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INSECTS OBSERVED ON COWPEA FLOWERS IN THREE DISTRICTS IN THE CENTRAL REGION OF GHANA

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ABSTRACT

Globally, it has been estimated that more than 100,000 species of wild plants depend on insects for pollination and reproduction. In Africa, and for that matter Ghana, not much is known about crop pollinators, especially legumes such as cowpea. In Ghana, little is known about even insects that visit the cowpea flowers. However, if the insects that visit the cowpea flowers are known it would serve as a platform to investigate insects that can possibly cause pollination in cowpea. Hence, this study was undertaken to verify the types of insects that visit cowpea flowers in three districts in the Central Region of Ghana. As a result, insects that visited cowpea flowers on surveyed, and the researcher's own established farms were observed on the petals, tip of the stigma and inside the flowers. Samples of insects collected were identified. Also, percentage frequency of occurrence of the insects on the various parts of the flowers was determined. Differences between total frequencies were determined using chi square (χ^2) analysis. The main insects observed on the cowpea flowers were bees such as *Apis mellifera, Ceratina sp, Megachile sp, Xylocopa calens, Xylocopa imitator, Braussepis sp., .Lipotriches* sp., *Melecta* sp and *Amegilla* sp. and other insects, such as thrips, flies, butterflies / moths, beetles, and *Dysdercus* sp. Thrips were the insects most often observed on the cowpea flowers in the surveyed farms, followed by flies or dipterans, *Lasioglossium* sp and butterflies/moths. From the researcher's own established farm, during the minor rainy season, the most active insect observed on the tip of stigmas of the flowers was *Megachil*e sp whilst thrips, butterflies / moths, L*asioglossum* sp. and flies were active on the petals of the flowers. The differences between the total frequencies were highly significant (χ^2 = 154.61; P = 0.001). Indications are that *Ceratina* is most likely to be cowpea flower pest rather than a pollinator. However, further research into the role of *Ceratina* on cowpea flowers is recommended.

Key words: Cowpea, flower visitor, pollination, insect, pest

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INTRODUCTION

Agriculture plays an important role in the economy of Ghana. It is estimated that about seventy per cent of the working population of Ghana is in the field of agriculture [1]. Going round the country one can see different types of crops under cultivation. The sizes of the various farms of the crops under cultivation generally depend on the economic importance of the crop or the capabilities of the farmers. Since Ghana largely depends on cocoa for foreign exchange, cocoa farms are generally big. Other important crops in the country are oil palm, coffee, citrus, cassava, rice, millet and sorghum. Some of these crops can also be grown on large, average or small- scale depending on the motive and capability of the farmer. Some other crops are generally grown on subsistent level, though they form part of the regular food chain of the country. One of such crops is cowpea.

Generally, farms can be considered as agro-ecosystems. An ecosystem is the basic functional unit of nature made up of living organisms and their non-living environment [2]. It can also be defined as an interacting system of living organisms in an area and their physical environments [3]. Other authors [4] defined it as biotic and abiotic components of an area. A number of interactive relationships exist between plants and animals in the ecosystem. One of such relationships is the interaction between flowers and flower visitors. A flower visitor can be any animal that visits the flowers of a plant [5].

It has been established by Eardley [6] that to attract visitors, plants use various cues such as shape, color and smell, and they usually provide a food reward. Many flower visitors end up causing pollination whilst others just end up obtaining food in the flowers and others are predators that feed on pollinators [5]. Pollination is the transfer of pollen grains from an anther to a receptive floral stigma [7]. Pollination takes place by means of animals (pollinators), wind and water. Pollinators are organisms that transfer pollen grains from the anther to the stigma of the same flower or different flower of the same plant or another plant of closely related species resulting in fertilization. Pollinators are considered as animals that provide pollination services [6]. No animal pollinates flowers deliberately. They visit flowers for food: nectar, pollen and plant oils. Pollination precedes fertilization and fertilization results directly in the plant producing seeds and fruits [7].

