STATUS AND TRENDS OF MONITORING INSECT POLLINATORS IN MANGO ECOSYSTEM IN SOUTHERN GHANA

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Abstract

Several insects including the bees and other animals like bats are estimated to boost pollination services of 35% of the world's food crops like mangoes, vegetables and medicinal plants. Researchers have shown declining trends of populations of some wild pollinators, particularly the honey bee. This study was to determine insect diversity, abundance and monitor seasonal trends of insect pollinators in the mango ecosystem of ten selected farms in the southern part of Ghana. In each farm, a radial transect of 10-meter diameter was constructed. Thirty small plastic pan traps were placed singly on 30 polyvinylchloride pipes fixed at 1-meter intervals. The pan traps filled with soapy water, were colored of ten cohorts of florescent blue, yellow and white respectively. Monitoring was conducted during the flowering periods of the minor and major mango seasons of 2012 and 2013. A total of 2364 insects were trapped; the most abundant were dipterans (1435) largely made up of house flies. The hymenopterans (504) consisted of 418 bees and 86 wasps respectively. Blue (2.85) and white (2.09) colored traps attracted bees more than yellow (1.62) colored traps ($p=0.89$). The flies were most attracted to white traps (5.38) followed by yellow (4.35) and blue (3.61), the least ($p=1.35$). In farms close to natural vegetation bees declined from 3.00 per trap per week in 2012 major season through to 1.00 in 2013 major season. The declining trend of bees in this study underscores the need to manage and conserve wild pollinators for sustainable food productivity

Keywords: Polyvinylchloride, Pollinators, Mango, Vegetation, Dipterans, Hymenopterans

1.0 **Introduction**

Mango, *Mangifera indica* L. (Anacardiaceae) is one of the most economically important tropical fruit crops. In Ghana most of the mango fruits produced are consumed on the local market as fresh fruits and some processed as fruit juice in the local industries; less than 1 % is exported to the European Union market (Gordon, 2008). The mango industry was estimated to have yielded over 19 million US dollars to the economy for the past two decades. It has a potential to change Ghana's economy much better than cocoa and other traditional export products if the needed attention were given (Freshplaza, 2006).

In Ghana, mango is produced as a non-traditional export crop, which develops well under weather conditions ranging from semi-humid to semi-arid (Ekesi and Billah, 2007). Additionally, the country has a comparative advantage in terms of good rainfall and soils. Ghana is one of the few countries in the world with two mango fruiting seasons, and with the right practices, both seasons can yield fruits for the growing international market (Ekesi and Billah, 2007). The two seasons usually occur from January-June/July and August- December/January for the major and minor fruit seasons respectively.

The main mango varieties cultivated in Ghana are Kent, Keitt, Palmer, Haden and Springfield. However, majority of farmers cultivate about 80-90 % of the Keitt (Gordon, 2008). Depending on the variety, it may take 3 to 4 years after seedling transplanting for a mango tree to start flowering and produce its first fruits. The mango flower is bisexual, bearing both male and female reproductive organs. A typical flower is tiny red-yellowish with 5 sepals and usually 5 petals borne on long branched and clustered panicles. Flowering period is short-lived and lasts for about 4-6 weeks during which pollination and fruit-set occur. The flowers attract large numbers of insect pollinators.

Pollinators are essential resources in the agro-ecosystems for production of seed crops as well as horticultural and forage production. Animal pollinators such as insects, bats and birds boost 35% of the world's crop production. This accounts for the increasing output of several leading food crops such as mango, cocoa, most spices and vegetable seeds, pigeon pea, coffee, avocado pear and many medicinal plants of pharmaceutical products (Klein et al, 2007).

Economically, the performance of pollinators in the reproduction of cultivated plants is estimated at over a trillion dollars (Hartfelder, 2013). In Brazil, the value of export of eight important agricultural commodities dependent on pollinators is estimated at seven billion Euros (€7 billion) annually (Freitas and Imperatriz-Fonseca, 2005). The annual economic value of insect pollination in East Africa has been estimated at €900 million (Kasina et al., 2009). In Kenya, 40% of crop production which is estimated at about €2.4 million annually could be attributed to bee pollination in the Kakamega district alone. Annual pollination services in Uganda were estimated to be worth about €370 million (Munyuli, 2011).

