frequently observed insect whatever the year of survey. The difference between these two percentages is highly significant (χ^2 = 8.94; P <0.05). The honey bee workers were active on flowers of the Myrtaceae all day long, with two peaks of visits, the highest between 6 h and 7 h and the lowest between 14 h and 15 h (table 1). A negative and significant correlation exists between the number of *A. m. adansonii* visits and the ambient temperature (r = - 0.86; n = 6; P <0.05 for 2006 and r = - 0.67; n = 6; P> 0.05 for 2007). A negative and significant correlation exist between the number of *A. m. adansonii* visits and the ambient relative humidity (r = - 0.99; n = 6; P <0.05 for 2006 and r = + 0.67; n = 6; P> 0.05 for 2007).

4.2.2 ***Floral product harvested***: During each of the two periods of flowering of *S. g.* var. *guineense*, the workers of *A. m. adansonii* were harvested regularly and intensely of the nectar (figure 2). No active harvest of pollen was noted in 2006 whereas in 2007, a weak harvest of pollen (11 visits left on five days) was recorded.

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Table 1: Daily distribution *Apis mellifera adansonii* visits on flower clusters of *Syzygium guineense* var. *guineense* according to the years and consistent on 32 days in 2006 and 27 days in 2007.

Years	Visit	Time frames						
		6-7 h	8-9 h	10-11 h	12-13 h	14-15 h	16-17 h	Total
2006	**Number**	1249	1010	404	544	756	415	4378
	%	28.53	23.07	9.22	12.43	17.26	9.49	100
2007	**Number**	1364	1176	565	978	859	363	5305
	%	25.72	22.16	10.66	18.43	16.19	6.84	100

Figure 2: A worker of *Apis mellifera adansonii* collecting nectar in a *Syzygium guineense* var. *guineense* flower.

4.2.3 ***Rhythm of the visits according to the flowering stages*****:** Visits were most numerous when the number of open flowers was highest. The correlation between the total number of flowers in full bloom and the number of *A. m. adansonii* visits is positive and highly significant, in 2006 (r = + 0.67; n = 32, P <0.01) as well as in 2007 (r = + 0.50; n = 27; P <0.01).

4.2.4 ***Density of the foragers:*** In 2006, the greatest number of *A. m. adansonii* workers foraging at the same time was one per flower (n = 100; s = 0.30; maximum = 2), 256 per 1000 flowers (n = 100; s = 116; maximum = 833) and 571 per plant (n = 100; s = 429; maximum = 1690). In 2007, the corresponding figures were one per flower (n = 100; s = 0.22; maximum = 2), 198 per 1000 flowers (n = 100; s = 77; maximum = 400) and 567 per plant (n = 100; s = 425; maximum =1680). The difference between the two mean abundances per 1000 flowers is highly significant (t = 4.17; P <0,001).

4.2.5 ***Duration of visits per flower*****:** It only concerns visits for nectar harvest. In 2006, the mean duration of a flower visit was 7.98 sec (n = 318; s = 7.40; maximum: 42 sec). In 2007, the corresponding figure is 6.22 sec (n = 236; s = 4.18; maximum: 37 sec). The difference between these two means is highly significant (t = 3.55; P <0,001). For the two cumulated years, the mean duration of a flower visit is 7.10 sec.

4.2.6 ***Foraging speed*****:** On a flower cluster of *S. g.* var. *guineense*, a worker of *A. m. adansonii* visited between 3 and 18 flowers/min in 2006, and between 4 and 22 flowers/min in 2007. The mean foraging speed was 7.10 flowers/min (n = 180; s = 2.18) in 2006 and 9.06 flowers/min (n =180; s = 3.45) in 2007. The difference between these means is highly statistically significant (t = 6.44; P <0.001). For the two cumulated years, the mean foraging speed was 8.08 flowers/min.

4.2.7 ***Influence of neighbouring flora*****:** During the period of observation, flowers of many other

plant species growing near *S. g.* var. *guineense* were visited for nectar (ne) and/or the pollen (po) by *A. m. adansonii* workers. The most representative of these plants were: *Ximenia americana* L. 1927 (Olacaceae) (ne + po), *Combretum nigricans* Lep. ex. Guill. and Perr. 1932 (Combretaceae) (ne+po), *Terminalia macroptera* Guill. and Perr. 1911 (Combretaceae) (ne+po), *Vitex doniana* Sweet 1827 (Verbenaceae) (ne), *Vitex madiensis* Oliv. 1862 (Verbenaceae) (ne), *Hymenocardia acida* Tul. 1899 (Hymenocardiaceae) (po). During one foraging trip, an individual bee foraging on *S. g.* var. *guineense* was not observed moving to the neighbouring plant and vice-versa.

4.3. *Sugars content in S. g. var. guineense nectar*: The mean concentration in total sugars of the *S. g.* var. *guineense* nectar was 45.53% (n = 100; s = 5.70) in 2006 and 46.16% (n = 100; s = 5.74) in 2007. The difference between these averages is not significant (t = 0.78; P> 0.05).

