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# The importance of a single floral visit of *Xylocopa olivacea* Fabricius and *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) in the pollination and the yields of *Sesamum indicum* Linnaeus (Pedaliaceae) in Maroua, Cameroon

**Joseph Blaise Pando, Denis Djonwangwé and Olivier Balti Moudelsia**

**Abstract**
To assess the pollination efficiency of a bee visit on the sesame; the research were conducted in Maroua-Cameroon. Three treatments were used on each 60 randomly-selected plants. These included Autonomous Self-Pollination (ASP) with flowers protected from insect's visit, flowers that received a Single Bee Visit (SBV) of *Xylocopa olivacea* Fabricius ($SB_1V$) and *Apis mellifera adansonii* Latreille ($SB_2V$). They developed and elaborated behaviour when they collected the nectar and/or pollen. These insects were effective pollinators; they shake flowers and this movement could facilitate the liberation of pollen by anthers, for the optimal occupation of the stigma and of course their visits increase yield of sesame. Impact of *X. olivacea* and *A. m. adansonii* visits in sesame yield is estimated at 74.85 % and 73.60%, 17.07 % and 16.98%, 21.74 % and 17.11 % and 65.65 % and 59.46 % respectively for the fruiting rate, seeds/fruit, seed weight and normal seeds. To improve the yield of *Sesamum indicum* Linnaeus, conservation or installation of *X. olivacea* nests and *A. m. adansonii* colonies close to sesame fields is recommended.

**Keywords:** Sesame, bees, pollination, efficiency, yields

## 1. Introduction
Insect pollinators provide a vital service of pollination to flowering plants by foraging and transferring the pollen from one flower to another. Among all insects, bees are crucial pollinators, as they are fully dependent on floral resources (nectar and pollen) for forage provision [1, 2]. Bees feed on the floral resources of a wide variety of flowering plants, from natural and semi-natural habitats to surrounding agricultural landscapes [3], and contribute to the pollination of more than 66% of the world's crop species [4].
Sesame (*Sesamum indicum* L.) is one of the important oilseed crops in many tropical and sub-tropical regions in the world. It is perhaps one of the oldest crops cultivated by man, having been grown in the Near East and Africa for more than 5000 years for cooking and medicinal needs [5].
Sesame's blossom structure facilitates cross-pollination, even though the crop is usually viewed as self-pollinating [6]. The rate of cross-pollination lies between 0.5% and 65% depending on insect activity, environmental conditions and availability of other vegetation [7]. Pharaon *et al.* [8] reported that the cross pollination rates were between 15.05 and 25.97 % in Cameroon.
The flowers are complete, gamopetalous, zygomorphic and with a short stalk. The calyx has five fused sepals. One of the petals serves as a landing platform for the visiting insects [9]. The tubular corolla is white, with a lobe upwards and the other downwards. She is a protogynous hermaphrodite [10], which opens early in the morning and closes after 5:00 pm [9] and produces nectar and pollen that attract insects [11-13, 6].
In Cameroon, the quantity of *S. indicum* available for consumers is very low, the demand for sesame seeds is high (93,498 tones/year: [14]), and its seed yields are low (43,498 tons/year: [15]). Therefore, it is important to investigate how the production of this plant could be increased in the country. The relationships between *S. indicum* and anthophilous insects have not been well studied in Cameroon.

The studies carried out by Pharaon *et al*. [8] in Obala and Tchuenguem and Népidé [16] in Ngaoundéré have shown that *A. m. adansonii* visits *S. indicum* flowers to harvest both nectar and pollen and increases its pollination possibilities. It is important to study pollination efficiency of this bee on sesame in Maroua. Also, there has been no previous research reported on the pollination efficiency of *Xylocopa olivacea* on *S. indicum* flowers. Carpenter bees possess several advantages as potential crop pollinators compared to other non-Apis bees [17]. Pando *et al*. [18] noticed that the size of *X. olivacea* plays an important role in crop pollination. According to Otieno *et al*. [19], when collecting nectar and/or pollen, it shakes flowers and this movement facilitates the liberation of pollen from anthers, for the optimal occupation of the stigma. This makes them potentially more versatile as agricultural pollinators.

