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Foraging activity of *Ceratina* sp. (Hymenoptera - Apidae) on the Fluted Pumpkin (*Telfairia occidentalis*; Cucurbitaceae) Flowers in Bayelle -Bamenda III (North-West Region- Cameroon)

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Abstract: *Studies on the Foraging activity of Ceratina sp. on the fluted pumpkin flowers in Bayelle under field conditions were conducted from April 2022 to March 2023. The insects were collected on three experimental beds (4.5m*1m each) by hand, aspirator and sweep net depending the type of insects. The results show that a total of 12 insect species belonging to five Orders were collected, stored in 70^0 alcohol and identified. Four insect species belonged to Diptera Order (78.27%) and five species to Hymenoptera Order (19.31%). The Orders Hemiptera (1.38%), Mantodea (0.85%) and Coleoptera (0.19%) showed one species each. Among all the insect species recorded, Ceratina sp. (10,74 %) was the main floral pollinator and harvested pollen and nectar. Ceratina sp was present the all day with a peak of activity between 1p.m-2p.m. Others Pollinivorous, nectarivorous, flowers, leaves, stem feeders and predatory insects were also found on the plant. Due to the dioecious characteristic of the plant with the presence of 7 female flowers compared to 6809 male flowers, the fruiting rate was low (28.5%). This study shows that the activities carry out by Ceratina sp. should be exploited to enhance the yield in quality and quantity of the fluted pumpkin.*

Keywords: *fluted pumpkin, Ceratina sp., flowers, nectar, pollen, yield, Bayelle.*

1. INTRODUCTION

The shortage of animal protein particularly in developing countries in Africa has necessitated investigation of several novel sources of protein such as leafy vegetables. In most recent years in Africa and south-east Asia, the consumption, demand and market value of leafy vegetables have been on the rapid and steady rise due to their high nutritional and health benefits [1]. *Telfairia occidentalis*, one of these vegetables, strongly enhances the livelihoods of poor resource base farmers because it can be harvested and sold throughout the year at weekly intervals [1]. Also known as the fluted pumpkin, courge cannelée (in French), and okonghobong (in Cameroon), *T. occidentalis*, is a tropical vine grown and vegetable of the Cucurbitaceae family that is primarily located in Africa's subtropical region [2]. The plant is common in Benin, Nigeria and Cameroon where it is highly valued and primarily used for its foliage, seeds and shoots [3, 4]. The plant contains a lot of protein, oil, vitamins and nutrients [5] with its leaves containing proteins (29%), fats (18%), minerals and vitamins (20%) [6]. It has a creeping growth habit that spreads across the ground to create an efficient cover against erosion [7]. Growing the fluted pumpkin improves the livelihoods of low resource base farmers because it can be harvested and sold at weekly intervals throughout the year, unlike other locally cultivated vegetable crops. The fluted pumpkin is one of the highly prized vegetable crops in Cameroon [1]. The harvested leaves are sold in Cameroon in bunches wrapped with plantains leaves, with prices ranging from 200 to 1000 F CFA based on quantity [8]. This is particularly true in the

Northwest and Southwest Region of Cameroon, where its culture is now a major source of income but its agronomy according to Olaniyi and Akanbi [9] has been neglected because it does not fall into the export category. Its production has remained traditionally on kitchen-garden scales with very low leafy yields leaving many people unable to consume this vegetable and as a result, people suffer from malnutrition and their source of income is reduced [10]. To meet the challenges of greater production, any constraints on *T. occidentalis* growth and cultivation must be addressed. Thus, it is necessary to improve the quantity and quality of this vegetable to meet up with the demands in local and urban markets. Agricultural development programs must consider all the factors that can lead to increased yields. Pollinating insects are among these variables [11]. Insects serve important ecological functions in a variety of processes, including nutrient cycling, seed dispersal, bioturbation, pollination, and pest control [12]. The presence of different insects on the plants each year has a significant effect on sustainable production [13]. According to Akoroda [14], the aphid *Nomia tridentuta* may be a pollinator of *T. occidentalis* due to its frequent presence on female flowers, but other insects such as bees, dipteran flies, bug nymphs, black ants, and carpenter bees also flourish in *Telfairia* farms. *Ceratina* sp. appears to prefer the color of the fluted pumpkin blossoms over other pollinating insects. The species have been observed to be drawn to white and yellow blooms [15]. Nonetheless, the faintly scented nectar and caryophyllaceous shape of the fluted pumpkin blooms encourage insect pollination. Among the insect visitors, the study of *Ceratina* sp. activities on the fluted pumpkin plant is therefore very important as this will help to exploit the data by farmers in order to increase their productivity especially in the Northwest Region.

