POPULATION ENHANCEMENT OF COCOA POLLINATORS, Forcipomyia spp.

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ABSTRACT

Population enhancement of cocoa pollinator, *Forcipomyia* spp., was carried out at four blocks at CRDC Hilir Perak, Malaysian Cocoa Board. The results showed that pollinator populations per tree for both sexes were low almost in all sampling occasions. The ANOVA showed significant difference at $p<0.05$ between first three months of augmentation date (samplings 1 through 6) and four to six months (samplings 7 through 12) after augmentation date for both male and female pollinators. However, number of pollinators recorded from different ranges of cocoa trees from rotten banana stumps showed that there were no significant differences for male, either sampled cocoa trees were within 1 meter (1.303a), 5 meters (1.187a), 15 meters (1.257a) and 30 meters (1.436a) from breeding sites. No significant different also found for female within 1 meter (1.307a), 5 meters (1.26a), 15 meters (1.238a) and 30 meters (1.564a) from breeding sites. Generally, numbers of pollinators collected per tree were very low in all different ranges. In order to enhance the population, more banana stumps must be placed at different locations within a block. The study may suggest that augmentation of heaps of fresh banana stumps must be carried out every two to three months to enhanced population of pollinators.

Keywords : Cocoa, cocoa pollinator, *Forcipomyia* sp.

INTRODUCTION

Cocoa *Theobroma cacao* L. (Sterculiaceae) is generally self-incompatible varieties and effected by Ceratopogonid insects, especially from the genera of *Forcipomyia* (Diptera: Cerotopogonidae) (Young, 1983). All varieties are strictly dependent on insect pollination, because the anthers with their sticky pollen are each enclosed by a folded petal (Klein *et al.* 2008). There are several important pollinators species found in different temperate and regions in cocoa growing areas all over the world (Azhar, 1990). Midges belong to Ceratopogonidae and Cecidomyiidae families were predominant cocoa flower visitors, with the former being overlay abundant (Frimpong *et al.* 2011). Eight species of Ceratopogonidae commonly found on cocoa flowers including four species of *Forcipomyia* (Kaufmann, 1975). In Hilir Perak, Malaysia, there are six subgenera of *Forcipomyia* with other four Ceratopogonids genera, *Dasyhelea*, *Atrichopogon*, *Brachypogon*, *Stilobezzia* and *Alluaudomyia* were collected in cocoa ecosystem. This Ceratopogonid is very small, approximately 2-3mm, commonly known as midges and capable to facilitate in the narrow flower space using few setae on their thorax. Cocoa pollinator is believed capable to fly for short distance up to 6 meters, although their foraging range can be enlarged up to 35 meters by wind (Klein 2008, citing Decazy *et al.* 1981). Pollinator populations are expected to depend on adjacent habitats closed to the available breeding sites due to their limited flying capability. Pollinators in the more open canopy are believed to be dispersed by wind from neighboring areas (Klein *et al.* 2008). Flight distances below the canopy of mature cocoa may be greater than within dense cocoa canopy and suggesting that they are dependent on air movement.

Cocoa yield is likely to increase with an increase in pollination, and furthermore the pollinator's population. Suitable breeding sites for pollinators, such as decaying organic matter were essential for their population built-up in the cocoa environment. The breeding substrate depends on the moist condition of the substrate, which are further influenced by the rainfall pattern. A substrate which is too moist especially after heavy

rain will less attractive to the pollinators (Azhar, 1990). There are several breeding sites investigated by previous researchers such as cocoa pod husks, rotten banana stumps, cocoa leaf litter, rotting jackfruits and rotted skin of durian (Azhar and Wahi, 1984). Rotten banana stumps or rotting fruits are common in smallholders' plantation, meanwhile cocoa pod husks and cocoa leaf litter enormously found in almost any type of cocoa plantation. A study by Young (1982) demonstrated that by providing rotten banana stumps, there was a significant increment of pollinator population and fruit set within the breeding substrate. However, their population highly affected when breeding substrates and organic waste is removed from plantations. Unavailability of suitable breeding sites will leverage the population of pollinators, and in a long term almost certainly the cocoa production.