Though, pollination is an essential ecosystem service nature provides worldwide [7], legumes including cowpeas have mixed stories of pollination. While some authorities are convinced that cowpeas are self-pollinated [8, 9, 10], others thought that they are cross-pollinated [11, 12], whereas yet another group has it that it undergoes both self- and cross-pollination [10, 13]. It is also established that insect pollinators are essential for many fruit and vegetable crops and the demand for pollinators grows as the need for agricultural productivity increases [7]. According to African Pollinator Initiative (API) [7], pollinators have real commercial values, although this is not always appreciated. For example, some West African beetles provide over US $150 million per year in terms of crop production in Southwest Asia. However, remarkably little is

known about pollinators in Africa, especially legumes such as cowpea. Though it has been estimated that more than 100,000 species of wild plants depend upon insects for pollination and reproduction [14], in Ghana little is known about even insects that visit the cowpea flowers. However, it is considered that knowledge of the very insects that visit the cowpea flowers will be a prelude to investigating those that can possibly cause pollination in cowpea. Hence, this study was undertaken to verify the types of insects that visit cowpea flowers in three districts in the Central Region of Ghana. Its specific objectives were to identify insect flower visitors of cowpea, and to find out which of them is most commonly found on cowpea flowers.

Research question

Which types of insects visit cowpea flowers in three districts in the Central Region of Ghana?

Hypothesis

There is no difference between the frequencies of occurrence of insects on cowpea flowers.

METHODOLOGY

The study area

There are 10 administrative regions in Ghana. One of such administrative regions is the Central Region. The Central Region is bordered by the Ashanti and Eastern Regions to the North, Western Region to the West, Greater Accra Region to the East and the Atlantic Ocean to the South [15] (Plate 1). There are 13 administrative districts in the region (at the time of this study) [15]. The districts are: Upper Denkyira, Twifo/Hemang Lower Denkyira, Assin North, Assin South, Abura-Asebu-Kwamankese, Cape Coast Municipality, Mfantseman, Ajumako/Enyan/Esiam, Asikuma/Odoben/Brakwa, Gomoa, Agona and Ewutu-Effutu-Senya districts (Plate 2) [15].

The study covered Agona, Gomoa and Ewutu-Effutu-Senya districts. The capital of Agona district is Swedru. The capital of Gomoa district is Apam. The capital of Awutu-Effutu-Senya district is Winneba [16]. There are two main rainy seasons in the region. The peak of the major season is in June. The vegetation is divided into dry coastal savanna stretching about 15 km inland, and a tropical rain forest with various reserve areas [17].

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Plate 1: Map of Ghana showing the various regions (not to scale)

The Agona District is in the forest zone and has two main growing/wet seasons. The dry season lasts from December to March with the highest mean monthly temperature of 33.8^{0}C being recorded between March and April. Gomoa and Ewutu-Efutu-Senya Districts have two main vegetation zones, the coastal savannah and the moist semi-deciduous forest. The coastal savannah consists mainly of grassland and trees of patches of shrubs, while the semi-deciduous forest is characterized by tall trees interspersed with grass cover, shrubs and soft woody species [18, 19].

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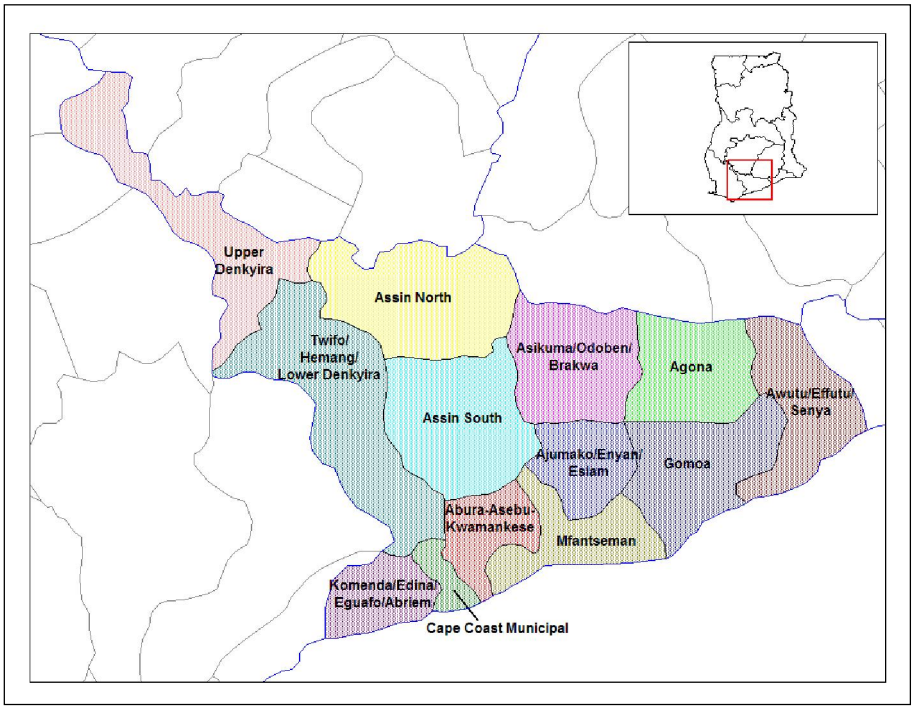