2. Study Site

The experimental investigations were carried out from the 4th of April 2022 to the 23rd of March 2023 in Bayelle-Bamenda III, Mezam Division, North-West Region of Cameroon (fig. 1). The experimental field was a plot centered on a point of 5.96344 N5 57’48.38291 of latitude, 10.17221 E10 10 19.9571 of longitude and 1345 m of altitude above sea level. The climate of Bamenda is mainly of the equatorial monsoonal type characterized by high rainfall and relative humidity with two main seasons: a short dry season of 5 months (November to March) and a long rainy season which last for 7 months, April to October [16]. The average annual temperature is 25ºC with mean annual rainfall of 2670 mm [17]. The primary vegetation is the savannah type called “The Bamenda Grass fields”, with stunted trees here and there which is intensely degraded by man for agriculture and urbanization; Red Ferrallitic soils in the uplands and Hydromorphic soils in the marshy valleys are the predominant soil types [18]**.** Agriculture, more specifically market gardening, which involves growing vegetables including huckleberry, waterleaf, and bitter leaf, is the main activity. A few people cultivate the fluted pumpkin on a small scale in their gardens and on the walls of their gates.

Figure 1: Location of study site

3. Materials and Methods

3.1. Biological material

The animal material was represented by the individuals of *Ceratina* sp. which came from the nests present on the study site and all the other insect fauna naturally present in the experimental environment. The plant material consists of seeds of the fluted pumpkin which were bought in Nkwen market and partially dried before planting (fig. 2).

Figure 2: (A) Dried seeds of fluted pumpkin; (**B**): *Ceratina* sp. specimen

3.2. Preparation of the experimental plot

A 28.21 m^2 experimental field was plowed. Prior to planting, the removed weeds were given time to rot and be integrated into the soil. Six ridges measuring 4.5m long, 1m wide, and 20 cm high each were created through tilling with a hoe.

3.3. Sowing and tending the crop.

On the 4^{th} of April 2022, two grains of seed were put into each hole, nine holes were made per line, and there were two lines. The spacing was 31cm by 45cm between the lines. To prevent the seeds from drying out and to boost their chances of surviving, the seeds were buried 5 to 6 cm beneath the surface of the soil and covered with topsoil.

Seven days after germination (1^{st} May 2022), the seedlings were manually uprooted to thin them out, leaving just one plant per hole (Only the strongest foot of each hole was chosen for the investigations). Bamboo's, nails, and a harmer were bought in Nkwen Market and utilized to build table beds on which the climbing tendrils could coil to prevent them from spreading uncontrollably on the ground. Ropes were used to guide newly sprouted plants so they could develop and wrap around the built-in table beds.

From germination to the appearance of the first flower buds, the experimental plot was weeded and hoed, respectively, every two weeks. After the first flower had blossomed, weeding was done by hand until harvest.

3.4. Determination of the reproduction mode of fluted pumpkin

From the 4^{th} of April 2022 to the 23^{rd} of March 2023, six ridges carrying 108 fluted pumpkin plants with 6816 flowers at the bud stage were studied. Three ridges carrying 54 plants with 5174 free flowers to allow the visits of insects (treatment 1) and three ridges carrying 54 plants with 1642 flowers were bagged to prevent visitors (treatment 2) using a 1mm² mesh screen (fig. 3).

Twenty days after shedding the last flower, the number of fruits was assessed in each treatment. The fruiting index (Fi) was then calculated as described by Tchuenguem et *al*. [19]: Fi = Fx/Fy where Fy is the number of fruits formed and Fx the number of viable flowers initially set. The allogamy rate (Alr) from which derives the autogamy rate (Atr) was expressed as the difference in fruiting indexes between treatment 1 (unprotected flowers) and treatment 2 (bagged flowers) as follows:

$$Alr = [(Fi_1 - Fi_2) / Fi_1] \times 100$$

where Fi_1 and Fi_2 are respectively the fruiting average indexes of treatments 1 and 2.

$$Atr = 100 - Alr.$$

Figure 3: Fluted pumpkin plants showing the different treatments; 1: Unprotected flower; 2: Protected flower using a 1mm² mesh screen**.**