Pollination usually occurred in the morning, however several factors; i.e climatic, weather, locations and hours of the day will highly influence on their dynamics (Entwistle, 1972). Pollinating process elevated in most clear sunny days and declined in rainy day. Young (1982) reported that pollination activities depend on moist conditions and long dry seasons can decrease their populations. Heavy rainfall in the morning is believed to eliminate pollination for the day; meanwhile little effects occurred with afternoon or evening rain. Kaufmann (1975) stated that high populations of Ceratopogonids in cocoa plantations are positively correlated with increased rainfall and excess soil water.

Effective pollination is considered the ultimate factor in determining fruit setting, and later on the cocoa productivity. Although the importance of pollination is well known for self-incompatible plants such as cocoa, research efforts in this field are unfortunately lacking in Malaysia. Thus, this research was conducted to evaluate the population enhancement of cocoa pollinators by using discs of banana stumps in cocoa ecosystem.

MATERIALS AND METHOD

A preliminary study on population enhancement of Ceratopogonid *Forcipomyia* spp., were carried out at four blocks; i.e 13A, 14A, 16D and 17C at Cocoa Research and Development Center (CRDC), Malaysian Cocoa Board Hilir Perak, Malaysia (Longitude E.100 M, 52' 0', Latitude N3 53' 42). All selected blocks were harbored almost similar block conditions with no banana trees were planted in the block or at the boundaries. The study was started in December 2011 with approximately 100-120 fresh cut of banana pseudostem, 0.5m in length were placed longitudinally in the middle of each block Twenty cocoa trees per block were selected as a sample trees, and the data taken every 1 meter, 5 meters, 15 meters and 30 meters from banana rows. Collection of pollinators were carried out by using aspirator by sucking the insects perching on flowers, cocoa cushion, dried cherelles, leaf-tips as well as those that were in flight. Each tree was sampled for five minutes by three trained staffs, from 7.30 to 10.00am. Captured pollinators were brought back to the laboratory for identifying their sexes. Monitoring on the pollinators populations were carried out fortnightly basis from December 2011 to June 2012. The data were arranged and pooled in Excel® program and analyzed using SAS® (SAS® system for Windows® V8).

Table 1. Meteorological data recorded at CRDC Hilir Perak

Metereological data	Month						Average for 2012
	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	
Total rainfall (mm)	140.40	89.30	201.90	58.40	110.70	70.20	163.35
Maximum rainfall for 24 days (mm)	81.20	23.20	52.70	15.60	57.50	35.80	53.98
Total wind speed (km)	1055.81	1086.24	1110.05	1233.70	1243.23	1184.93	1153.89
Average daily wind speed (km)	34.05	37.45	35.80	41.12	40.10	39.49	37.83
Maximum temperature (◦ C)	34.20	34.40	34.00	34.60	35.50	36.60	34.39
Minimum temperature (◦ C)	22.20	22.30	20.20	23.00	22.00	20.10	22.11
Average temperature (◦ C)	27.80	27.50	26.90	28.30	28.70	28.50	27.90

RESULTS AND DISCUSSIONS

Data on rainfall, wind speed and temperature were recorded from January through June 2012 (Table 1). Maximum, minimum and average temperature; and wind speed were almost similar and showed little fluctuations during sampling occasions Total rainfall and maximum rainfall although were more diversified throughout the study period, was lesser than average for 2012. Throughout six months of the study, it was stated that hot and humid environment, with less rainfall was recorded in all blocks. This meteorological data might play a role in affecting pollinator populations, due to unfavorable conditions for their breeding necessity. Successful pollination and their population dynamics which later on will regards to flowering may influenced by rainfall distribution rather than temperature (Azhar and Wahi, 1984). The flight activity of pollinators was observed to be higher during sunny weather but no outside activity took place during rainy period. Their study also denoted that pollinator's population expansion occurred just before the wettest month, and declined to a lower level in dry month. With less rainfall recorded, it allows little chance for banana stumps become a suitable breeding substrates for pollinators.