Plate 2: Map of Central Region showing the various districts at the time of the study (not to scale)

Survey of cowpea farms

Thirteen cowpea farms along major lorry roads in three districts (four in Agona District, four in Ewutu – Effutu – Senya District and five in Gomoa District) in the Central Region of Ghana were surveyed for cowpea flower insect visitors. This was done when about half of the plant population started flowering (12^{th} to 29^{th} November, 2005). Selection of farms along major roads was done because ease of entry. The survey was basically to find out the types of insects that visit the cowpea flowers. Since cowpea farms could mainly be found at a kilometer away from each other along the roads, the selected farms were at least one kilometer apart. Farms were visited between 6.00 am and 12.00 mid-day each day. This is because the cowpea flowers open early, around 5.30 am and close by 12.00 mid-day. At least three farms were visited each day. Each farm was visited two times on two different days. Fifty flowers were selected randomly at 3-metre interval in each farm. All the insects observed were recorded according to the specific part of the flower where they were observed (on petals, on the tip of the stigma and inside the flower (Plate 3). Samples of insect visitors observed on the flowers were collected and identified. The percentage frequency of occurrence of each species on each part of the flower was determined. The differences between the frequencies of occurrence on various parts of the flowers were calculated by means of chi-square (χ^2) analysis.

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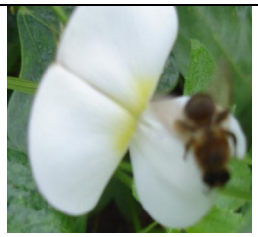
 **A) Cowpea flower with a fly (a dipteran) on the petals**	 **B) Cowpea flower with a bee piercing its tongue into the ovary**	 **C) Cowpea flower with a bee on the petals**

Plate 3: Cowpea flowers with insects on different

Sampling on self-established farm (experimental farm)

A cowpea farm was established about one kilometer away from Ekwamkrom, a village in the Gomoa District. Ekwamkrom is about one kilometer away from Agona Swedru on the Winneba-Swedru highway. The experimental site was made up of a mixture of elephant grass and *Chromolaena odorata,* commonly known as Acheampong weed in Ghana (Transitional forest). The farm was 15 by 25 metres in dimension.

It was observed that cowpea farmers in the experimental area were doing major rainy season sowing between April and June, while the minor rainy season's sowing was done between August and October. Some experts [20, 21] stated that in the transition forest zone sowing should be done from April to May in the major rainy season and from August to September in the minor rainy season. Since the experimental site was more of transition forest zone than forest zone, the major rainy season sowing was done on 3rd April, 2006 and in the minor rainy season sowing took place on 21st September, 2006. It was also observed that farmers preferred a cowpea variety commonly called black eye to the nationally recommended varieties. A survey of bean sellers in the area revealed that black eye is commonly consumed by the public. The reasons given for this were that the variety is easy to cook and swells considerably. Hence, black eye was the variety used for this experiment. The seeds were purchased from seed and agrochemical sellers in Agona Swedru. Three seeds were sown per hole about 2.5cm deep. Seeds were sown 30 cm between plants and 90 cm between rows. When seedlings were two weeks old, the plants were thinned to two per hole. Plants depended on natural rainfall. Throughout the experiment there was no pesticide application.

When the plants started flowering, fifty flowers were selected randomly at 3-metre interval and observation for flower visitors was made every other day. It has been observed that cowpea flowers open early in the morning, close before noon and fall the same day [22]. Hence, observation was made between 6am and 12 mid-day. Since the main intention of this study was just to find out the insects that visit cowpea flowers in the area, all the insects observed were recorded according to the specific part of the flower that they were observed (on petals, on the tip of the stigma and

inside the flower (Plate 3). Samples of the insect visitors observed on the flowers were collected and identified. The frequency of occurrence of each species on each part of the flower was determined. Percentage frequencies were calculated. The frequencies were compared using chi-square (χ^2) analysis to determine the differences between the frequencies of occurrence of the insects on various parts of the flowers.