*Xylocopa olivacea* and *A. m. adansonii* can be managed for pollination on *S. indicum* [18, 8]. The present work is aimed at assessing the activity period, the foraging activity of these bees on *S. indicum* and the effects of pollination efficiency of these insects on yields. The information recorded on the interaction of sesame flowers and *X. olivacea* and *A. m. adansonii* will enable farmers to develop strategies that will increase the overall quality and quantity of sesame yield.

## 2. Material and Methods

### 2.1. Site and biological materials

The research were carried out in Wourndé locality (10°38'15.7''N, 14°18'40.4''E and 437 m) in 2018 at Maroua (Far North; Cameroon: Figure 1). These coordinates were obtained using a GARMIN Beingx 10 brand GPS. The experiment was taken place from July to September 2018 and fruit were harvested in October 2018.

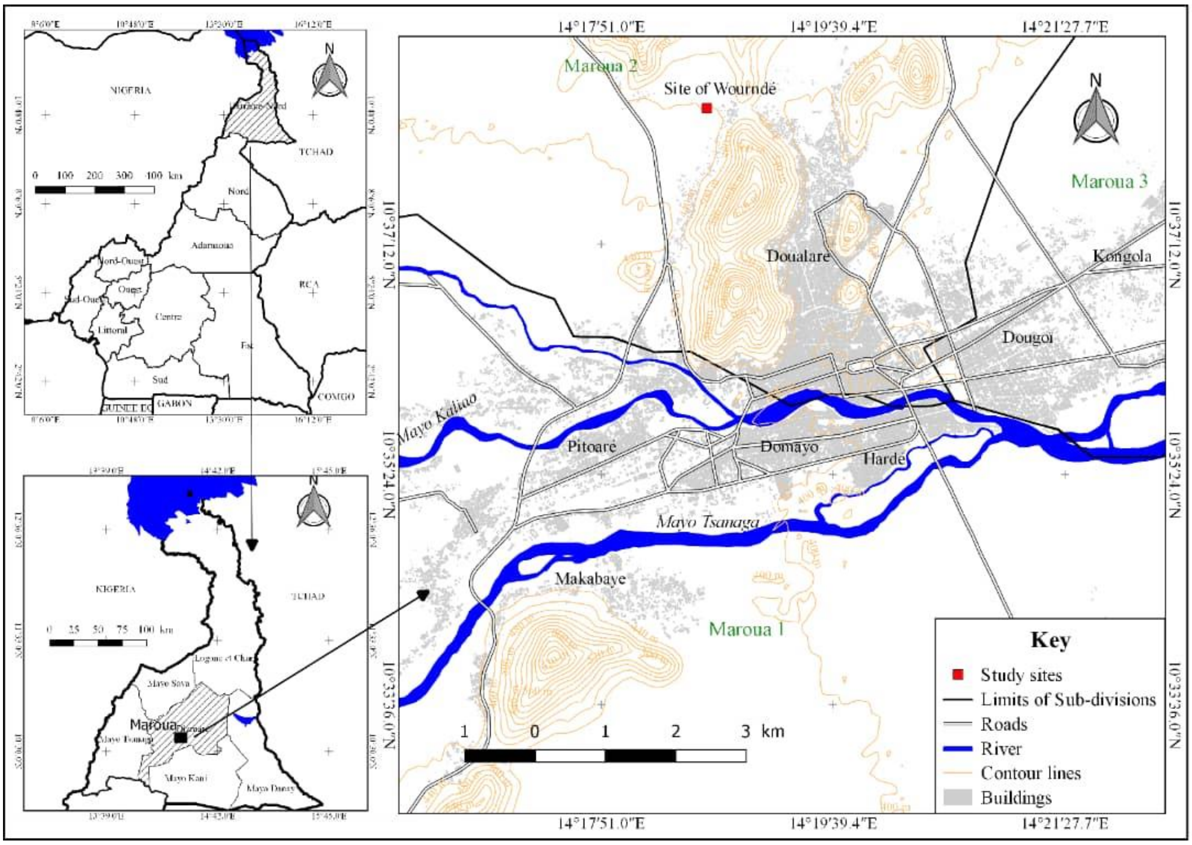

**Fig 1:** Map of Maroua town locating the experimental fields.

The predominant climate in the region is Sahel-Sudanian, according to Kuete *et al.* [20] classification, and the average annual temperatures is 35° C and mean annual rainfall is 700 mm, with the rainy season from June to October. The choice of the study site is justified by the existence of peasant fields of other crops and the guarantee of safety of experimental plots and observer. The plant material was represented by: (a) sesame seeds variety S42 which were bought at the Pala market (Mayo-kebbi West; Chad); (b) the various plant species located near the experimental plot and which were in bloom at the same time as *S. indicum*. The animal material was represented by *X. olivacea* and *A. m. adansonii* naturally present in the environment and which visited the flowers of *S. indicum*