The influence of ambient temperature and hygrometry on sugar concentration of *S. g.* var. *guineense* nectar was not significant (table 2)

Table 2: Distribution of the concentration in total sugars of the nectar (CTS) of *Syzygium guineense* var. *guineense* during the day according to years and consistent on 7 days.

Years	Parameters recorded	Time frames					
		6-7 h	8-9 h	10-11 h	12-13 h	14-15 h	16-17 h
2006	**CTS (%)**	45.22	44.67	46.71	45.01	45.79	44.71
	Température (°C)	24.67	28.53	29.63	28.80	28.87	29.60
	Hygrometry (%)	24.80	21.00	20.57	20.93	20.93	20.50
2007	**CTS (%)**	44.49	44.81	45.25	45.25	44.79	45.84
	Température (°C)	22.4	29.27	28.8	28.8	28.87	29.6
	Hygrometry (%)	28.4	21.13	21.07	21.07	18.93	19.9

The temperature and the hygrometry are the means of five observations. Data analysis for 2006: (a) CTS and T: r = 0.64; ddl = 4; (b) CTS and H: r = - 0.57; ddl = 4. Data analysis for 2007: (a) CTS and T: r = 0.19; ddl = 4; (b) CTS and H: r = - 0.12; ddl = 4. P > 0.05 for all correlations.

4.4 *Apicultural value of S. g. var. guineense*: During the two flowering periods of *S. g.* var. *guineense*, a well elaborated activity of *A. m. adansonii* workers was registered on flowers. In particular, there were high daily and seasonal frequency of visits, high density of workers per plant, very good nectar harvest, low pollen collection and fidelity of the workers to the flowers. Furthermore, our field observations revealed that in the dry season (main period of honey flow), each *S. g.* var. *guineense* tree can produce 150 to more than 1000 flowers clusters, the mean number of flowers carried by a flower cluster being 45 (n = 200; s = 20.61). In addition, according to our investigations, during four to six days (m = 4; s = 0.60; n = 50), each flower of *S. g.* var. *guineense* produces nectar that is rich in sugars (up to 45.85%) and easy for honey bees to harvest. These data point out the strong attractiveness of *S. g.* var. *guineense* nectar and the low attractiveness of its pollen to *A. m. adansonii*. They allow *S. g.* var. *guineense* to be classified in the category of highly nectariferous and slightly polliniferous bee plants.

4.5 *Effect of A. m. adansonii on S. g. var. guineense pollination and the fruit yields*: During the harvest of nectar on flowers, *A. m. adansonii* workers were always in contact with the stigma and the anthers. Therefore, they greatly increase pollination possibilities of *S. g.* var. *guineense*. The comparison of the mean fruiting indexes (table 3) showed that observed differences were highly significant between lots 1 and 2 (t = 8.50; P <0.001), non significant between lots 2 and 4 (t = 0.34; P> 0.05), highly significant between lots 3 and 4 (t = 8.55; P <0.001), and significant between lots 1 and 3 (t = 2.04; P <0.05).

Consequently: - in 2006, fruiting of flower clusters in free pollination (lot 1) was high than that of bagged flower clusters (lot 2); - in 2007, fruiting of flower clusters in free pollination (lot 3) was high than that of bagged flower clusters (lot 4); - trees were more productive in 2006 than in 2007.

In 2006, the percentage of the fruiting index due to the action of insects (*Fi* for 2006) was 56.90%. In 2007, this rate (*Fi* for 2007) was 52.00%. For the two years of survey, the percentage of the fructification index due to the influence of the

insects was: *Fi* = {[(*Fi* for 2006) + (*Fi* for 2007)] / 2} = 54.45% and the contribution of *A. m. adansonii* in the fructification of *S. g.* var. *guineense* was 42.05%.

Table 3. Average mean of fructification index (I_{fr}) of inflorescences in *Syzygium guineense* var. *guineense* lots.

Number of lots	Characteristics of lots	Number of flower clusters studied	Fructification index[1]	
			Mean	Standard déviation
1	Unprotected flower clusters in 2006	60	0.58	0.23
2	Protected flower clusters in 2006	60	0.25	0.15
3	Unprotected flower clusters in 2007	100	0.50	0.22
4	Protected flower clusters in 2007	100	0.24	0.21

[1] (I_{fr}) = number of fruits / number of flowers on inflorescence.

The influence of the African honey bee on the fruiting of *S. g.* var. *guineense* was therefore positive and significant. Besides, a positive and highly significant correlation coefficient was found between the number of *A. m. adansonii* visits on *S. g.* var. *guineense* flower clusters and the fruiting index of the Myrtaceae, in 2006 (r = + 0.69; n = 100 = 98; P <0.001) as well as in 2007 (r = + 0.72; n = 100; P <0.001). The contribution of *A. m. adansonii* in the fruiting of the Myrtaceae was 48.78% in 2006, 35.31% in 2007, and 42.05% for the two cumulated years of survey. The difference between the contribution of the African honey bee in the fruiting of *S. g.* var. *guineense* in 2006 and 2007 is significant (χ^2 = 4.87; P <0.05).