Some studies show that pollinator diversity rather than abundance is essential to achieve optimal pollination. The presence of wild pollinators has also been shown to increase the efficiency of managed honey bee foragers (Greenleaf and Kremen 2006).

Despite the invaluable contribution of pollinators in crop production, they are usually taken for granted since their services are largely provided by nature at no cost to farmers, especially those in small-scale farming (Greig-Gran & Gemmill-Herren, 2012). Studies conducted over the past few years however, indicated that the services provided by wild pollinators are showing declining trends (Potts et al., 2010; Vaissiere, et al., 2011; LeBuhn, et al., 2013). The population of managed pollinators, especially the honey bee, *Apis mellifera* and *Apis cerana* are under serious threats of diseases, attack by pests and pesticide misuse, among other factors (Biesmeijer, et al, 2006; Potts et al, 2010; Cameron, et al, 2011; van der Valk, 2013).

In many developing countries, including Ghana, there is inadequate scientific research and information on monitoring the status and trend of pollinators in pollination service. It is therefore essential to undertake such studies in the various agro-ecosystems. In addressing this situation, the Food and Agriculture Organization (FAO) in conjunction with the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP), instituted a project entitled “Conservation and Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach” for seven countries including Ghana, from 2009 to 2014.

This paper was a research work conducted as part of the project to determining diversity, abundance and seasonal trends of insect pollinators in the mango ecosystem in southern Ghana, specifically in the Dodowa-Somanya mango farming zone.

2.0 **Materials and Methods**

2.1 Study Location

The studies were carried out in the Dodowa-Somanya mango growing areas in the coastal savannah agro-ecological zone of southern Ghana. Dodowa (05^0 53'11.62’’N, 00^0 06'46.69’’W) is situated in the Dangme-West District of the Greater-Accra Region, adjoining Somanya (06^o06'17.22"N, 00^o00'54.48W) located in the Yilo-Krobo Municipality in the Eastern Region. The rainfall amount across the enclave ranges from 600 to 1150 mm per annum. Ten mango farms located in three communities were selected. Six of the farms were located in Ayikumah and Agomeda both in the Dangme-West District and the remaining four farms were in Somanya. The criteria for selection were based on closeness to un-cultivated natural vegetation or cultivated land areas. The distances between the various farms ranged from 2 to14 km apart from one another.

2.2 Field sampling and data collection

Monitoring the population of insect pollinators was conducted during the flowering periods, January-March and August-September of the major and minor mango fruiting seasons respectively in 2012. Similar monitoring was continued in 2013 however, the flowering period of the minor fruiting season was excluded due to unforeseen technical challenge. Sampling was started within the first week of mango flowering inception and continued weekly for six weeks by which time fruits were setting.

Three transects of 10-meter radius each and crossing each other at their mid-points, were constructed at the center of each farm and thirty polyvinylchloride (PVC) pipes were fixed at intervals of 1 meter apart (Fig. 1). This technique developed by Gretchen LeBuhn (Pers. communication) was adopted in this study. Each PVC pipe measuring 100 cm long and 9 cm in diameter was buried 10 cm deep, leaving 90 cm vertically above ground.

Thirty plastic pan traps, each of dimensions 6 cm diameter and 5 cm deep had their inner parts colored with three colors of ten cohorts of florescent blue, yellow and white were used to sample the pollinators. These colored pan traps were placed singly on each PVC pipes along the transects and arranged alternating one another such that the same colors appeared at the ends of each transect as indicated in Figure 1. During the sampling period between the hours of 07.00 and 11.00 am, each pan trap was filled almost full with soapy water and placed on individual erected PVC pipes. Twenty four hours after setting the plastic traps, they were inspected in all the 10 farms and insects trapped were emptied separately into clean labeled plastic containers. The collected insects were rinsed with tap water and then preserved in 70 % alcohol. They were conveyed to the laboratory of the Biotechnology and Nuclear Agriculture Research Institute (BNARI) of the Ghana Atomic Energy Commission (GAEC) for counting, identification and proper storage. Further identification and classification were done with the assistance of insects and bee taxonomists at the Department of Entomology and Wildlife of University of Cape Coast, Ghana.