### 2.2. Planting and maintenance of culture

The experimental plot was a plot of 20 m long by 15 m wide with an area of 300 m$^2$. On July 10$^{th}$, 2018, the following operations were successively carried out on the experimental plot: clearing, plowing and training of the six sub-plots. On July 12$^{th}$, 2018 in Wourndé, sowing was done, online on the sub-plots, at a rate of 11 lines per sub-plot. 5 seeds were sown per seed hole; the spacing was 15 cm between the rows; 60 cm on rows and 4 cm deep. The de-pairing was done when the plants had four leaves and two of the most vigorous plants were kept per hole. From germination (which occurred from July 18$^{th}$, 2018) to the development of the first flower (September 22$^{nd}$, 2018), hoe weeding operations were carried out regularly every two weeks. After the first weeding, the soil was amended with ash and then the chemical fertilizer NPK (20-10-15) according to the recommendations of Rongead [21]. From the flowering period to the ripening of the fruit, weeding was done regularly by hand according to the recommendations of Pando *et al*. [22].

### 2.3. Activity of *Xylocopa olivacea* and *Apis mellifera adansonii* on *Sesamum indicum* flowers

#### 2.3.1. Determination of floral products harvested

The floral products (nectar or pollen) harvested by *X. olivacea* and *A. m. adansonii* during each floral visit were registered based on its foraging behaviour. Nectar foragers were seen extending their proboscises to the base of the corolla while pollen gatherers scratched anthers with the mandibles or the legs. At the same time *X. olivacea* or *A. m. adansonii* encounter on flowers were registered, we noted the type of floral products collected by these bees. This parameter was measured to determine whether *X. olivacea* and *A. m. adansonii* were strictly gathering pollen, nectar or both, because this has impact on its efficacy as a cross-pollinator of *S. indicum.*

#### 2.3.2. Evaluation of duration of visits and foraging speed

During the registration of visits, the duration of the individual flower visits was recorded too (using a stopwatch) at least six periods: 7:00-8:00 am, 9:00-10:00 am, 11:00-12:00 am, 1:00-2:00 am and 3:00-4:00 am. Moreover, the foraging speed, according to Jacob-Remacle [23], is the number of flowers visited by a bee per min. According to Tchuenguem *et al.* [24], the foraging speed can be calculated using the following formulation: $Vb = (Fi / di) \times 60$ (1) where $di$ is the time (s) given by a stopwatch and $Fi$ is the number of flowers visited during $di$.

#### 2.3.3. Assessment of the pollination efficiency of *Xylocopa olivacea* and *Apis mellifera adansonii* on *Sesamum indicum.*

To assess of the pollination efficiency of *X. olivacea* and *A. m. adansonii*, during the experimentation, two treatments were done:

- Treatment 1: Pollination restricted using gauze bags (ASP) (12 × 16 cm; Osmolux®, Pantek France, Montesson: Figure 2) - 160 flower buds were monitored for the occurrence of autopollination in sesame. The flower buds were isolated, bagged with paper bag and tagged the day before their anthesis. The bags remained in flowers for 3 days, preventing any contact with biotic and abiotic pollinators.

**Fig 2:** Bagged inflorescences (ASP) of *Sesamum indicum*

- Treatment 2: Single bee visit (SBV) in which flower buds were isolated (320 Inflorescences protected: Figure 3).