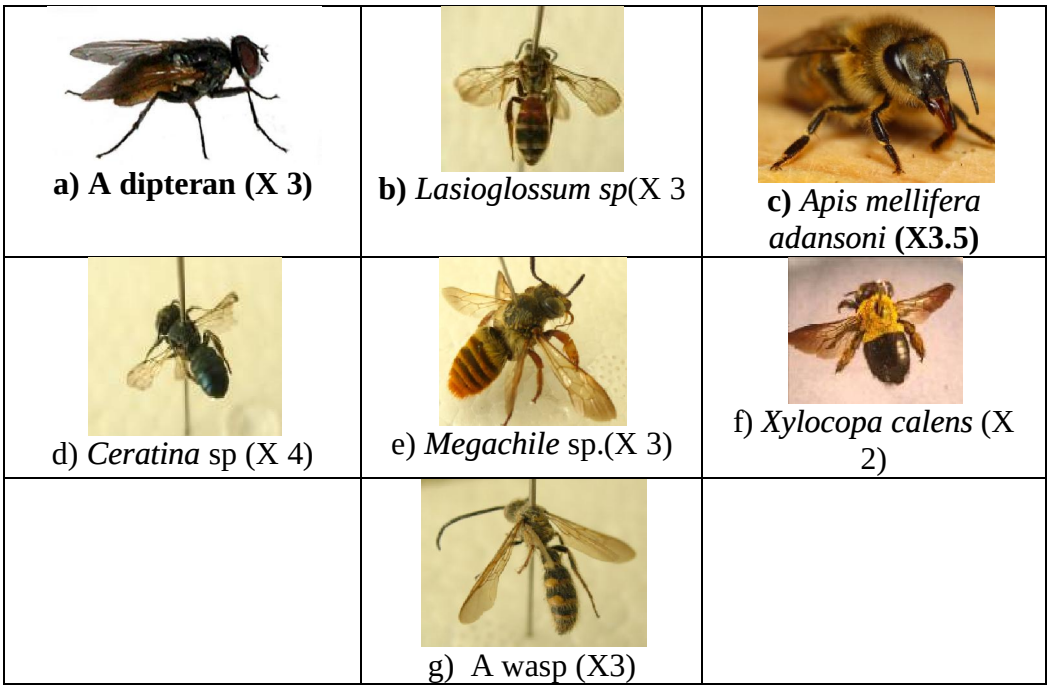
In the major rainy season in 2006, observation was made for three weeks and later when the plants started re-flowering observation was made for one week. However, in the minor rainy season in 2006, the plants died off after sampling for three weeks. Therefore, there was no other sampling after three weeks.

RESULTS

From survey farms

Throughout the survey, the insects observed on the cowpea flowers were flies (Dipterans), wasps (Hymenoptera); bees such as *Lasioglossum* sp (Hymenoptera: Halicitidae; Halicitinae), *Apis mellifera adansoni* (Hymenoptera: Apidae), *Ceratina sp*

(Hymenoptera: Apidae; Xylocopinae), *Megachile* sp. (Hymenoptera: Megachilidae; Megachilinae), and *Xylocopa calens* (Hymenoptera: Apidae; Xylocopinae) (Plate 4). Other insects collected were thrips, lepidopterans and ants.



a) A dipteran (X 3)

b) *Lasioglossum sp*(X 3

c) *Apis mellifera adansoni* **(X3.5)**

d) *Ceratina* sp (X 4)

e) *Megachile* sp.(X 3)

f) *Xylocopa calens* (X 2)

g) A wasp (X3)

Plate 4: Insects on cowpea flowers from survey farms

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Thrips were the insects most often observed on the cowpea flowers in the surveyed farms (total number of 490 = 44.75%), followed by flies (Dipterans) (total number of 243= 22.19%), lepidopterans (total number of 99 = 9.04%), and *Lasioglossum* sp (Halicitidae: Halicitinae) (total number of 92 = 8.40%). Thrips recorded 17.44% on the tip of stigma and 16.26% on petals while flies recorded 11.87% on the tip of stigma and 10.32% on petals. *Lasioglossum* sp. also recorded 6.39% on the tip of stigma and 2.0% on the petals. The differences between the total computed frequency of occurrence of insects on flowers were very highly significant (df= 9; χ^2= 1879.12; P = 0.001) (Table 1).