5 DISCUSSION

5.1 *Activity of A. m. adansonii on the flowers of S. g. var. guineense and apicultural value of the Myrtaceae:* The high nectar harvest and the low pollen collection on *S. g.* var. *guineense* by *A. m. adansonii* were also registered in Dang (Tchuenguem Fohouo et al., 2008). In Ethiopia, only the collection of the nectar of this Myrtaceae by *A. m. adansonii* has been noted (Fichtl & Adi, 1994). Thus, types of floral products collected by *A. m. adansonii* on flowers of *S. g.* var. *guineense* vary with time and region. The variations observed could be explain mainly by the needs of the colonies from which originated the workers honey bee. Results showed that there are two peaks of activity of *A. m. adansonii* on flowers of *S. g.* var. *guineense*. The first peak appears in the morning (6-7h each year) and the second in the afternoon (14-15h in 2006 and 12-13h in 2007). Peaks of visits could correspond to the periods of high availability of nectar in flowers of *S. g.* var. *guineense*.

The high abundance of the workers per 1000 flowers reveals the high attraction exerted by the nectar of this Myrtaceae on *A. m. adansonii*. This nectar attraction could be explained by its concentration in total sugars (mean 45.85%) that is high, considering the range of 15 to 75% for several plant species (Proctor et al., 1996). The high density of workers per 1000 flowers is due to the natural faculty of honey bees to recruit a high number of workers to exploit an interesting food source (Frisch, 1969; Louveaux, 1984; Schneider & Hall, 1997; Goodman, 2003). The abundance per plant was lower than the 3600 recorded in Dang by Tchuenguem Fohouo et al. (2008). This difference could be explained by the low availability of plants in bloom (119 plants) in Dang. In these conditions, *A. m. adansonii*'s colonies are obliged to concentrate their workers on the available trees.

The mean duration of a visit per flower for nectar harvest was lower than the 12.89 sec (t = 3.35; p <0.01) in 2002 as well as the 9.70 sec (t = 1.66; p>0.05) in 2003, obtained in Dang by Tchuenguem Fohouo et al. (2008). This difference could be explained by the lower availability of flowers and therefore of nectar in this village. In these conditions, a honey bee worker is obliged to exploit available flowers in an optimal manner.

The fact that an individual bee exploiting *S. g.* var. *guineense* plant was not observed visiting another plant species suggested that *A. m. adansonii* show flower constancy (Louveaux, 1984; Backhaus, 1993; Basualdo et al., 2000) for *S. g.* var. *guineense* flowers.

This observation is in agreement with those made at Dang (Tchuenguem Fohouo et al., 2008). This flower constancy could be partially due to the high sugar content of the nectar. Indeed, it is known that the workers of *A. mellifera* are generally constant on a plant species when the concentration in sugars of its nectar is more than 15% (Philippe, 1991).

The activity of *A. m. adansonii* on *S. g.* var. *guineense* flowers was more intense in 2006 that in 2007. The highest activity recorded in 2006 could be explained by the fact that the number of *A. m. adansonii* colonies in the station of survey was high for a smaller number of plants of *S. g.* var. *guineense* in bloom. As a highly nectariferous and slightly polliniferous bee plant, *S. g.* var. *guineense* can be cultivated and protected to increase honey production and to strengthen *A. m. adansonii* the colonies, as previous researches suggested at Dang (Tchuenguem Fohouo et al., 2008).

5.2 *Impact of the A. m. adansonii activity on the pollination and fruiting of S. g. var. guineense:*

During the collection of nectar and pollen on each flower, *A. m. adansonii* workers regularly come into contact with the stigma and anthers. They could thus enhance auto-pollination which has been demonstrated in the present study. *A. m. adansonii* workers could provide allogamous pollination through carrying of pollen with their furs, legs and mouth accessories, which is deposited on another flower belonging to the same plant (geitogamy) or to a different plant of the same species (xenogamy).

The intervention of *A. m. adansonii* workers on the pollination of *S. g.* var. *guineense* is especially probable since their density per 1000 flowers and their foraging speed are high.

The positive and significant contribution of *A. m. adansonii* in the fruiting of *S. g.* var. *guineense* is justified by the action of the workers on auto-pollination and cross-pollination.

6 CONCLUSION

This study reveals that, *S. g.* var. *guineense* is a highly nectariferous bee plant that benefits from the pollination by insects among which *A. m. adansonii* is the most important. The comparison of the fruits set of unprotected flower clusters with that of floral clusters protected from insects in the gallery forests of Tchabal-Bambi and Béka underscore a significant increase of 41.22% of the fruiting index due to *A. m. adansonii*. Thus, *S. g.* var. *guineense* should be planted and protected to increase honey production and to strengthen honey bee colonies.

Installation of *A. m. adansonii* colonies near the population of *S. g.* var. *guineense* is recommended to increase fruits production.

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