**Fig 3:** Bagged inflorescences (SVB) of *Sesamum indicum*

Between 9:00 am and 12:00 am, the hydrophilic bags were delicately removed from each inflorescence carrying new opened flowers and this inflorescence is observed up to 20 min by four persons (observer team) positioned in the study field. The flowers visited by *X. olivacea* or *A. m. adansonii* were marked and the new opened flowers that were not visited were eliminated. Each flower was monitored until it received a single bee visit by *X. olivacea* ($SB_1V$) or *A. m. adansonii* ($SB_2V$). After bee visit, the flower was bagged with a hydrophilic plastic bag (12 × 16 cm) until the next day to avoid any additional insect visit according to Vaissière *et al*. [25] method, after which the flower and the equivalent plant were also tagged. At maturity, pods were harvested from each treatment, seeds/pod, average weight of seeds and normal seeds were counted. The fruiting rate due to the influence of Pollinator Effectiveness were evaluated using Tchuenguem *et al*. [24] method: $Fr_i = \{[(Fr_Y - Fr_X) / Fr_Y] \times 100\}$ (2), where $Fr_Y$ and $Fr_X$ are the fruiting rate in treatment Y (protected flowers and visited exclusively by Pollinator effectiveness) and treatment X (protected flowers). $Fr = [(F_2 / F_1) \times 100]$ (3) where $F_2$ is the number of pods formed and $F_1$ the number of viable flowers initially set. The impact of Pollinator effectiveness flowering on number of seeds/fruit, percentage of the average weight of seeds and percentage of normal seeds were evaluated using the same method as mentioned above for fruiting rate according to Tchuenguem *et al*. [24] method.

#### 2.3.4. Influence of neighboring floral

During the survey period, flowers of several other plant species including: *Abelmoschus esculentus* (L.) Moench, 1794, *Ipomea eriocarpa* (Robert Browns, 1810), *Glycine max* (L.) Merr., 1917, *Vigna unguiculata* (L.) Walp., 1843, *Sorghum bicolor* (L.) Moench, 1794 and *Zea mays* (L., 1753) in vicinity bloom of the experimental plot were observed to attract *X. olivacea* and *A. m. adansonii.*

#### 2.3.5. Data analysis

Data were analyzed using descriptive statistics, Student's t-test for the comparison of means of the two samples, chi-square ($\chi 2$) for the comparison of the percentages using SPSS statistical software (version 19.0; SPSS, Inc. Chicago, Illinois, USA) and Microsoft Excel 2010.

## 3. Results and Discussion
### 3.1. Results
#### 3.1.1. Activity of *Xylocopa olivacea* and *Apis mellifera adansonii* on *Sesamum indicum* flowers

From this study's field observations, *X. olivacea* and *A. m. adansonii* foragers are found to collect nectar and pollen on *S. indicum* flowers. To harvest nectar, *X. olivacea* rarely enters the interior of the flower. This bee lands on the external face of the standard, evolves towards the base of the corollary tube (Figure 4), and pierces a hole through which it takes the nectar. From 160 visits of *X. olivacea* recorded, 26.87% were intended for the harvest of pollen and 73.13% for the harvest of nectar. In the 73.13% collecting nectar, Carpenter-bee takes the nectar through the hole drilled at the base of the corollary tube for 91.45%. *Apis mellifera adansonii* to collect nectar enters the interior of the flower, plunges its head into the bottom of the nectary, and using the trunk to harvest enough nectar (Figure 5). This bee also uses the hole drilled by the Carpenter to collect the nectar. In the other hand, using its mandibles and legs, it scrapes the anthers of the flower to collect the pollen (Figure 6). The collected pollen can be observed on the collecting hairs, baskets, belly brushes and legs. Out of 160 visits of *A. m. adansonii* recorded, 30.63% were intended harvesting the pollen and 69.37% for the collection of nectar; and 6.31% of visit for nectar collection by this bee was made through the hole created by the Carpenter-bee. It is noticed that the foraging activity of these two bees on sesame flowers is intensely intended for the collection of nectar as pollen. No simultaneous harvesting behaviour of the two floral products was observed.

