Measurement level of incursion cocoa pod borer
(Conopomorpha cramerella snella) at community cocoa plantations in East Aceh Regency, Aceh, Indonesia

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Abstract. East Aceh Regency constitutes as one of the central cocoa production areas in the Aceh Province. The main problem faced in the cultivation of cocoa plants is the high instances of attack from the Plants Gadfly Organism, especially the Cocoa Pod Borer (CPB), which can lead to a decrease in the production of cocoa. The purpose of this research is to investigate the percentage and the intensity of CPB pest attacks at community cocoa plantations. The study was conducted in the East Aceh Regency of the Aceh Province in Indonesia. Research was initiated from January until April of 2020. This research utilized a survey method; here the location was determined using a purposive sampling method. Each plantation was classified by untreated plantations, sober treated plantations, intensive treated plantations that implemented the Integrated Pest Management (IPM) practice. The occurrences of CPB attacks were observed in each classification. The results showed that the levels of incursions by CPB pests was different depending on the classification level of the plantation. The findings highlighted the importance of implementing the practice of IPM to reduce instances of CPB incursion.

1. Introduction
Cocoa is one of the most important commodities in the East Aceh Regency. The East Aceh Regency constitutes territorially the second largest number of cocoa plantations in the Aceh Province after the Southeast Regency. The larger cocoa plantations in the East Aceh Regency span an area of roughly 12.821 Ha with a production level of 6.441 tons per hectare and typically produce 750 kg/ha [1]. Cocoa production areas in the central territory of the East Aceh Regency consist of the Pantee Bidari Sub District, Darul Ihsan, Darul Aman, Ranto Peurelak and Peunaron. The cultivation of cocoa in the East Aceh Regency is generally still conducted traditionally and not yet meet the standards of modern cultivation practices. One of these practices is the system of

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pest control, which mainly deals with pest attacks from the cocoa pod borer. Due to the lack of modern standards surrounding the control of such pests, cocoa plantations in the East Aceh Regency have as of yet been unable to reach their maximum levels of production. One of the problems faced in the development of cocoa plantations is attacks by the cocoa pod borer (CPB) caused by Conopomorpha cramerella Snellen. CPB is the most problematic barrier facing cocoa production around the world. The C. Cramerella insect, which Snellen denotes as an endemic species of Southeast Asia, is considered to be the most damaging pest when it comes to cocoa cultivation. It is hypothesized that C. cramerella evolved from the similar species that typically feed on Rambutan (nephelium). The adaptation process likely occurred sometime in 1860 in North Sulawesi, and is widely considered to be the first recorded instance of the CPB pest attacking cocoa plants [2].

The main problem facing cocoa plantation management in the East Aceh Regency is the height of OPT attacks especially the CPB pest. This happens because of the methods of cocoa cultivation practiced by the farmers of the East Aceh Regency who do not fully follow modern guidelines in regards to the use of pesticides as a means to control OPT. As a consequence of OPT attacks, CPB has increased and caused cocoa productivity to drastically decrease. CPB attacks represent a critical obstacle in the production and cultivation of the in Aceh Province. This can lead to low productivity as well as a decrease in the quality of the cocoa being produced [3].

Due to this, CPB pest attacks have led to a significant in the income that farmers depend on. One of the causes of the decrease in cocoa productivity in Ghana is also attacks by the CPB pest [4]. CPB pests can reduce cocoa production as much as 80% and damage up to 82% of all cocoa beans produced [5]. Deterioration of the cocoa plant occurs when CPB larva burrow into a cocoa pod which prevents the seed from being extracted [6]. In Papua New Guinea, CPB is the biggest threat towards public economic matters. The CPB pest has created tremendous difficulties for the farmers who depend on the cocoa plants for their income [7].

CPB pest attacks have been observed to have different levels of incursion. It is because of the weft availability that is found in the cocoa pod, which remains in the field, that triggers pest attacks. CPB pests, which mainly attack cocoa plants in the East Aceh Regency, constitute the main pest for which the decline of cocoa pod production can be attributed to. This problem is caused by the CPB larva, which target the cocoa pods and damage the cocoa seeds which have high economic value. In order to reduce the loss of cocoa plants, data related to CPB attacks and outbreaks needs to be collected in the field. The purpose of this research is to know the percentage and the intensity of CPB pest attacks at cocoa plantations in the East Aceh Regency.

2. Materials and methods
2.1. Place and time of research
This research was carried out at three sub districts in the East Aceh Regency they are Pantee Bidari Sub District, Darul Ihsan and Peunaron. This research was conducted for six months, starting from January until June 2020. Determination of research locations was done in a “purposive” manner, that is they were selected directly or deliberately how much land had been dedicated to the cultivation of cocoa.