3.5. Determination of anthophilous insect's fauna and study of their activities on fluted pumpkin plant.

The frequency of insects in the fluted pumpkin was determined based on observations on the different parts of the plant flowers every two days, during each of the following daily time frame, from 4th of April 2022 to the 23rd of March 2023: 7-8 a.m., 9-10 a.m., 11-12 noon, 1-2 p.m., 3-4 p.m. and 5-6 p.m. In a slow walk along all plants, the identity of all insects that visited the fluted pumpkin was recorded. At each passage, the different insects were counted on the stems, the leaves and the blooming flowers (those that could offer nectar and / or pollen to insects). Specimens of all insect taxa were caught with an insect net and for each species, 3 to 5 insect specimens were captured. These insects were conserved in 70^0 ethanol for subsequent taxonomy determination except for Lepidoptera which were conserved following Borror and White [20] recommendations. All insects encountered on the plant were registered and the cumulated results expressed in number of visits to determine their relative frequency in the anthophilous entomofauna of the fluted pumpkin plant. In addition to the determination of the insects' frequency, direct observations of the foraging activity on stem, leaves and flowers were made on insect fauna in the experimental field. The products harvested by the insect species during each visit were registered based on their foraging behavior. Nectar foragers are expected to extend their proboscis to the base of the corolla and the stigma, while pollen gatherers are expected to scratch the anthers with their mandibles or legs [21]. Harvested pollen can be observed on transport organs, especially in the baskets of the hind legs in Apidae, the collecting hairs of the legs in Halictidae and the ventral brush in Megachilidae [20]. Pollen harvesting can be active (if pollen is collected) or passive if by taking the nectar, the pollen accumulates on the insect's tegument and then collects it in its storage organs [22]. Stem feeders and leaf feeders were seen eating those parts of the plant. During the same time that the insects encountered on the different part of the plant were registered, the types of products collected by those insect species were noted (using a stopwatch). The time that an insect takes to collect a product (nectar and / or pollen) on a flower is the duration of visit. The duration of pollen harvest visits and that of nectar collection was timed separately during the same dates and according to five daily periods (8-9 a.m, 10-11 a.m, 12-1 p.m, 2-3 p.m and 4-5 p.m), at the rate of at least five observations per daily period. In the morning of each sampling day, the number of opened flowers carried by each ridge was counted and was registered. During each daily period of observations, the temperature and relative humidity of the station were registered using a mobile thermo-hygrometer, every one hour.

3.6. Evaluation of the impact of insects on the fluted pumpkin fruit yields

This evaluation was based on the impact of insect visiting flowers on pollination, the impact of pollination on fructification of the fluted pumpkin, and the comparison of fruiting rate of treatment 1 (unprotected flowers) and treatment 2 (bagged flowers). At maturity, fruits grown from each treatment were harvested and were individually tagged. A comparison was done on the fruit set rate between treatments. The fruit set rate [(number of fruits formed/number of flowers formed) ×100] was determined based on the number of flowers and the number of actual fruits formed. The percentage of the fruit set rate due to the influence of the foraging insects was calculated based on the relative difference in fruit set between bagged (treatment 2) and open-pollinated flowers (treatment 1) [23].

3.7. Data analysis

The data was processed using descriptive statistics (calculation of means, standard deviations and percentages) and three tests: Pearson correlation coefficient (r) for studying the linear relationships between two variables, Student (t) for comparison of means of two samples and Chi-square (x^2) for comparison of percentages [24]. This was done using Excel.

4. RESULTS

4.1. Mode of reproduction of the fluted pumpkin

The fruiting index was 0 for treatment 1 and 0.29 for treatment 2. The total number of flowers studied in treatment 1 (free flowers) was essentially male flowers while in treatment 2 (protected flowers), 7 flowers were female, and the rest were male flowers. This resulted in no fruit set in treatment 1 and 2 fruits set in treatment 2. This result could not allow us to calculate the allogamy rate (Alr) and the autogamy rate (Atr)

4.2. Diversity of insects in the entomofauna of the fluted pumpkin

A total of 3195 visits of 12 species of insects were collected on the different parts of the fluted pumpkin in Bayelle from May 2022 to February 2023. The insect species (fig.4) were grouped into 10 Families under 5 Orders (Table 1). Order Hymenoptera was the order with the greatest number of species (5), followed by Order Diptera with 4 species, followed by Coleoptera, Hemiptera and Mantodea with one species each. *Musca domestica* was the most frequent (36.68 %) insect visitor, followed by *Drosophila melanogaster* (30.92%) and *Ceratina* sp. (10.74%). The rest of the species had less than 7% visit rates. The number and percentage of visits of the different insects are displayed in Table 1.

Table1: Insects recorded on the fluted pumpkin plant in Bayelle from May 2022 to February 2023, number and percentage of visits by the different insects.

