COMMUNICATION II
Role of Insects in the Pollination of Cocoa Flowers

ABSTRACT
Theobroma cacao L. produces 4553 ± 687 flowers over a six month period but relatively low percentage (<1%) of these flowers attain pod maturity. The low pod production is due to poor fruit set and high cherelle wilt. The exclusion of insect pollinators by caging the cocoa flowers resulted in no pollination. Those insects which mainly visit the flowers from 0800 to 1600 h are the cecidomyiids and Forcipomyia spp.

INTRODUCTION
Theobroma cacao L. is a major crop in Malaysia, ranking third after rubber and oil palm. The cocoa hectarage under smallholding is fast expanding and there is the potential of cocoa replacing rubber as the main crop. However, there are many factors affecting cocoa production such as attack by pests and diseases and lack of pollinators. Many insects including the stingless bees are known to visit cocoa flowers (Young, 1985). It is universally accepted that the ceratopogonids especially Forcipomyia spp are the main pollinators of cocoa. (Hernandez, 1965; Soria, 1970). Though pollination activity of insects had been extensively studied by Young (1983, 1985) in South America, published work in Malaysia is confined merely to preliminary studies of species composition and their natural habitats (Azhar & Ibrahim, 1986, Ibrahim & Yusof 1986). The objective of this investigation is to study the percentage of fruit set and the role of insects as pollinating agents in the cocoa field.

MATERIALS AND METHODS
The field study was conducted at the Universiti Pertanian farm (14.5h) planted with Sabah hybrid cocoa intercropped with coconuts. The plants were 4 – 5 years old and bearing flowers profusely. Three field trials were conducted.

Determination of Total Flower Production
In this trial, ten cocoa plants were selected at random. At the onset of the trial, all the flowers and pods were removed from the plants. A mosquito netting was placed under the individual plant, for collection of fallen flowers and pods. The number of flowers, cherelle wilt and pods on the individual plant were recorded for a period of six months (8th August 1985 to 14th February, 1986).

Comparative Study of Caged and Uncaged Flowers
Fifty branches, each with an average length of 1m accommodating 40 newly opened flowers were selected at random. The height of the branch was 1.5m from the ground. Twenty-five branches were left uncaged thereby exposing the flowers to the pollinators while the other twenty five branches were caged with fine muslins. A fortnight after the exposure to the pollinators, fruit set was recorded. The trial was conducted from 14th to 28th October, 1985.
Identification of Insects Visiting the Cocoa Flowers

The insects were collected using aspirators every 2h commencing from 0800 to 1600h. Fifteen plants were selected for this study and 5 minutes were spent per plant sample. Similar observations were made for 5 consecutive days from 3rd to 7th December 1985. The insects collected were kept in 70% ethyl alcohol for identification.

RESULTS AND DISCUSSION

The findings show that a cocoa plant can produce an average of $4553 \pm 687$ flowers over a six month period (Table 1). The percentage of effective pollination i.e., where fruit set was observed was only 5.2%. Winder (1977) and Young (1985) had reported that less than 5% of the flowers were effectively pollinated by insects. A significant proportion of fruits (77.2%) became cherelle wilt which might have been caused by pest infestation or physiological phenomenon (Wood, 1973). Apparently, in this study each plant was capable of producing an average of 43.4 pods free from cherelle wilt over a 6 month period. Assuming that a plant is capable of producing 9000 cocoa flowers/year, the yield per plant/year will therefore be in the region of 87 harvestable pods only. This low yield could be attributed to other factors such as poor field management. However, our findings suggest that failure of pollination is also a limiting factor in crop yield.

Comparative study between caged and uncaged flowers showed that the percentage of effective pollination in the caged flowers was only 5.0 ± 0.54% (Table 2). This result agrees well with the flowering capability of a cocoa

<table>
<thead>
<tr>
<th>Plant No.</th>
<th>No. of flowers</th>
<th>No. of 'Cherelle wilt'</th>
<th>No. of unmatured pods</th>
<th>No. of matured pod*</th>
<th>Total</th>
<th>% of effective pollination**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8082</td>
<td>182</td>
<td>29</td>
<td>82</td>
<td>8375</td>
<td>3.5</td>
</tr>
<tr>
<td>2</td>
<td>3309</td>
<td>70</td>
<td>17</td>
<td>10</td>
<td>3406</td>
<td>2.8</td>
</tr>
<tr>
<td>3</td>
<td>7399</td>
<td>116</td>
<td>5</td>
<td>9</td>
<td>7529</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>2679</td>
<td>485</td>
<td>7</td>
<td>80</td>
<td>3251</td>
<td>16.2</td>
</tr>
<tr>
<td>5</td>
<td>1509</td>
<td>77</td>
<td>4</td>
<td>0</td>
<td>1590</td>
<td>5.1</td>
</tr>
<tr>
<td>6</td>
<td>2509</td>
<td>77</td>
<td>23</td>
<td>22</td>
<td>2635</td>
<td>5.1</td>
</tr>
<tr>
<td>7</td>
<td>3596</td>
<td>140</td>
<td>15</td>
<td>10</td>
<td>3701</td>
<td>4.4</td>
</tr>
<tr>
<td>8</td>
<td>5789</td>
<td>70</td>
<td>20</td>
<td>0</td>
<td>5879</td>
<td>1.5</td>
</tr>
<tr>
<td>9</td>
<td>5042</td>
<td>234</td>
<td>58</td>
<td>2</td>
<td>5536</td>
<td>5.5</td>
</tr>
<tr>
<td>10</td>
<td>3532</td>
<td>195</td>
<td>21</td>
<td>9</td>
<td>3763</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Total 43,439 1646 210 224 45525 51.8

Mean 164.6 ± 40.1 21.0 ± 0.52 22.4 ± 9.4 4552.5 ± 687.6 + 1.3

*Pod stage ready for harvesting

**% of effective pollination = \[
\frac{\text{No. of matured} + \text{No. of unmatured} + \text{No. of pods}}{\text{Cherelle wilt}} \times 100
\]
ROLE OF INSECTS IN THE POLLINATION OF COCOA FLOWERS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of branches</th>
<th>No. of flowers/branch</th>
<th>Mean No. of fruit set/branch</th>
<th>% effective pollination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caged flowers</td>
<td>25</td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Uncaged flowers</td>
<td>25</td>
<td>40</td>
<td>2.0 ± 0.2</td>
<td>5.0 ± 0.54</td>
</tr>
</tbody>
</table>

The majority of the *Forcipomyia* spp were caught at noon, for they were resting on the flowers. Though the number of cecidomyiids caught was higher than *Forcipomyia* spp, they are not effective pollinating agents (Ibrahim & Yusof 1986).

The *Forcipomyia* spp are universally known as effective pollinators. The thorax of *Forcipomyia* spp measuring 0.16mm width and 1.0mm length can accommodate many pollen grains, each measuring 16 μm in diameter. A greater transfer of pollen grains is necessary because <35 pollen grains on the pistil can cause aborted pollination (Kaufmann, 1975). All the *Forcipomyia* spp collected were females, although Kaufmann (1975) recorded male *Forcipomyia* spp. in Ghana. Environmental factors such as temperature, relative humidity and light intensity differ slightly under the plant canopy during the day (cf. Fig. 1). However, these factors appeared not to have any influence on the activity of the pollinators.

A. GHANI IBRAHIM and ABDUL MANAB HUSSEIN

Dept. of Plant Protection, Faculty of Agriculture, Universiti Pertanian Malaysia, 43400 Serdang, Selangor, Malaysia.

REFERENCES


(Received 6 October, 1986)