Self-established (experimental) farm results

The main insects observed on the cowpea flowers from the self-established (Experimental) farm during the major rainy season in 2006 were beetles and bees such as *Apis mellifera adansoni* (Hymenoptera: Apidae), *Ceratina sp* (Hymenoptera: Apidae; Xylocopinae), *Megachile* sp (Hymenoptera: Megachilidae; Megachilinae), *Xylocopa calens* (Hymenoptera: Apidae; Xylocopinae), *Xylocopa imitator* (Hymenoptera: Apidae; Xylocopinae), *Brausepis sp*. (Hymenoptera: Halictidae; Halictinae), *Lipotriches* Sp.(Hymenoptera: Halictidae; Halictinae), *Melecta* sp (Apidae; Apinae), and *Amegilla* Sp. (Hymenoptera: Apidae; Apinae) (Plate 5). Other insects observed on the flowers were thrips (Thripidae), flies (Dipterans), Lepidopterans (butterflies and moths), and *Dysdercus* sp.

a) *Xylocopa imitator (X 3)*

b) *Brausapis* sp (X2.5)

c) *Lipotriches sp* (X3)

d) *Melecta* sp. (X 3)

e) *Amegilla* sp. (X3)

f) A beetle (X 3)

Plate 5: Insects collected on the cowpea flowers from the self-established (experimental) farm

In the major rainy season, the insect most observed on flowers was thrips (total of 525 = 27.27%) followed by beetle (total of 519 = 26.96%), *Xylocopa calens* (total of 258 = 13.40%), *Ceratina* sp. (total of 175 = 9.09%), Lepidopterans (total of 119 = 6.18%), flies (total of 111 = 5.77%) and *Xylocopa imitator* (total of 107 = 5.56%) (Table 2). Though most often observed on the petals, thrips and beetles were also observed quite a number of times on the stigma and inside of the flowers. *Xylocopa calens* and *Ceratina* sp. were most often observed on the tip of the stigma. *Ceratina* was most often observed excavating the flowers and appeared to be feeding on the pollen grains .The differences between the total frequency of occurrence of the insects were very highly significant ($\chi^2 = 3051.15$; P = 0.001) (Table 2).

Results of insects observed on flowers from the experimental farm during the minor rainy season in 2006 are presented on table 3. The main insects observed on the cowpea flowers during the period were bees such as Apis *mellifera, Ceratina sp, Megachile sp.*, and *Lasioglossum* sp.; and non-bees such as thrips, flies and Lepidopterans. *Xylocopa* sp.were not observed. The most active insect on the tip of stigmas of the flowers was M*egachil*e sp (total of 79 = 36.24%) whilst thrips (total of 43 = 19.72%), Lepidopterans (total of 31 = 14.22%), L*asioglossum* sp (total of 20 = 9.17%) and flies (total of 19= 8.72%) were fairly active on the petals of the flowers. The differences between the total frequency of occurrence of insects were very highly significant ($\chi^2 = 154.61$; P = (Table 3).

DISCUSSION

Survey and field experiment results revealed almost the same types of insects observed on the cowpea flowers. Though most often observed on the petals, thrips and beetles were also observed quite a number of times on the stigma and inside the flowers. Some authors [23, 24] consider thrips (*Megalurothrips sjostedti*) (Trybon) and flower beetles as some of the major insect pests of economic importance on cowpea. These insects become pests when factors favour their abundance. Furthermore, it was alleged that among cowpea pests, the bean flower thrips, *Megalurothrips sjostedti* (Trybon) is the most destructive, attacking the reproductive structures of cowpea during plant development [25]. In this study, however, thrips was not observed causing any harm to the flowers. They were only observed on the petals and at times inside the flowers. However, the spotted beetles observed in abundance on the cowpea flowers were mostly found feeding on the cowpea flowers. It so happened that the beetles could eat all the flowers including the flower stalk. Hence, the beetles can be described as cowpea flower eaters, for that matter, pests. Furthermore, *Ceratina* sp was most often observed excavating the flowers and appeared to be feeding on the pollen grains. This behaviour portrayed *Ceratina* sp. also as cowpea flower eater more than a pollinator. This suggests that *Ceratina* sp. can also be described as cowpea flower pests than pollinators.