Order	Family	Common name	Scientific name	n	P (%)
Coleoptera	Coccinellidae	Lady bug (l, s)	*Coccinella septempunctata*	6	0.19
Diptera	Calliphoridae	Blow fly(l, s, f)	*Chrysomya rufifacies*	200	6.26
	Drosophillidae	Fruit fly(l, s)	*Drosophila melanogaster*	988	30.92
	Muscidae	Housefly(l, s, f)	*Musca domestica*	1172	36.68
	Sarcophaginae	Flesh fly(l, s)	*Sarcophaga africa*	141	4.41
Hemiptera	Pentatomidae	Rice stink bug(s)	*Oebalus pugnax*	44	1.38
Hymenoptera	Apidae	Honeybee(f)	*Apis mellifera*	6	0.19
		small carpenter bees(f)	***Ceratina* sp.**	**343**	**10.74**
		Capenter bee(f)	*Xylocopa olivacea*	15	0.47
	Formicidae	Ant (l, s, f)	*Camponotus*	142	4.44
	Pompillidae	Small black wasp(l, s)	*Auplopus carbonarius*	111	3.47
Mantodea	Mantidae	Praying Mantis (l, s)	*Sphodromantis viridis*	27	0.85
Total			12	3195	100

f: flowers; l: leaves; s: stem; n: number of visits to 6816 flowers in 44 days; P: percentage of visits = (n / 3195) × 100.

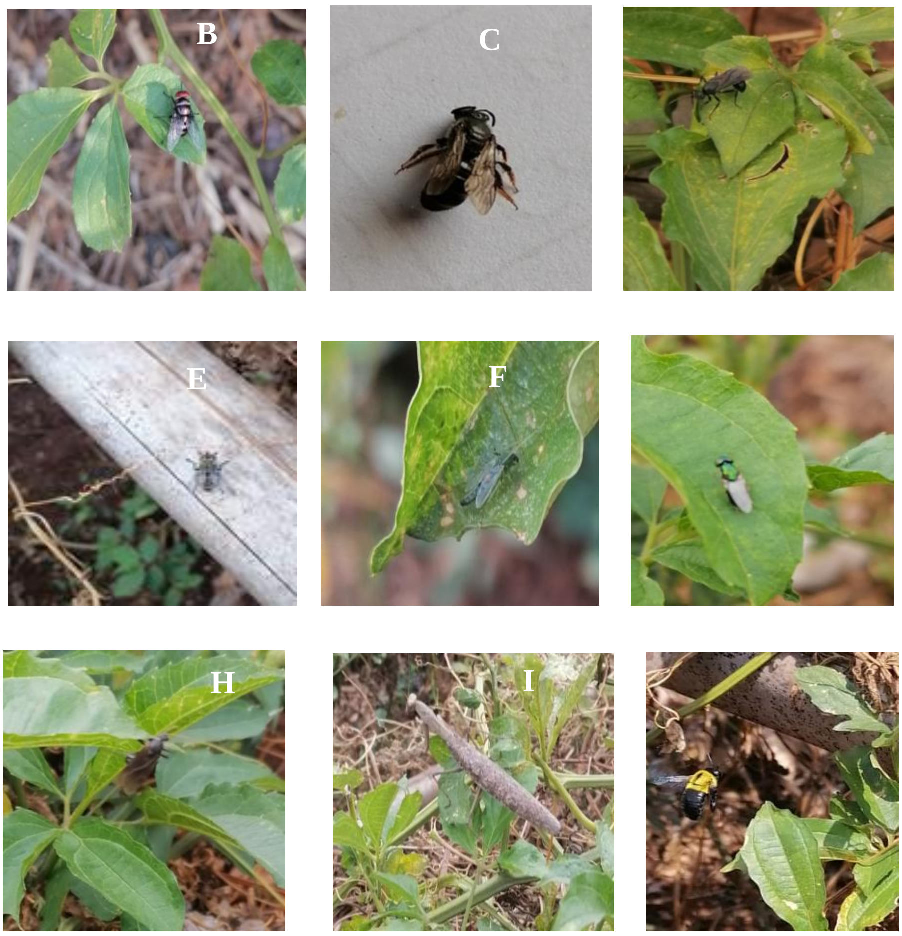

Figure 4: Some insects associated with the fluted pumpkin. **A:** *Musca domestica* (housefly); **B:** *Ceratina* sp. (small carpenter bees); **C:** *Auplopus carbonarius* (small black wasp); **D:** *Sarcophaga africa* (flesh fly); **E:** *Drosophila melanogaster* (fruit fly); **F:** *Chrysomya rufifacies* (blow fly); **G:** *Oebalus pugnax* (rice stink bug); **H:** *Sphodromantis viridis* (Praying mantid); **I:** *Xylocopa olivacea* (carpenter bee).