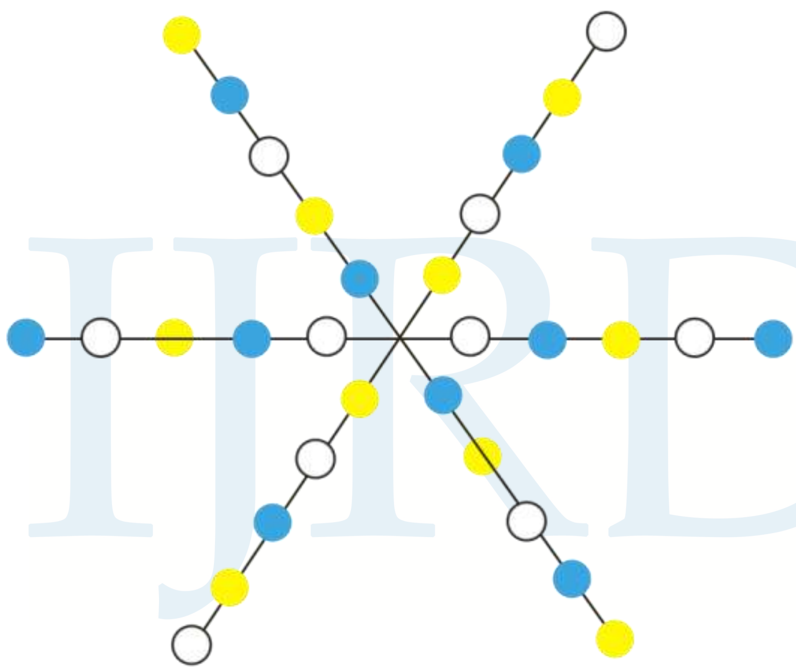

Figure 1. Colored plastic pan traps arranged in the transects for sampling insect pollinators

(Courtesy: Gretchen LeBuhn)

2.3 Statistical analysis

Trap catches were converted to relative density and expressed as number of insects per trap per week. The relative densities of insect pollinator groups collected in the different colored traps were compared using ANOVA and where there were significant differences LSD was used for mean separation. Relative densities for each pollinator groups were compared across the three fruiting seasons using ANOVA and LSD. T-test was used to compare trap densities of each insect group between farms close to natural vegetation (natural vegetation present, NVP) and those without natural vegetation (natural vegetation absent, NVA). Similar comparison was done for farms with managed bees and those without managed bees.

3.0 **Results**

Overall total number of 2,364 insects was collected at the end of the monitoring period (Table 1). The most abundant of the insects were in the Order Diptera recording 1,435 (60.70%). The Bees and the Wasps (Order Hymenoptera) were 418 and 86 respectively. The Orders Coleoptera and Lepidoptera recorded 271 Beetles and 154 Butterflies respectively. Identified species of dipterans largely included *Lucilia* sp. (Blow flies) and *Musca domestica* (House flies) whilst the hymenopterans were *Apis mellifera* (Honey bees) and *Lasioglossum* sp. (Stingless bees).

Table 1 Order and insect pollinators collected at the end of the monitoring period

Common Name	Order	Total No. Collected
Bees	Hymenoptera	418
Wasps	Hymenoptera	86
Flies	Diptera	1435
Butterflies	Lepidoptera	154
Beetles	Coleoptera	271
Total		2364

Apart from the flies and bees, the different trap colors did not have any significant effect on the number of insects attracted to them (Table 2). The flies were most attracted to the white and yellow colored traps (5.38 and 4.35 flies/trap/week respectively), with the blue colored traps being least attractive (3.61 flies/trap/week) (LSD = 1.35). With the bees, blue and white colored traps attracted more insects per trap per week 2.85 and 2.09 respectively (LSD = 0.89) than the yellow colored traps 1.62 flies/trap/week.