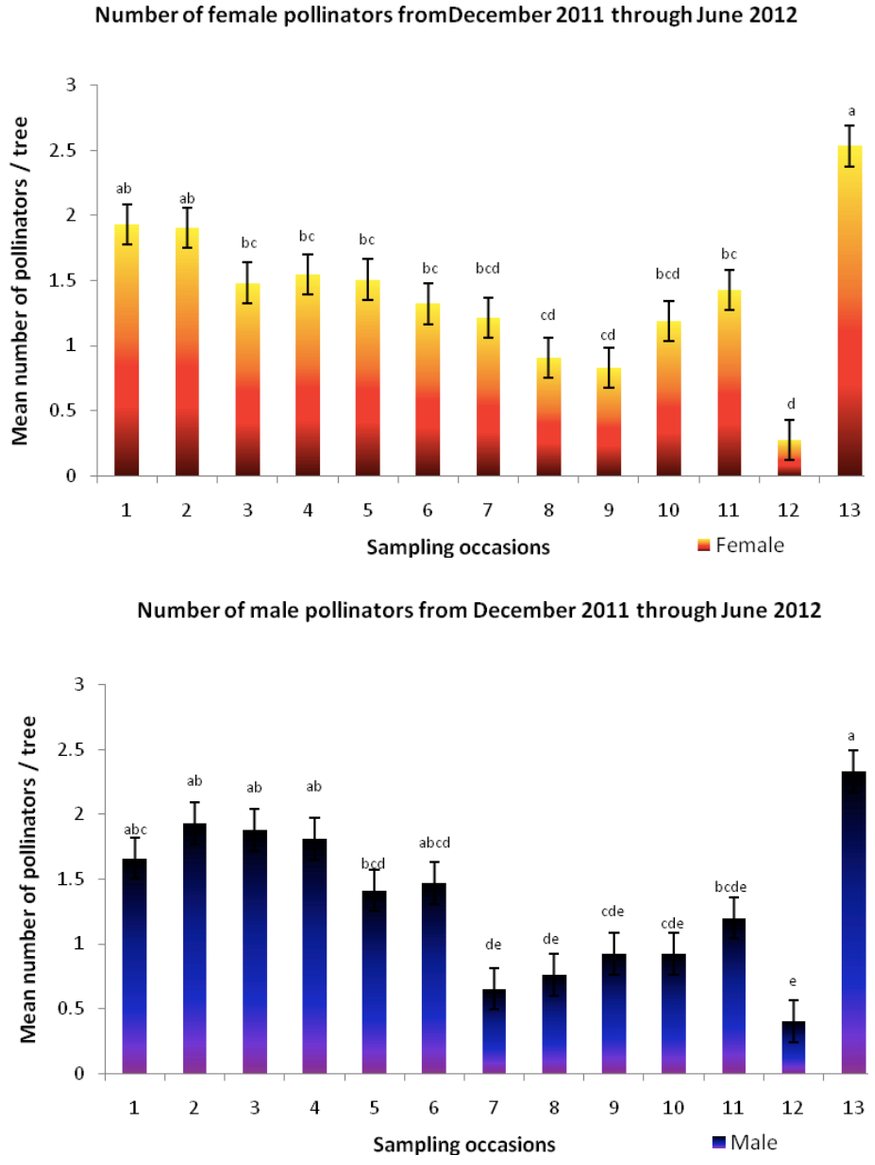
Decaying pod husks may also served as breeding sites especially during rainy seasons. However with less rainfall recorded throughout the study, this may have little influence on cocoa pollinators. Prolonged dry season may negatively affected pollinator population as in Africa (Entwistle, 1972; Young, 1983), when cocoa are under moisture stress. Pictures of the banana stumps (Figure 1) were taken from Day 1 until Day 119. It was found that most of the stumps still in a good shape after 21 days. The stumps become dry after that, and this may influence by low rainfall received in this six months of observations.

Figure 1. Pictures of banana stumps at Day 0, 21, 42, 63, 84, 98, 105 and 119

Figure 2 shows the number of male and female pollinators collected from December 2011 (sampling 1), January (2 and 3), February (4 and 5), March (6 and 7), April (8 and 9), May (10 and 11) and June 2012 (12 and 13). Mean number of both sexes were low almost in all sampling occasions, although the augmentation of banana stumps were placed longitudinally in the middle of each block. However, there are significant differences between first three months from augmentation date (samplings 1 through 6) and four to six months (samplings 7 through 12) after augmentation date for both male and female pollinators. Greater number of female pollinators is believed to be more important due to their role in pollinating the cocoa flowers as cited in Azhar and Wahi (1984). Only adult females of Ceratopogonid, especially genera *Forcipomyia* were observed to actively pollinate cocoa flowers, and this was in agreement with several previous researches conducted in the 50's and 60's. Kaufmann (1975) stated that there is no report on male ceratopogonids pollinate cocoa trees in Malaysia, while male play a role as pollinator as observed in Ghana. The time spends by the females on cocoa flowers varied from just a few seconds to more than 5 minutes and they flew away when disturbed. The males were only observed to perch on flower petals and surprisingly