4.3. Products harvested on the fluted pumpkin plant

The fluted pumpkin plant recorded diverse insect visitations (Figure 5). However, the percentage of insect visitors was higher on the stem (39.13 %), followed by the leaves (34.78 %) and finally on the flowers (26.09 %)

4.3.1. On the stem and leaves

Insects such as *Oebalus pugnax* were found on the stem meanwhile other species such *Coccinella septempunctata*, *Drosophila melanogaster*, *Sarcophaga africa*, *Auplopus carbonarius* and *Sphodromantis viridis* were seen on the stems and leaves. They were observed consuming leaves as food, using leaves for mating, laying of eggs, resting and movement. Others such as *S. viridis* were also seen on the stems consuming other insect species and using the stems and leaves as support and for movement.

4.3.2. On the flowers

On the flowers of the fluted pumpkin, each of the individuals of *Ceratina* sp. collected pollen and/or nectar (fig. 5). It does so by plunging its head downwards at the base of the flower stamens using its mouth parts to collect nectar and using its legs as well as the hairs on its thorax and abdomen to collect pollen. Of all *Ceratina* sp. visits on the fluted pumpkin flowers, 8.75% were spent harvesting nectar, 50.73% collecting pollen, and 40.52% harvesting both nectar and pollen. Other insects that visited the flowers of the fluted pumpkin were *A. mellifera* and *X. olivacea*. Meanwhile, insects such as *C. rufifacies, M. domestica* and *P. clavate* visited the flowers, the leaves and the stems.

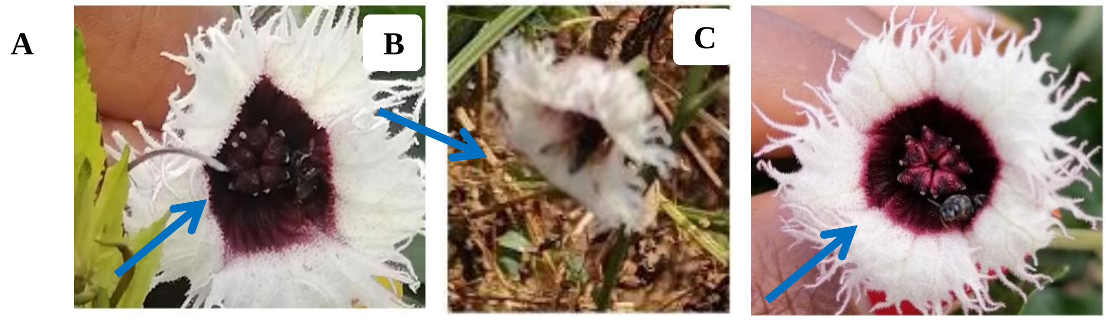

Figure 5: *Ceratina* sp. harvesting pollen (**A**) and nectar (**B**) in the flowers. *Ceratina* sp. leaving flower (**C**) after harvesting floral product.

4.4. Frequency of *Ceratina* sp. visits according to the daily observation time slots

Ceratina sp. often visit the blossoms of the fluted pumpkin between the hours of 7 a.m. and 6 p.m., the peak of activity of this insect species is between 1p.m and 2p.m (Fig. 6). The average humidity during this period is 48.07%, while the average ambient temperature is 26.07°C. These circumstances would favor a higher pollen and nectar content in the fluted pumpkin flowers, which would increase *Ceratina* sp. 's allure. The increasing frequency of visits by *Ceratina* sp. during this time may be partially explained by these variables.

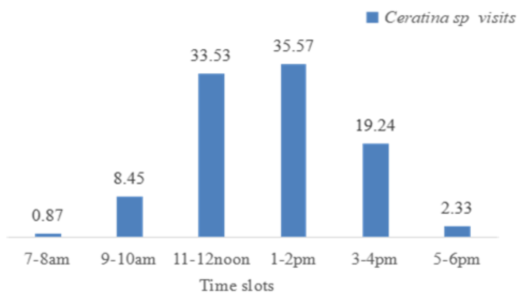

Figure 6: *Ceratina* sp. visits according to time slots from October 2022 to February 2023 in Bayelle.