2.2. Kind and source of data
The gathered data is in the forms of primary and secondary. Primary data was obtained through the result of field observation and interviews. Interviews are conducted with cocoa farmers at the research locations. Field observation results and interviews were related to the incursion intensity data and loss as a result of CPB pests. As for the secondary data, it was gathered from the literature of other studies as well as information gathered from the Agricultural and Plantation Department of Aceh Province, Statistic Centre Agency of East Aceh Regency, stakeholders in East Aceh Regency and cocoa farmer groups at the research location.
2.2.1. Sample location of CPB pest incursion. Sample Location to know the intensity of CPB pest incursion selected at the farm which has the following criterion:

(A) Untreated farm (not conducted treatment, cocoa farm its condition likely forest);
(B) Sober treated farm (farm treatment conducted incidentally, irregular time);
(C) Farm which was treated intensively (cocoa farm conducted treatment by providing fertilizer, pruning, treated side joint on cocoa trees which have passed productive period). This treatment is done by the farmer based on knowledge they obtain from Non Government Organization (NGO) of Swiss Contact, NGO Keumang and related agencies, however its nature incidental) and;
(D) Farms that practice Integrated Pest Management (IPM). Has applied IPM by the guidance from NGO of Swiss Contact, NGO Keumang, Plantation Department and Counseling Agency at each sub district. Monitoring is carried out by related agencies with regular timing.

2.3. Analysis method
Level Intensity Observation of CPB pest incursion on research location carried out at four farm locations which have different treatment criterion (not treated, sober farm treated, treated intensive and IPM practice). Sample taking was conducted at 3 (three) sub district locations. At every sub district samples are taken from (3) three villages. Sub Districts and villages which were chosen for research samples are the areas that have the largest cocoa plantations at those sub district/villages. Sub Districts which were chosen to be sample taking locations are Pantee Bidari, Darul Ihsan and Peunaron.

Sample taking is carried out at all farm criterions at every village. The total number of samples are taken in this research in the amount of 36 samples. If the village does not have one of the four different treatment criteria, then samples are taken from the existing farm criteria. For farms that follow the criteria, cocoa pods were taken at every village which had been attacked by the CPB pest with an amount of 10% from the sum total of cocoa trees grown. The pods which were taken as samples are pods which would have been be harvested due to their ripeness. The taken pods have homogeneous conditions observed with different varieties of age and locations on the farm. Harvesting of the cocoa pods occurs twice during the harvest interval.

2.3.1. Measurement of CPB pest incursion level
To measure the damage level and the loss resulting from CPB incursions on cocoa pods, was conducted according to attack percentage (PS), attack intensity (IS) and loss of result (Y). Attack percentage (PS) indicates the quality of harvested pods, which can be observed from their outer symptoms. This PS calculated by using the pattern as follows [8]:

\[ P = \frac{a}{b} \times 100\% \]  

Explanation:
\( P \) = Attack Percentage (%)  
\( a \) = Sum of attacked pod each tree  
\( b \) = Pod Total each tree

Attack Intensity (IS) is the number which describes pod damage levels. Attack intensity is the measurement of CPB utilizing 4 (four) categories based on how many seeds retain their stickiness in each observed pod, that are healthy, light (R), moderate (S), and weight (B). Intensity calculation CPB attack utilized pattern:

\[ IS = \frac{[1R + 3S + 9B]}{AT} \]  

Explanation:
\( IS \) = Attack intensity  
\( R \) = Sum of light attacked pod  
\( S \) = Sum of moderate attacked pod
B = Sum of weight attacked pod
A = Highest weighting value
T = Sum of observed pod

The scale of CPB pest attack level on cocoa pods gives the weight with the score presented on Table 1.

Table 1. Scale level of CPB pest attack.

| Score | Attack level  | Explanation                                      |
|-------|---------------|--------------------------------------------------|
| 0     | Lusty Pod     | No seed sticky                                   |
| 1     | Light         | There is sticky seed <10%, but all of the seed still can be taken out of pod skin |
| 3     | Moderate      | There is sticky seed between 10-50%, for the most part of seed can still be taken out of pod skin |
| 4     | Weight        | There is sticky seed >50%, and largely seed cannot be taken out of pod rind |

3. Result and discussion

3.1. Pest attack percentage of cocoa pod borer

From the result of field observations, almost all of the community cocoa plantations in East Aceh Regency were attacked by CPB pests by a variety of attack levels at all of the observed farm classifications. The results of the CPB pest attack percentages calculated based on farm classifications at research locations is presented on Table 2.