Xylocopa calens, *Megachile* and *Ceratina* sp. were most often observed on the tip of the stigma. Similar results were reported by Asiwe 10] where butterflies (Lepidoptera), moths (Lepidoptera), *Mylabris* spp., *Oothecca mutabilis* Sahlberg, dragonflies (Odonata), cotton stainer (*Dysdercus suturellus* Herrich Schäffer) and

Medythia quaterna Fairmaire were observed on cowpea flowers. However, these insects were not associated with pollen movement. On the other hand, carpenter bees (*Xylocopa virginica* L.), Digger bees (*Anthophora occidentalis* Cresson), Honey bees (*Apis mellifera* L.), Bumble bees (*Bombus grieocollis* De Geer), Bumble bees (*Bombus pennyslvanicus* De Geer), Leaf-cutting bees (*Megachile latimanus* Say) were associated with pollen movement [10]. Working on multiple floral visitors, Adler and Irwin [26] observed that *Xylocopa*, *Osmia* and *Habropoda* carried the most *Gelsemium sempervirens* (*Carolina jessamine*; Loganiaceae) pollen, followed by *Bombus* and *Apis*. They further observed that all bee species carried almost the same proportion of *G. sempervirens* pollen except *Apis*. *Xylocopa* visited flowers through the corolla opening rather than robbing. In this study also, pollen grains were observed on the legs and body surfaces of *Xylocopa* spp, *Melecta* sp., and *Apis mellifera*. Hence, these insects might have caused pollination of the cowpea flowers if they had dropped pollen grains on the stigmas.

Since bees and thrips were most often observed on the flowers, then it can be said that bees and thrips are very much associated with cowpea flowers from the survey and experimental farms. Also, since *Xylocopa* sp were very active during the major season but not in the minor season and *Megachile* sp. very active in the minor season but not in the major season, it is possible that there may be some conditions favoring the availability and activities of the two species during the various seasons. However, these conditions may need to be studied in subsequent works.

The most efficient pollinators must carry plenty of pollen on their bodies, brush against stigmas of flowers, transferring the pollen, visit several flowers of the same species in succession and more frequently from flower to flower and plant to plant [27]. These descriptions fit the behavior of *X. calens* and *Megachile* sp. on the cowpea flowers. It was realized that both *X. calens* and *Megachile* sp. carried a lot of pollen grains on their bodies. Both insects were also found to move fairly fast from flower to flower. On the flowers, they inserted their tongues down the ovary and their bodies brushed against the tip of the stigma of the flowers. Within one minute, one *X. calens* or *Megachile* sp. visited between 6 to 8 flowers. These characteristics of *Xylocopa calens* and *Megachil*e sp. put them in favorable positions to cause pollination in cowpea. However, there is the need to undertake another study using a technique that will help in finding out whether pollen grains deposited on the stigmas of flowers visited by the insects are actually deposited there by the insects, and if such pollen grains are from flowers of other cowpea plants.

CONCLUSION

The main insects that visited cowpea flowers from the survey and experimental farms were beetles, *Apis melliferaadansoni* (Hymenoptera: Apidae), *Ceratina sp* (Hymenoptera: Apidae; Xylocopinae), *Megachile* sp (Hymenoptera: Megachilidae; Megachilinae), *Xylocopa calens* (Hymenoptera: Apidae; Xylocopinae), *Xylocopa imitator* (Hymenoptera: Apidae; Xylocopinae), *Brausepis sp*. (Hymenoptera: Halictidae; Halictinae), *Lipotriches* Sp. (Hymenoptera: Halictidae; Halictinae), *Melecta* sp (Apidae; Apinae), and *Amegilla* Sp. (Hymenoptera: Apidae; Apinae).

Others were thrips (Thripidae), flies (Dipterans), Lepidopterans (butterflies and moths), and *Dysdercus* sp. Thrips and beetles were the commonest and were observed quite a number of times on the stigma and inside the flowers. Beetles and *Ceratina* sp feed on flowers. However, *Xylocopa calens*, and *Megachile* sp are likely to cause pollination of the cowpea flowers because they were most often observed on the tip of the stigma. The findings revealed that the differences between the frequencies of occurrence of the insects on flowers were not due to chance. This shows that actually thrips and beetles are the most occurring insects on the flowers during the major season and *Megachile* sp. as well as thrips the most common for the minor season.