4.5. Frequency of visits according to the opened flowers

From Figure 7, we see that *Ceratina* sp's visit increased from October 2022 progressively up to the month of December 2022 where it recorded the highest visit. This could be associated with the progressive increase in flower growth and production as many of the fluted pumpkin plants matured with time with many flowers opening fully. From the month of January 2023, the number of opened flowers as well as the number of *Ceratina* sp. visits began decreasing progressively until February 2023. We can see that the relationship between the number of opened flowers and the insect visit is directly proportional ($r=0.86$; $df=6$; $p<0.05$)**.**

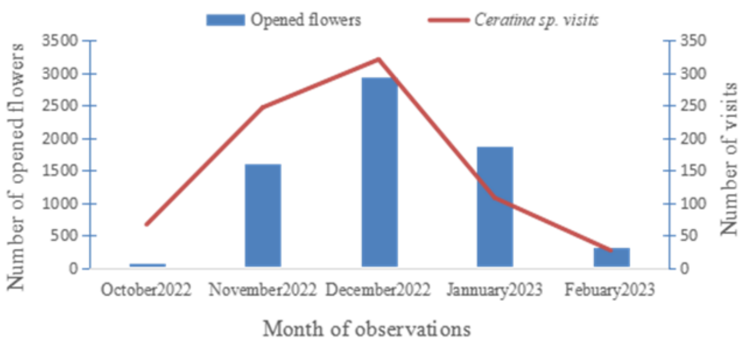

Figure 7: Frequency of Visits of *Ceratina* sp. to the opened flowers of the fluted pumpkin in Bayelle from October 2022 to February 2023.

4.6. Duration of visits on the flowers

Table 2 presents the duration of *Ceratina* sp. visits to a flower of the fluted pumpkin. It appears from the table that:

a) The average duration of a visit to a flower was 43.47 sec and 50.37 sec for the collection of nectar and pollen respectively; the difference between these two means is highly significant.

b) The average duration for pollen + nectar collection is 268.92 sec; the difference is highly significant between the average duration of nectar and pollen + nectar on the one hand and between the average duration of pollen and pollen + nectar on the other hand.

Table 2: Duration of nectar and pollen harvest of *Ceratina* sp. from the flowers of the fluted pumpkin in Bayelle from October 2022 to February 2023.

Parameters	Nectar (sec)	Pollen(sec)	Nectar + Pollen (sec)
m	43.47	50.37	268.92
s	10.6	26.81	140.86
n	60	62	50
max	73	174	658
min	17	14	62

m: average duration of visit; s: standard deviation; n: number of duration of visits; maxi: maximum; mini; minimum. Comparison of the average duration of *Ceratina* sp. visit: -t (nectar / pollen) = - 10.18, df = 120, p<0.001, HS); - t (nectar / nectar+ pollen) = - 63.94, df = 110 p<0.001, HS); -t (pollen / nectar+ pollen) = - 62.31, df = 110, p<0.001, HS).

4.7. Influence of some climatic factors on foraging activity

The activity of *Ceratina* sp. in the fluted pumpkin flowers appears to be influenced by temperature and humidity. High temperatures and low humidity were shown to be the ideal circumstances for insect activity, while low temperatures and high humidity were found to result in generally low insect activity (fig. 8). The correlation between temperature and number of visits was found positive and significant (r = 0.86; df = 4; p<0.05). Regarding the relative humidity of the air, our investigations on the fluted pumpkin revealed a correlation negative and significant (r = - 0.91; df = 4; p< 0.05).

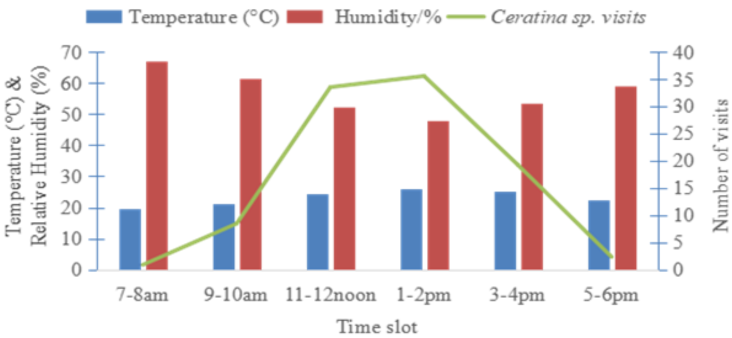

Figure 8: Daily variation of temperature, relative humidity of air and number of visits of *Ceratina* sp. on the flowers of the fluted pumpkin from October 2022 to February 2023 in Bayelle.