**Fig 4:** *Xylocopa olivacea* harvesting nectar on the flower of *Sesamum indicum*

**Fig 5:** *Apis mellifera adansonii* harvesting nectar on the flower of *Sesamum indicum*

**Fig 6:** *Apis mellifera adansonii* collecting pollen on the flower of *Sesamum indicum*

#### 3.1.2. Duration of visits and foraging speed

Table 1 shows the mean duration and foraging speed of *X. olivacea* and *A. m. adansonii* visits on *S. indicum* flower. It appears that duration varies significantly according to the type of floral poduct harvested. It is 8.67 ± 3.15 sec and 12.71 ± 7.23 sec for nectar collected, against 3.64 ± 0.98 sec and 6.28 ± 3.58 sec for pollen collected respectively for *X. olivacea* and *A. m. adansonii*. The difference between the duration of the visit for nectar and pollen collection is highly significant for *X. olivacea* ($Z$= 48.41 [$df$ = 78; $P$<0.05]) and *A. m. adansonii* ($Z$ = 39.26 [$df$ = 78; $P$<0.05]). On the experimental plot of *S. indicum*, *X. olivacea* and *A. m. adansonii* visited between five and 30 flowers/min and the mean foraging speed were 16.83 ± 15.05 flowers/min and 9.8 ±7.77 fleurs/min respectively. The comparison between the two speeds foraging is significant ($Z$ = 13.46 [$df$ = 78; $P$<0.05]). The passage from flower to flower by *X. olivacea* and *A. m. adansonii* on an inflorescence of *S. indicum* occurs only through flight.

**Table 1:** Duration of visits and foraging speed of *Xylocopa olivacea* and *Apis mellifera adansonii*

| Parameters | *Xylocopa olivacea* | *Apis mellifera adansonii* | Comparison bee |
|---|---|---|---|
| **Duration of visit (Second)** | | | |
| ***Nectar*** | 8.67 ± 3.15 | 12.71 ± 7.23 | $Z$= 12.17 [$df$ = 78 ; $P$<0.05]* |
| ***Pollen*** | 3.64 ± 0.98 | 6.28 ± 3.58 | $Z$= 11.21 [$df$ = 78 ; $P$<0.05]* |
| ***Comparison*** | $Z$= 48.41 [$df$ = 78 ; $P$<0.01]* | $Z$ = 39.26 [$df$ = 78 ; $P$<0.05]* | |
| **Foraging speed (Flowers/minute)** | | | |
| | 16.83 ± 15.05 | 9.8 ±7.77 | $Z$= 13.46 [$df$ = 78 ; $P$<0.05]* |

*: Significant at $P$<0.05.

During the observation period, flowers of many surrounding plant species of *S. indicum* were visited by *X. olivacea* for pollen (P) and *A. m. adansonii* for nectar (N) and/or pollen (P). Among those plants there are: *Abelmoschus esculentus* (L.) Moench, 1794 (P) and *Vigna unguiculata* (L.) Walp., 1843 (P) for *X. olivacea; Ipomea eriocarpa* (Robert Browns, 1810) (P), *Glycine max* (L.) Merr., 1917 (N), *Vigna unguiculata* (L.) Walp., 1843 (N, P), *Sorghum bicolor* (L.) Moench, 1794 (P) and *Zea mays* (L., 1753) (P) for *A. m. adansonii*. During a single foraging trip, an individual bee foraging on *S. indicum* was not observed moving from *S. indicum* to the neighbouring plant and vice versa.

**3.1.3. Pollination efficiency of *Xylocopa olivacea* and *Apis mellifera adansonii* on *Sesamum indicum***

During nectar and/or pollen collection from *S. indicum*, foraging *X. olivacea* and *A. m. adansonii* always shake flowers and regularly induce contact with the anthers and stigma, increasing the possibility of cross-pollination. With this pollen, they flew frequently from flower to flower. Table 2 shows that the percentage of the total number of visits during which forager bees came into contact with the anther and stigma of the visited flowers were 100.00% and 84.62 % to harvest pollen and nectar respectively by *X. olivacea*. In the same parameter, *A. m. adansonii* gives the results to 100% (pollen) and 100% (nectar).