Table 2. Percentage CPB pest attack based on farm classification.

| Sub district | Not treated (%) | Sober treat (%) | Intensive treat (%) | IPM practice (%) |
|--------------|-----------------|-----------------|--------------------|-------------------|
| Pante Bidari | 72.80           | 53.60           | 34.30              | 25.00             |
| Darul Ihsan  | 76.08           | 55.00           | 48.00              | 19.00             |
| Peunaron     | 49.00           | 43.33           | 20.50              | 16.50             |
| Average      | 65.96           | 50.64           | 34.27              | 20.17             |

From Table 2 above it can be viewed generally CPB pest attacks occurred at almost all of the cocoa plantation research locations. The highest CPB pest attack percentages occurred at the research locations classified as untreated farms, with an average of 65.96%. As for, the lowest CPB pest attack percentages, these were found on farms classified as IPM practice with an average of 20.17%. Existing conditions of each farm classification in the research location is presented on Figure 1.

High and low percentages of CPB pest attacks in the research locations were caused by unprofessional farm management; for instance, unperfected pruning, fertilizer rarely being executed by the farmers, no availability of shade plants, and sanitation towards the attacked cocoa pod skins that have been pared but were not buried by farmers. These conditions, combined with high humidity, will support the development of CPB pests. At untreated cocoa plantations and sober treated plantations the vulnerability towards CPB pest attacks was very high. It was discovered that in these research locations part of the cocoa farms had not been maintained properly, and as a result these areas had become overgrown with native vegetation. The pruning of cocoa trees will in long-term CPB pest control; if the trees are pruned to less than 3 m; it This will help to provide air circulation and sunrise; for the fruit, which are less than desired conditions for the CPB pest. High
attacks of CPB pests tend to occur in the conditions of untreated cocoa plantations where there is adequate shade; as this is where CPB pests tend to breed [2;9].

![a. Not treated](image1)
[a. Not treated](image2)
![c. Intensive treated](image3)
[c. Intensive treated](image4)

**Figure 1.** Existing condition of each farm classification.

The reluctance of the cocoa farm owners to grow shade plants is due to the fact that they believe that shade plants can negatively affect the growth of cocoa plants due to the occurrence of absorption competition of nutrients. Also, farmers believe that with the existence of shade plants this will narrow the cocoa cultivation area at their farms. According to the farmers, cocoa trees without shade produce cocoa pods that have measurements that are much larger at the third year of harvest when compared to the first.

The existence of shade plants plays an important role in creating optimal micro climates needed by cocoa plants in order to thrive [10]. *C. cramerella* attacks green cocoa pods up to harvest age pods and tends to prefer cocoa pods at a length ± 9 cm. This pest attack can contribute to a reduction in cocoa pod production at upwards of > 80% and is relatively difficult to control [11]. The height of CPB pest attacks at farms that are not treated are related to the amounts of shade experienced by the plants, and are due to the high activities of CPB imago. CPB imago during the day rest on branches that are protected from sun light. Outbreaks of CPB tend to be aided by the wind [12]. Cocoa farms that practice IPM have low CPB pest attack levels. Low attack percentage is due to farmers having applied correct cultivation techniques and the existence of black ants (*Dolichoderus thoracicus*) which are a natural enemy and of CPB insects. It is more difficult for
CPB insects to lay their eggs on the surface of cocoa pods when black ants are present as the ants will eat the eggs.

In East Kalimantan the IPM application along with integrated prune techniques, harvesting regularly, sanitation of pod skins, black ant breeding and wrapping pods with plastic bags has proven to be successful in the suppression of CPB attack percentages up to 20% [11]. Argue that ant *Dolichoderus thoracicus* is able to prevent CPB attacks in the field [13]. Ant *Dolichoderus thoracicus* can repress CPB attacks up to 8.30%, and seed damage become less than 25.40%, and seed descent percentages decrease to 16.20% [14]. The advantage of the IPM system is that it is able to reduce production costs to the amount of 11% from previous practices [15], also it can increase the results significantly and be more advantage than traditional pest control practices that have been used all this time by farmers [16].

3.2. **CPB pest incursion intensity**

Based on the results of the observations in the research locations, CPB attacks tend to occur on the cocoa pods which are still green and ripe. The total intensity of CPB incursion in general is higher on the untreated farm criterion. However, most parts of the cocoa seeds can still be harvested and sold (Figure 2).

![Level of CPB pest incursion which is observed on cocoa pod sample.](image)

| a. Not attack | b. Light attack |
| c. Moderate attack | d. Severe attack |

*Figure 2. Level of CPB pest incursion which is observed on cocoa pod sample.*
CPB incursion on cocoa pods that were made as samples were marked by waning of pod skin color and appeared to be a mottle color of yellow and green or red and yellow. Then if cocoa pods are shaken, they do not produce a sound. Lastly, if the pod is split and black pod seeds are visible and stick to one another. In consequence of this CPB pest incursion, the pod is relatively green, and the seeds stick on the pod skin and will also stick to each other. As for on the ripe pods they do not raise damage on the seeds, however they can reduce seed quality.