4.8. Foraging Ethiology of *Ceratina* sp.

Among the various insects observed, *Ceratina* sp. was seen to be the main insect foraging on a flower, they were very swift in their foraging habit. Movement from the tip of the petals to the anthers and then to the nectar chamber for nectar, feeding lasts between one and three minutes sometimes lasting longer when the sun was shining very bright (30- 32°c) and when not interrupted by wind, rain, or man. *Ceratina* sp. spend time (3 minutes averagely) on a male flower, and they fly and land on the petals of another male flower. This foraging was observed till about 5 pm because by 6 pm, most flowers had fallen off or withered.

4.9. Impact of *Ceratina* sp. on the pollination of the fluted pumpkin

Ceratina sp. was completely in contact with the anthers of the flowers in treatment 1 (free flowers) while collecting pollen and nectar. Flowers have pedicels, and the male flowers are placed on a straightforward pedunculate raceme. 30-100 flower buds can be found on a single raceme. On treatment 1 (free flowers), only male flowers were visible. Since the fluted pumpkin was found to be a dioecious plant with two defective flowers borne on distinct plants, the impact could not be measured as long as only male flowers were on treatment 1. However, insects were seen gathering floral product.

4.10. Fruit yields of the fluted pumpkin

The total number of flowers studied in treatment 1 (free flowers) was essentially male flowers while in lot 2 (protected flowers), 7 female flowers were observed, and the rest were male flowers. This resulted in no fruit set in treatment 1 but with 2 fruit set in treatment 2 (fig. 9). The fruit yields of protected flowers and unvisited flowers were higher 28.57% than those of flowers free pollinated from insects even though the overall fruiting rate was not considerable (Table 3).

Figure 9: Fluted pumpkin fruit set in treatment 2

Table 3: Fruiting rate according to the fluted pumpkin treatments from October 2022 to February 2023 in Bayelle

Treatments	NFS		NFF	FR(%)
	♂	♀		
1 (Ff)	5174	0	0	0
2 (Pf)	1635	7	2	28.57

NFS: number of flowers studied; NFF: number of fruits formed; FR: fruiting rate; Ff: free flowers; Pf: protected flowers; ♂: male flowers; ♀: female flowers

5. Discussion

The results from this study show that diverse insects carry out various activities on the fluted pumpkin plant in Bayelle-Bamenda III. A total of 12 insect species were observed on the plant and they belonged to 12 families and 5 Orders. The order Hymenoptera and Diptera were the main ones with 5 and 4 species respectively. Fayeun *et al.* [3] reported that insects from the Diptera Order such as *Cheilosia meigen* (Hoverfly*)*, *Musca* sp. (Green fly) and *Drosophilia* sp. (fruit fly) were floral visitors of the fluted pumpkin on their studies on the floral biology of the same plant in Nigeria.

The stem recorded the highest percentage of insect visits (39.13%) with 9 different species visiting them followed by the leaves (34.78%) with the visit of eight species with *Musca domestica* dominating with the number of visits on the stem and leaves. Most of the insects were seen feeding on the stems and leaves whereas others used the leaves as shade from excessive sunlight on sunny days as well as during rainy days. The flowers on the other hand recorded 26.09% of visits with 6 species of insects. These insects visited the flowers in other to feed the nectar found in the flowers during which the white sticky pollen of the fluted pumpkin plant adhered on their bodies enabling pollination from multiple floral visits.

This study has demonstrated that *Ceratina* sp. was the main floral visitor of the fluted pumpkin flowers during the observation period. This observation differs from the main floral visitor *Cheilosia* sp. reported on the fluted pumpkin plant by Fayeune *et al*. [3] on their study in Nigeria on the floral biology of that plant. Akoroda, [25] in his study on the ethnobotany of *T. occidentalis* in Nigeria suggested that the aphid, *Nomia tridentuta*, could be a pollinator of the fluted pumpkin because of its frequent presence on the female flowers. The change in geographical location could be a major account for this difference. As such, we can say that insects' activity varies from year to year and from place to place.

In this study, *Ceratina* sp. always visited the fluted pumpkin flowers for the collection of nectar and pollen. *Ceratina* sp. was found to be polylectic as they were found visiting numerous and diverse floral resources such as the okra plant found near the experimental farm. A similar observation was made by Ali *et al*. [26] in Pakistan on the activities of *Ceratina smaragdula* on leguminous and cucurbit crops in the region. *Ceratina* sp. has also been reported to be pollinators of *Citrullus lanatus* and *Brassica rapa* flower from their collection of nectar and pollen [27, 28]. According to Doyle *et al*. [29], flowers are vital to insects for different reasons: they provide nectar as a food source and the pollen required for ovarian development. Such visits by insect pollinators usually impact the quality and quantity of agricultural crops by the transformation of nectar and pollen from one flower to another flower in agricultural and horticultural crops. As such *Ceratina* sp. being an important pollinator has the potential for use in agroecosystems [26]. According to Haldhar *et al*. [30], horticulture crops are highly cross-pollinated in nature, so intervention of pollinator insects is mandatory to improve the yield and quality of these crops. Moreover, Stein *et al.* [31] reported that insect pollinators are responsible for maintaining the yield and genetic variability accompanying sexual reproduction and reducing inbreeding depression in crops. The relative humidity and temperature of the study site seemed to influence the visits of *Ceratina* sp. on the fluted pumpkin. Tuell & Isaacs [32] reported that the weather during bloom affects the abundance and foraging of insect pollinators. Moreover, flowering insects preferred warm and sunny days for good floral activity [33].