**Table 2:** Number and frequency of contacts between *Xylocopa olivacea* and *Apis mellifera adansonii* and the stigma during floral visits to *Sesamum indicum*

| Bee | | Number of Contact Visits | | | |
|---|---|---|---|---|---|
| | Number of studies visits | Anther | | Stigma | |
| | | $N_a$ | $P_a$ (%) | $N_s$ | $P_s$ (%) |
| *Xylocopa olivacea* | 160 | 43 | 100 | 117 | 84.62 |
| *Apis mellifera adansonii* | 160 | 49 | 100 | 111 | 100 |

$N_a$: number of contact anther visits; $P_a$: percentage of anther contact visits; $N_s$: number of contact stigma visits; $P_s$: percentage of stigma contact visits

To harvest floral product, these bees enter into interior of flowers; this justified the obtained results. Thus, *X. olivacea* and *A. m. adansonii* greatly increased the pollination rate of *sesame* flowers.

(a) The number of fruit set, five days after anthesis of flowers, and harvested showed significant difference ($p$<0.05) between treatments of pollination in Maroua, Far North Region (Table 3). It appears that, the Single Bee Visit of *X. olivacea* ($SB_1V$) pollination set significantly more fruits in five days, followed by Single Bee Visit of *A. m. adansonii* ($SB_2V$) pollination and Pollination restricted using gauze bags (ASP). The differences were highly significant between $T_1$ (ASP) and $T_2$ ($SB_1V$) [$\chi^2$ = 114.46; $P$<0.01], $T_1$ (ASP) and $T_2$ ($SB_2V$) [$\chi^2$ = 98.39; $P$<0.01] and significant between $T_2$ ($SB_1V$) and $T_2$ ($SB_2V$) [$\chi^2$ = 2.84; $P$<0.05]. The percentage of the fruiting rate due to *X. olivacea* and *A. m. adansonii* pollination efficiency were 74.85 % and 73.60 % respectively.

**Table 3:** Fruiting rate, percentage of normal seeds, mean seeds/pod, mean seed weight according to the treatments of *Sesamum indicum*

| Parameters | Fruiting rate | Normal seed | Seeds/pod | Seeds weight/pod |
|---|---|---|---|---|
| | | Treatments | | |
| $T_1$ (ASP) | 24.73% | 82.93% | 71.48 ± 7.16 | 0.45 ± 0.09 |
| $T_2$ ($SB_1V$) | 98.34% | 100% | 91.34 ± 8.25 | 1.31 ± 0.60 |
| $T_2$ ($SVB_2$) | 93.67% | 99.89% | 86.23 ± 9.04 | 1.11 ± 0.48 |
| | | comparison | | |
| $T_1$ (ASP) &$T_2$ ($SB_1V$) | $\chi^2$ = 114.46 $P$<0.01* | $\chi^2$ = 18.66 ; $P$<0.01* | $Z$ = 8.82; $P$<0.05* | $Z$ = 12.24 ; $P$<0.05* |
| $T_1$ (ASP) &$T_2$ ($SB_2V$) | $\chi^2$ = 98.39 $P$<0.01* | $\chi^2$ = 18.32 ; $P$<0.01* | $Z$ = 3.14 ; $P$<0.05* | $Z$ = 7.84 ; $P$<0.05* |
| $T_2$ ($SB_1V$) &$T_2$ ($SB_2V$) | $\chi^2$ = 2.84 $P$<0.05* | $\chi^2$ = 0.11; $P$>0.05 | $Z$ = 1.35 ; $P$>0.05 | $Z$ = 1.89 ; $P$>0.05 |

$T_1$ (ASP) : Autonomous Self-Pollination; $T_2$ ($SB_1V$) : Single Bee Visit of *Xylocopa olivacea*; $T_2$ ($SB_2V$) : Single Bee Visit of *Apis mellifera adansonii*; *: Significant at $P$<0.05.

(b) Single Bee Visit of *X. olivacea* ($SB_1V$) Pollination produced fruits with a larger amount of seeds in the fruit; follow by Single Bee Visit of *A. m. adansonii* ($SB_2V$) pollination and Pollination restricted using gauze bags (ASP) (Table 3). Probably, *X. olivacea* has greater deposition of pollen directly on the stigma, which is enough to fertilize all the ovules present in the ovary. This indicates that the treatment of pollination efficiency of *X. olivacea* resulted in an advantage to the plant's reproductive success than others. The differences were high significant between $T_1$ (ASP) and $T_2$ ($SB_1V$) [$Z$ = 8.82; $P$<0.05], $T_1$ (ASP) and $T_2$ ($SB_2V$) [$Z$ = 3.14; $P$<0.05] and not significant between $T_2$ ($SB_1V$) and $T_2$

($SB_2V$) [$Z$ = 1.35; $P$>0.05]. The contribution of *X. olivacea* and *A. m. adansonii* pollination efficiency to the increment of the number of seeds per pod were 21.74 % and 17.11 % respectively.