CPB attack symptoms include cocoa pods that are colored rather orange or whitish pale, with pods that become heavier and when shaken there is no knocking sound that can be heard between the seeds and the pod wall [17]. This happens because of the emergence of mucus and dirt on pod meat and seed breakdown in the pod. Pod meat damage is due to CPB attacks caused by *heksokinase, malate dehydrogenase, fluorescent esterase* and *malic polymorphisme* enzymes which are secreted by CPB. This is from CPB larva attacking the anterior part of the pod which will induce more serious damage towards seed development or even cause decomposition [9].

The results of observation towards intensity of CPB pest attacks in the research location (Table 3) indicates the highest CPB pest attack intensity in the research locations obtained on untreated farm criterion by an average value of 38.67%. As for the lowest CPB pest attack intensity, this was discovered to be on IPM practice farm criterion with an average of 3.93%.

| Sub District       | Farm Classification |       |       |       |       |
|--------------------|---------------------|-------|-------|-------|-------|
|                    | Not treated (%)     | Sober treat (%) | Intensive treat (%) | IPM practice (%) |
| PanteeBidari       | 55.70               | 32.80            | 13.90               | 4.90            |
| Darul Ihsan        | 34.30               | 27.75            | 17.00               | 3.00            |
| Peunaron           | 26.00               | 11.30            | 7.10                | 3.90            |
| Average            | 38.67               | 23.95            | 12.67               | 3.93            |

The lowest CPB pest attacks on IPM practiced farm criterion was hypothesized to be due to the existence of cocoa tree pruning and *Dolichoderus thoracicus* utilization as effective natural enemies in the reduction of CPB pest incursion and cocoa seed damage.

It can be concluded that the primary pests that attack cocoa plants in the East Aceh Regency are *Phytophthora palmivora* and *Conopomorpha cramerella*, Snellen (Lepidoptera: Gracillariidae) known as CPB. In the Peunaron Sub District of East Aceh Regency, the incursions of both kinds of this plant malady pest generate losses of cocoa plant production at about 40-65% [18]. Interpolate that effect of CPB attacks can detract production up to> 80% and cocoa seed damage up to 82% [19]. Interpolate CPB incursion intensity above 70% will endanger cocoa productivity and cause huge losses [20]. CPB incursion intensity in the amount of 60% or lower induce a slight loss, while the disadvantage increases drastically when its incursion intensity rises above 60% [21].

The low attack levels of CPB pests in the criteria for gardens that implement the IPM practice is due to the high effectiveness of the technology in reducing CPB pests and damage to cocoa beans compared to other farm criteria. The IPM technology practiced by cocoa farmers in the East Aceh District includes the use of superior clones in planting activities or side grafting of cocoa. ICCRI 07 and Sulawesi 03 clones have been proven to be CPB-resistant, making them suitable for rejuvenation and rehabilitation of cocoa gardens in CPB endemic areas [22].

Implementation of the PsPSP system (frequent harvesting, pruning, sanitation, and fertilization) in cocoa gardens is very effective in preventing CPB attacks; along with farmers who harvest often when the fruit is ripe with a rotation period of 1 week. The harvesting activity is followed by fruit management on the same day, and then the fruit peels are collected and immersed in the ground and filled with soil as thick as 20 cm. This activity can significantly break the life cycle of the CPB. Cocoa farmers in research locations that apply IPM technology must also maintain periodic...
pruning. This is done in consideration of the fact that one of the weaknesses of imago CPB is the absence of direct sunlight.

Garden sanitation is maintained by cleaning the garden area of dry leaves, unhealthy plants, dry skin, fruit skins, or weeds around the plants. Clean environmental conditions are not suitable environments for the development of CPB pests. Fertilization of cocoa plantations is carried out in a balanced manner by combining chemical fertilizers and organic fertilizers that utilize cocoa leaf litter, cocoa pods infected with pests and diseases, cocoa shells, and other cocoa plantation waste.

Then young fruits measuring 5-8cm are sheathed with plastic. This technique of covering the fruit is very effective and especially effective for cocoa trees with short trees or side grafting cocoa trees. By cloaking the fruit, female imago cannot lay eggs on the skin of the fruit so that the fruit will be protected from CPB attacks. Finally, the technique of fighting CPB with natural predators in the form of black ants (*Dolichoderus thoracicus*) has been proven to be able to control the Helopeltis spp.

4. Conclusions
Cocoa farms in the research location are largely attacked by the CPB pest with a variety of attack levels. Percentages and the highest intensity of CPB attacks in the research locations was found on untreated farm classifications and the lowest on IPM practicing farm classifications. The low percentage of CPB attack intensity was attributed to farm criterion where IPM practices had been applied, along with cocoa pruning techniques and the usage of black ants as a natural enemy (*Dolichoderus thoracicus*).

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