Other insects such as ladybugs, blowflies, fruit flies, houseflies, flesh flies, hoverflies, Rice stink bugs, ants, small black wasps and praying mantis were observed on the stems and leaves of the fluted pumpkin plant. They were seen to eat vegetation; using plant sap or cell contents as a food source and numerous flies have larvae that live in or on plants. Many insects like *Sphodromantis viridis* (praying mantid) were seen preying on others, including bugs, flies, ants, and wasps. Akoroda [14] in his work in Nigeria also recorded that other insect like bees, dipteran flies, nymphs of bugs, black ants and carpenter bees thrive in Telfairia farms too since *T. occidentalis* depend on sufficient pollen transfer to the stigma by their pollinators (such as Bees and ants). Ann and Julius [34] reported that ants are very slow pollinators of *T. occidentalis* and the activities of the bees are being affected by low temperature and insufficient food supply (nectar and pollen grains). This makes bees unable to use their wings at temperatures lower than 25°C which can be attained at night [34].

The fluted pumpkin is a dioecious plant and treatment 1 contained only male flowers hence no fruits were produced in that treatment. Schaefer and Renner [35] reported that within the Cucurbitaceae, monoecy is common and dioecy is comparatively rare. Fayeune *et al*. [3] in their studies in Nigeria reported that the male flowers of the fluted pumpkin do dominate the flowering period with a ratio of about 1000:1 male to female flowers per plant. This was like the observations made in this study where only 7 female flowers were seen compared to thousands of male flowers. Akoroda [14] also reported in his work in Nigeria that about 10-15% of a given female population do not flower in the first year of planting and abortion of fruits is high. This probably explains why in our study only 2 fruits were formed. In addition, the few fruits set could have resulted because female flowering took longer than expected and the female flowers were being fertilized later. However, Akoroda [14] reported that fluted pumpkin grown in isolation produced a fruit with four seeds which the authors opined to be either a monoecious plant or it was exhibiting parthenocarpy. Ann and Julius [34] attributed the limited quantity of fruits to be linked to the female flower's brief anthesis and the small number of female plants. Ejimofor *et al*. [36] in Nigeria reported that the developing fruit can occasionally hinder the later-setting fruit, resulting in only 1-4 of approximately 18 solitary blooms generated by female plants maturing into ripe fruits.

The fruit yields were 28.57%. this result is in accordance with the one of Ejimofor *et al.* [36] in Nigeria where only 35% of the female plants in a population bear fruit.

Contrary to the high temperatures (26.07°C) and humidity of 67.27% recorded in this study which led to poor fruit set, Sugiyama [37] associated meteorological circumstances typified by a low temperature and little sunshine to be blame for cucurbits' poor fruit setting ratio and abortion of female flowers. Ineffective pollination practices (viable pollen grains, the existence of receptive stigma, and adequate pollen transport to the stigma) were also a contributing factor in the loss of fruit yield [38]. Pollinators must transmit enough pollen to the stigma for the fluted pumpkin to thrive.

6. Conclusion

Telfairia occidentalis is a plant that attracts diverse insect species found on the stem, leaves and flowers of the plant. A total of 12 insect species belonging to five Orders were collected between 7am and 6pm; Four insect species belonged to the Order Diptera (78.27%) and five species to the Order Hymenoptera (19.31%). The Orders Hemiptera (1.38%), Mantodea (0.85%) and Coleoptera (0.19%) showed one species each. Among all the insect species recorded, *Musca domestica* (36.68%) was the most active and abundant visiting species. *Ceratina* sp. (10,74 %) was the main floral visitor and harvested pollen and nectar. Due to the dioecious characteristic of the plant with the presence of 7 female flowers, the fruiting rate was low (28.5%). This study shows that the activities carried by *Ceratina* sp. should be exploited to enhance the yield of this vegetable in order to meet the nutritional needs of the demanding population.

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