(c) Table 3 shows higher normal seed yield for Single Bee Visit of *X. olivacea* ($SB_1V$) Pollinations treatment compared to Single Bee Visit of *A. m. adansonii* ($SB_2V$) pollination treatment and Pollination restricted using gauze bags (ASP) treatment. This may show high pollination deficit on the crop, indicating the need of *X. olivacea* and *A. m. adansonii* management to increase developed seeds. The differences were highly significant between $T_1$ (ASP) and $T_2$ ($SB_1V$) [$\chi^2$ = 18.66; $P$<0.01], $T_1$ (ASP) and $T_2$ ($SB_2V$) [$\chi^2$ = 18.32; $P$<0.01], but $T_2$ ($SB_1V$) and $T_2$ ($SB_2V$) [$\chi^2$ = 0.11; $P$>0.05] was not significantly different. The contributions of Single Bee Visit of *X. olivacea* and *A. m. adansonii* to increase the percentage of normal seed were 17.07 % and 16.98 % respectively.

(d) the same to the data concerning the seed weight, significant difference ($p$<0.05) was observed in the average seed weight between the different treatments (Table 3). The Single Bee visit of *X. olivacea* $T_2$ ($SB_1V$) pollination showed a significant difference between the Pollination restricted using gauze bags (ASP) [$Z$ = 12.24; $P$<0.01] and Single Bee Visit of *A. m. adansonii* ($SB_2V$) pollination [$Z$ = 7.84; $P$<0.01], and not significant between $T_2$ ($SB_1V$) and $T_2$ ($SB_2V$) [$Z$ = 1.89; $P$ > 0.05]. The results suggest that the type of pollination or pollinator affect the seed weight per fruit. The percentages of seed weight due to the pollination efficiency activity of *X. olivacea* and *A. m. adansonii* were 65.65 % and 59.46 % respectively.

## 4. Discussion

Bees, *X. olivacea* and *A. m. adansonii*, were found to be the visitors in *S. indicum*. The bees land on the flower to collect pollen and nectar. Otiobo *et al*. [26] in Bamenda and Tchuenguem and Népidé [16] in Ngaoundéré also reported that *A. m. adansonii, Amegilla* sp., and other insects visit the flower of *S. indicum*. Pharaon *et al*. [8] have reported that *A. m. adansonii* was the major insect species responsible for the pollination of this crop. However, during the present study *X. olivacea* was not noticed on sesame crop in this region. The attractiveness of nectar can be partially explained to inherent character such as colour of the flowers, presence of nectar guides on the flowers, availability of forage source [9]. Mahfouz *et al*. [13] and Kamel *et al*. [6] in Egypt reported that nectar produced by *S. indicum* attracts various insects in natural conditions.