the males were usually found swarming over a small stem or within the broken cocoa canopies. Swarming behavior of both adults in the air that been observed several times in this study may associate with mating process, although little is known about this activity.

The results suggest that number of pollinators increasing in the early phase of augmentation and during rotting process. After rotting process completed and the banana stumps were fully rotten and dried, the capability of rotten banana stumps as a breeding site were decreased through time. The study may suggest that augmentation of fresh banana stumps must be carried out every two to three months to enhanced population of pollinators.

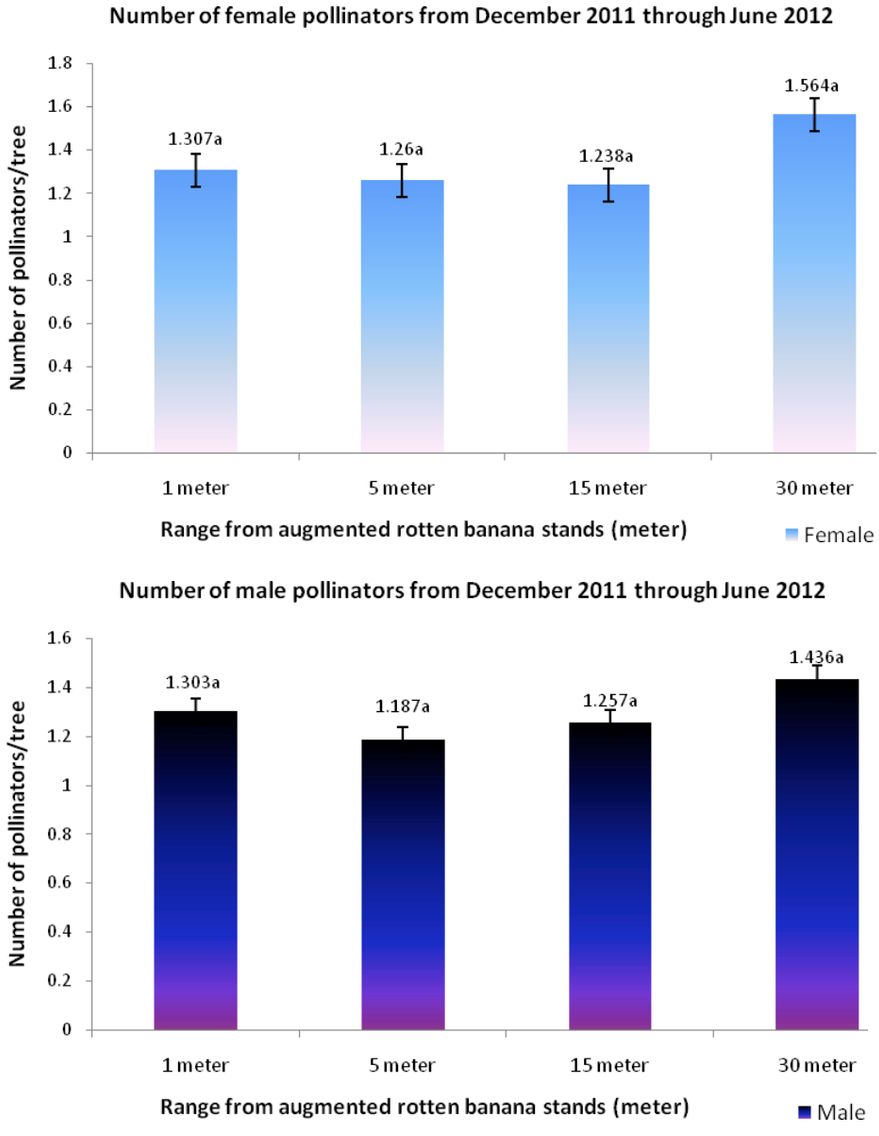


Means followed by same letters are not significantly different ($p \geq 0.05$).