Table 2 Mean trap catches of insect pollinator groups in different colored pan traps

	No. of Insects/Trap/Week			
Group	Blue	Yellow	White	LSD
Bees	2.85	1.62	2.09	0.89
Flies	3.61	4.35	5.38	1.35
Wasps	1.74	1.61	1.85	NS
Butterflies	1.68	1.44	1.71	NS
Beetles	2.38	1.68	2.71	NS

NS: No significant difference at the 0.05 confidence level

Trend in seasonal differences was prominent for the Bees, showing a decline in numbers from one season to the other (Table 3). The relatively high densities of 3.00 and 2.91 flies/trap/week for farms near natural vegetation present (NVP) and those of natural vegetation absent (NVA) respectively were recorded in the major season of 2012. The densities declined to 1.29 for NVP and 2.13 for NVA in the minor season of 2012 and further decreased to 1.00 per trap per week for both habitat types in the major season of 2013. Using this trend as a baseline, the Bees population appeared to decline three folds in one year.

Table 3 Seasonal trends and effect of habitat type on the abundance of insect pollinators

	No. of Insects/Trap/Week					
	Major Season 2012		Minor Season 2012		Major Season 2013	
Pollinator Group	NVP	NVA	NVP	NVA	NVP	NVA
Bees*	3.00	2.91	1.29	2.13	1.00	1.00
Wasps	-	-	1.41	2.09	0.00	0.00
Flies	3.06	3.48	5.63	3.84	4.80	5.44
Butterflies	2.14	1.56	1.30	1.33	1.00	1.00
Beetles^{+}	1.71	1.88	1.61	3.42	1.00	1.00

NB: NVP (natural vegetation present), NVA (natural vegetation absent)

- Data were not taken

*Seasonal trends were significant when pooled for both vegetation types

$^{+}$Habitat type had significant effect on densities

Considering the remaining insect pollinator groups there was generally no clear seasonal trend of relative densities in relation to farms closeness to vegetation present or vegetation absent. In the minor season of 2012 however, farms close to vegetation absent appeared to have more Beetles (3.42 beetles per trap per week) than farms near vegetation present (1.61 beetles per trap per week)

During the flowering periods of major and minor fruiting seasons in 2012, pollinator populations appeared to show some characteristic trend patterns (Figs. 2 - 4). General trap catches showed a pollinator peak population during the third week of the flowering period and began to decline thereafter (Fig. 2). Similar trends were observed for the major pollinator groups including bees and wasps though not quite so for flies in the minor season (Fig. 3). However, during the major season total catches of flies and bees showed similar declining trends after the third week (Fig. 4).

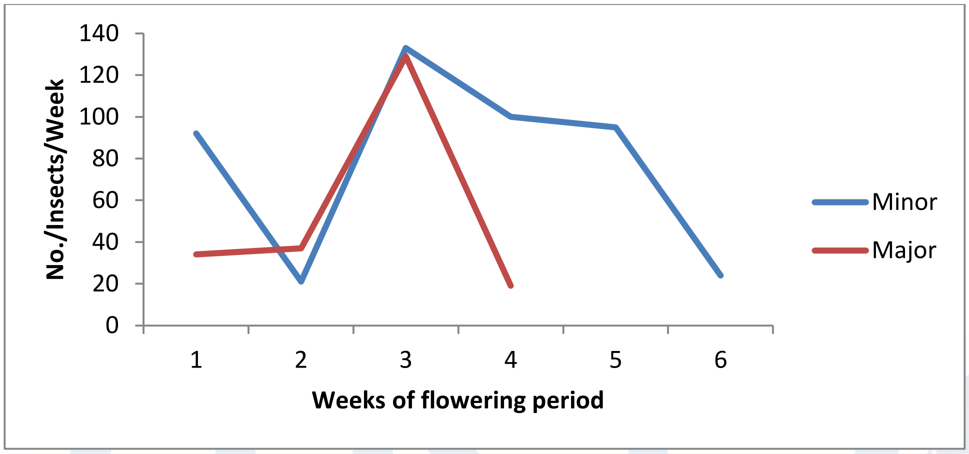

Figure 2 Trends in total trap catches during the major and minor fruiting seasons of 2012