The significant difference observed between the duration of pollen collection visits and that of nectar collection visits could be explained by the accessibility of each of these floral products. Floral morphology of this crop ensures high protection of the nectar such that the keel is forcefully opened and this ensures tripping of the flowers, resulting to pollen release. Under these conditions an individual bee must spend more time on flowers to obtain its nectar load, compared to the time it needs for pollen load. The results reported by the Tchuenguem and Népidé [16] and Pharaon *et al*. [8] are comparable with the present findings. The present study shows that during one foraging trip, an individual bee foraging on a given plant species scarcely visited another plant species. This result indicates that *X. olivacea* and *A. m. adansonii* show flower constancy [27] for the flowers of Sesame. *Xylocopa olivacea* and *A. m. adansonii* have been previously reported as good constancy visitor then effective pollinators by Tchuenguem *et al*. [24] on *Cajanus cajan* in Yaoundé and Pharaon *et al*. [8] on *S. indum* in Obala respectively. Flower constancy is an important aspect in the management of pollination and this shows that *X. olivacea* and *A. m. adansonii* can provide advantages of pollination management for *S. indicum*. Investment in *X. olivacea* and *A. m. adansonii* management may provide high yield of this crop. During the collection of nectar and pollen on each flower, bees regularly come in contact with the stigma. It could enhance auto-pollination, which has been demonstrated in the past by Pando *et al*. [18] on *Phaseolus coccineus*, Tchuenguem *et al*. [24] on *Cajanus cajan* and Tchuenguem and Népidé [16] on *S. indicum* respectively. However, *A. m. adansonii* would provide allogamous pollination high than *X. olivacea* through carrying pollen within their furs, legs and mouth accessories, which is consequently, deposited to another flower of different plant belonging to the same species. This is due to the fact that during the nectar collection visit, xylocope is in contact with the pollen only when it enters the interior of the flower. Unlike *A. m. adansonii* where the harvesting of nectar is mainly done by entering into the interior of the flower. The positive and significant contribution of bee in the pod, seeds yields and weight of *S. indicum* is justified by the action of these forager bees on self-pollination and cross-pollination. During foraging behaviour on flowers of sesame, *X. olivacea* and *A. m. adansonii* play a positive role. *Xylocopa olivacea* have behavioral and anatomical traits that greatly increase the efficiency and accuracy of pollen delivery. When collecting nectar and/or pollen, this bee shakes flowers and this movement could facilitate the liberation of pollen by anthers, for the optimal occupation of the stigma. *Apis mellifera adansonii* foragers regularly come into contact with the stigma. They were also able to carry pollen with their hairs, legs and mouth accessories from a flower of one plant to stigma of another flower of the same plant, to the same flower or to that of another plant [26, 8].

Tchuenguem and Népidé [16] reported that *A. m. adansonii* is a good pollen collector and effective pollinator of sesame in Ngaoundéré. During our investigations, the falling of pollen carried by the foragers and its deposition on the stigma and stamens of the flowers to be visited by the action of gravity and that of wind have been observed. Such pollen losses by bees are frequent at the end of single flower or inflorescence visits, especially during the hovering flight of foragers above these organs. The flowers that are exposed exclusively to single bee visit of *X. olivacea* pollination set significantly more fruits, more seeds per pod with the heavier seeds better shape, followed by single visit of *A. m. adansonii* bee pollination and Pollination restricted using gauze bags. This can be explained in the fact that the weight of *X. olivacea* is playing a positive role during nectar and pollen collection. This bee shook flowers and could facilitate the liberation of pollen by anthers for the optimal occupation of the stigma. The higher productivity of floral access exclusively to *X. olivacea* and/or *A. m. adansonii* visits compared to bagged flowers explains that the visits of these bees' visits were effective in increasing cross pollination. The effect of these bees pollination on fruit and seed set significant than self-pollination (bagged flowers). The fruit set was found to be maximal during bee pollination; this indicated that *X. olivacea* and *A. m. adansonii* play an important role in pollination of sesame.

## 5. Conclusion

In Maroua, *X. olivacea* and *A. m. adansonii* harvested pollen and/or nectar on *S. indicum*. The nectar being the most intensely harvested floral product for each bee than pollen. They developed and elaborated behaviour when they collected these floral products and the duration of visits were 8.67 ± 3.15 sec and 12.71 ± 7.23 for nectar collected, against 3.64 ± 0.98 s and 6.28 ± 3.58 for pollen harvested for *X. olivacea* and *A. m. adansonii* respectively. The comparison of yields of flowers visited exclusively by *X. olivacea* or *A. m. adansonii* with that of the flowers protected from insects visits then uncovered underscores the capacity of these bees in increasing fruits production as well as seeds quality. So, the impact of pollination efficiency of *X. olivacea* and *A. m. adansonii* on *S. indicum* was estimated at 74.85 % and 73.60%, 17.07 % and 16.98%, 21.74 % and 17.11 % and 65.65 % and 59.46 % for the fruiting rate, the number of seeds/fruit, the percentage of the average seed weight and the percentage of normal seeds respectively. This research shows the necessity of management of *X. olivacea* in terms of nest provision and the installation of *A. m. adansonii* colonies close to sesame farm is worthy to increase quantity and quality of the production. Furthermore, insecticides and/or herbicide treatments should be avoided during the flowering period of *S. indicum* to protect pollinating insects such as *X. olivacea* and *A. m. adansonii*.

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