Figure 2. Number of pollinators collected from December 2011 through June 2012

Figure 3 shows number of pollinators recorded from different ranges of cocoa trees from the placement of discs of banana stumps. There were no significant differences for both sexes, either sampled cocoa trees were selected within 1 meter, 5 meters, 15 meters and 30 meters from breeding sites. Generally, numbers of pollinators collected per tree were very low in all different ranges. This might occurred due to the longitudinally placement of banana stumps and not as a heap. Other factor is as stated by Klein (2008, citing Decazy *et al.* 1981) that this Ceratopogonid will only capable to fly

for very short distance from breeding substrates, and in addition with dense cocoa canopy it will limited their flying capability. In order to enhance the population, heaps of banana stumps must be placed at different locations within a block. Planting of banana at the boundaries may also helps in population increments. Frimpong et al (2011) denoted that availability of plantain or banana had a marked influence on the abundance of pollinators, and obtained positive association between abundance and the number of plantain or banana intercropped with cocoa.



Means followed by same letters are not significantly different ($p \geq 0.05$).

Figure 3. Number of pollinators collected at different ranges from breeding sites

Low number of pollinators usually occurred in the cocoa field, and in long term it probably will affect the flowers, cherelle development and later on the cocoa productivity. Thus, in order to maintain or to enhance the population of pollinators, providing a favorable breeding site is very crucial. Placement of rotten banana stumps, or heaps of rotten cocoa pod husk in the field may served as breeding sites for the pollinators, and may result in population increment. Adjaloo *et al.* (2013) suggested that pollinators highly depending on moist rotten plant material for breeding, and prolonged provision of banana stems cutting may helps in providing favorable breeding sites for *Forcipomyia* sp. Discs of freshly cut of banana stumps or any suitable breeding materials maybe supplemented especially during high intensity flowering, which will best served as a breeding sites (Young, 1983).

Although previous research (Azhar and Wahi, 1984) denoted that both rotten cocoa pod husks and rotten banana stumps yielded high number of Ceratopogonid, using cocoa pod husk may become as a threat in the area that historically infested by Cocoa Pod Borer (CPB), *Conopomorpha cramerella* Snellen (Lepidoptera: Gracillariidae). CPB is the major threat for cocoa producing area in South East Asia, and their larvae will burrowing into the pod for 15 to 17 days before turning into pupae. In a zero or very low CPB's population, supplement of heaps of cocoa pod husk to ensure greater distribution of pollinators may not become a problem. However, in a heavily or moderate CPB infested area, cocoa husks may be placed in a gunny sack for two weeks, before putting under the cocoa trees. This may helps in interfering and hindering the CPB to complete their life cycle.

Longitudinally placement of banana stumps as in this study may regards on low population of pollinators. Banana stumps must be placed together as a heap and stumps should be piled a meter or so high thus the bottom of the piles remains moist during the dry season. The heaps will served as breeding substrates due to moisture retention at the base of the heaps. Placement of rotten plant material under cocoa trees to encourage pollination is more effective (Adjaloo *et al.* 2013), rather than just placement longitudinally as in this study.

Placement of rotten plant material under cocoa trees to encourage pollination is more effective (Adjaloo *et al.* 2013), rather than just placement longitudinally as in this study. Any rotting leaves on the plantation floor should be left undisturbed, meanwhile leaving a rotting fruit of shade trees or rotting tree trunks may cause a problem because they probably become substrates for diseases and termites infestation. Cocoa field may also be planted by banana trees at specific locations as suggested by Azhar (1990), and this will provide continuous breeding sites throughout years. Standing plantain and banana in cocoa farms at boundaries could thus be manipulated to augment midge population especially during dry season (Frimpong *et al.* 2011).

CONCLUSION

Growers' intervention in providing conducive cocoa field for pollinators especially through environment manipulation, proper management and agronomic practices will helps in population enhancement. Placement of breeding substrates such as discs of banana stumps and planting of banana trees at the boundaries may helps in population enhancement of cocoa pollinators. More research on pollinators must be conducted and there are a lot more disciplines to be explore in the future, due to their importance in the sustainability of cocoa plantation.

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