RECOMMENDATIONS

Further research into the actual roles of all the insects observed on the cowpea flowers is recommended. Since *Megachile* sp and *Xylocopa* sp were observed on flowers in different cropping seasons of the year, there is the need to undertake further studies to find out if there is any weather condition influencing their activities for different seasons. There is also the need to study the pollen load of the various insects and to ascertain if the pollen grains were coming from cowpea flowers or alternate host plants.

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Table 1: The frequency of insects on flowers from 13 surveyed farms

Type of insect	No of farms	Position on the flower						TOTAL	
		On petal		On tip of stigma		Inside flower			
		Freq.	%freq	Freq.	% freq.	Freq.	% freq.	Freq.	% freq.
Apis mellifera adansoni	7	11	1.0	45	4.10	0	0	56	5.11
Ceratina Sp	4	6	0.55	24	2.19	4	0.37	34	3.11
Thrips	12	178	16.26	191	17.44	121	11.05	490	44.75
Crickets	1	2	0.18	0	0	0	0	2	0.18
Flies	11	113	10.32	130	11.87	0	0	243	22.19
Butterfly / moth	12	60	5.48	39	3.56	0	0	99	9.04
Megachile sp.	2	7	0.64	22	2.0	0	0	29	2.65
Lasioglossum sp	9	22	2.0	70	6.39	0	0	92	8.40
Ants	2	10	0.91	7	0.64	21	1.92	38	3.47
Wasps	1	2	0.18	0	0	0	0	2	0.18
Beetles	1	2	0.18	3	0.27	0	0	5	0.46
Xylocopa sp.	1	2	0.18	3	0.27	0	0	5	0.46
TOTAL		415	37.88	534	48.73	146	13.34	df= 9; χ^2= 1879.12	

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Table 2: Frequency of insect visitors on cowpea flowers in the experimental farm during the major rainy season, 2006

Type of insect visitor	Position of insect on flower and frequency						
	On petals		On tip of stigma		Inside flower		Total
	Freq.	% freq	Freq.	% freq	Freq	% freq	Freq. (%)
Apis mellifera	0	0	26	1.35	0	0	26 (1.35)
Xylocopa calens	59	3.06	189	9.82	10	0.52	258 (13.40)
Xylocopa imitator	32	1.66	75	3.90	0	0	107 (5.56)
Ceratina sp	44	2.29	110	5.71	21	1.09	175 (9.09)
Braussepis sp	0	0	4	0.21	0	0	4 (0.21)
Megachiles sp	3	0.16	5	0.26	0	0	8 (0.42)
Lipotriches sp	1	0.05	0	0	0	0	1 (0.05)
Melecta sp	5	0.26	7	0.36	0	0	12 (0.62)
Amegilla sp	0	0	4	0.21	0	0	4 (0.21)
Thrips	189	9.82	215	11.17	121	6.29	525 (27.27)
Flies	58	3.01	53	2.75	0	0	111 (5.77)
Butterfly / moth	68	3.53	44	2.29	7	0.36	119 (6.18)
Beetle (spotted)	169	8.78	242	12.57	108	5.61	519 (26.96)
Dysdercus sp	30	1.56	18	0.94	8	0.42	56 (2.91)
Total	**658**		**992**		**275**		**1925**
SD	**61.22**		**84.94**		**40.72**		**179.63**
χ^2 = **3051.15**							

Table 3: Frequency of insect visitors on cowpea flowers in the experimental farm during the minor rainy season, 2006

Type of insect visitor	Position of insect on flower and frequency						
	On petals		On tip of stigma		Inside flower		Total
	Freq.	% freq	Freq.	% freq	Freq	% freq	Freq. (%)
Apis mellifera	3	1.36	0	0	0	0	3 (1.36)
Megachile sp.	0	0	79	36.24	0	0	79 (36.24)
Ceratina sp.	0	0	5	2.29	0	0	5 (2.29)
Lasioglossum sp.	20	9.17	0	0	0	0	20 (9.17)
Flies	19	8.72	0	0	0	0	19 (8.72)
Butterflies/ moths	31	14.22	0	0	0	0	31 (14.22)
Thrips	43	19.72	8	3.67	10	4.59	61 (27.98)
TOTAL	**116**		**92**		**10**		χ^2 = **154.61**

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