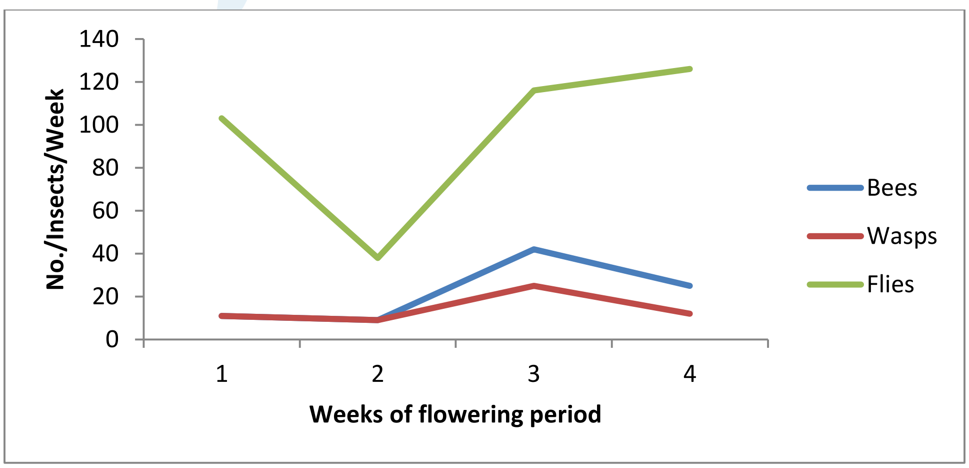

Figure 3 Trends of major insect pollinator groups during flowering period of the minor season of 2012

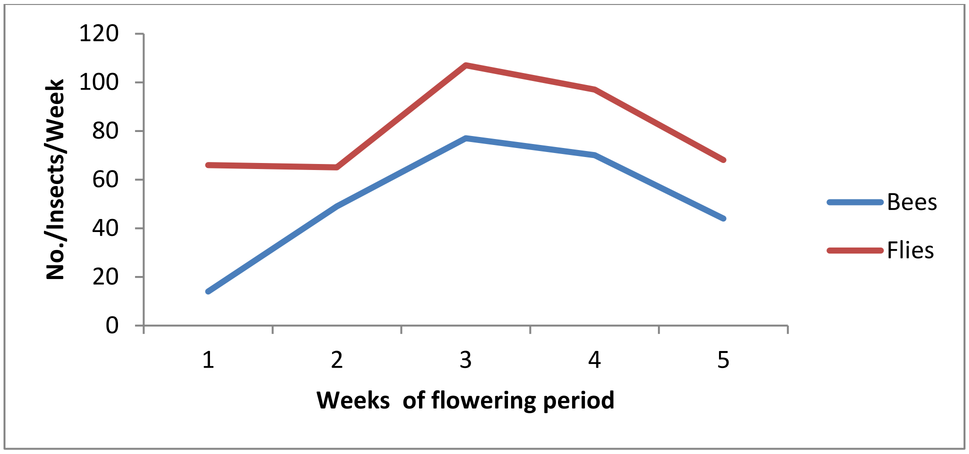

Figure 4 Trends of major insect pollinator groups during flowering period of the major season of 2012

The presence or absence of managed bees close to mango farms did not affect pollinator diversity and abundance (Table 4). There was no difference in the diversity and abundance of insect pollinators collected on both farm types.

Table 4 Effect of managed bees on diversity and abundance of insect pollinators

	No. of Insects/Trap/Week	
Pollinator group	Managed bees present	Managed bees absent
Bees	2.33	2.24
Wasps	1.80	1.61
Flies	4.23	4.60
Butterflies	1.62	1.62
Beetles	1.62	2.76

4.0 **Discussion**

Several varieties of mango are considered to be self-incompatible as a result of degeneration of the endosperm and nucleus in fruits resulting from self-pollination (Sharma & Singh, 1970). This makes effective insect pollination essential for good fruit set and yield. Insects in the Orders Diptera, Hymenoptera and Coleoptera (Anderson et al. 1982; Dag and Gazit 2001; Sung et al. 2006) and to some extent flower thrips (Wolfenbarger 1977) have been noted for pollinating mango flowers. Similar insects were recorded in mango farms in this study with the dipterans being in the majority. The dipterans found pollinating mango flowers in the Dodowa-Somanya farm sites were largely blowflies, *Lucilia sp*. and several houseflies *Musca domestica*.

Robert J. Knight Jr., a Horticulturalist with the United States Department of Agriculture (USDA) Subtropical Horticulture Research Unit in Miami, Florida first gave the lead to the role of blowflies in mango pollination (cited in Wolfenbarger 1977). Since then, they have been reported as the dominant pollinators of mango in Ghana (Gordon 2008), Australia (Anderson et al. 1982), Israel (Dag & Gazit 2001) and Taiwan (Sung et al. 2006). Anderson et al. (1982) found that the most efficient pollinators were those that carried large numbers of pollen grains on their thoraces and used a short proboscis to obtain nectar. In the present study, the numbers of bees recorded were less than a third that of the dipterans, though bees are considered more effective pollinators than flies on some crops. Nectar and pollen collection are the reasons bees are effective pollinators, and these same reasons make them very selective in their choice of flowers for foraging. Wolfenbarger (1977) indicated that lower numbers of bees found on mango at certain times of the year could be due to competition of different species of insects and the kinds of flowers that attract honey bees. This phenomenon is further buttressed by the fact that seasonal declining trends were prominent for the bees.

The dipterans were most attracted to the white and yellow colored traps, which appeared closer to the color of the mango flowers. Bees on the other hand were more attracted to blue and white colored traps. Color therefore appears to influence the kinds of pollinators attracted by flowers. This could explain why the presence or absence of natural vegetation as well as managed bees did not appear to have any effect on pollinator diversity and abundance.

The density of pollinators varied within and between seasons in the Dodowa-Somanya mango farming zone. The density of all the major pollinators peaked in the third week after flowering and then declined in the fourth and fifth weeks, except for the dipterans in the minor fruiting season that appeared to continue increasing. This could be expected because by the third week from the onset of flowering, there would be more matured open flowers ready for pollination. By the fourth and fifth weeks, fruit set would have begun with majority of the flowers already pollinated.

This study also showed the decline of pollinator (especially bees) density over the seasons. Generally world-wide pollinator diversity and abundance are on the decline and one of the reasons has been attributed to indiscriminate use of pesticides. The insect pests (especially fruit fly) and fungal disease infestations on mangoes in the southern part of Ghana are posing a big challenge to farmers, resulting in serious loss of farmers' investments. In order to save the situation, many farmers have resorted to intense pesticide use, which could be having adverse effect on insect pollinators.

5.0 **Conclusion**

The major Orders of insect pollinators of mango, in decreasing order of abundance are Diptera (blowflies and house flies), Hymenoptera (bees including honey bees, stingless bees and wasps), Coleoptera (beetles) and Lepidoptera (butterflies and moths).

The flies and the bees are the most abundant and important pollinators in the mango ecosystem.

The diversity and abundance of the pollinators (bees) on the mango farms were not affected by habitat type, the presence or absence of managed bees close to the farms.

6.0 **Recommendations**

Measures should be instituted by policy-makers to ensure sustainable management and conservation of insect pollinators.

Farmers must avoid the use of insecticides on their farms, especially during the flowering period when pollinator density could be at the peak.

Proper timing of pest control activities and application of best pollinator-friendly practices will enable farmers benefit from the free ecosystem services provided by pollinators and thereby increase crop yields.

7.0 **Acknowledgements**

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