

Strategies for Controlling Cocoa Pod Borer, *Conopomorpha cramerella* Snellen, on Cocoa Farmers in Langkat District, North Sumatra, Indonesia

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ABSTRACT

Cocoa Pod Borer (CPB) *Conopomorpha cramerella* Snellen is the primary cause of significant yield loss up to 80- 90% for smallholders. It is hard to control the pest because most of their lives are in cacao pods, which makes them protected from natural enemies and insecticide applications. This study was conducted to obtain CPB control strategies that can be applied by farmers and to increase their cocoa productions. We observed CPB infestation, the population of its natural enemies Cocoa Black Ant (CBA) *Dolichoderus thoracicus* along Cocoa Mealybugs (CM) *Exallomochlus hispidus*, and the cocoa canopy at 10 cocoa farms from March 2018 to June 2019. Mutual association was found between the cocoa black ants and cocoa mealybugs in 62% of the cocoa trees that grown under shade trees. They were found nesting on coconut (*Cocos nucifera*), soursop (*Annona muricata*), kapok (*Ceiba pentandra*), and jackfruit (*Artocarpus heterophyllus*), that grow around or mixed with cocoa trees inside the farm areas. Most of the cocoa trees had dieback because they did not apply fertilizer and, in some areas, there were no shade trees. In Langkat District, the cocoa black ants and cocoa mealybug symbiosis and populations have grown naturally. Thus, it is enough to provide empty artificial nests of ants as a strategy to increase their populations in the cocoa farms.

Keywords: *Conopomorpha cramerella*, *Dolichoderus thoracicus*, *Exallomochlus hispidus*, *cocoa*, *pest*

1. INTRODUCTION

The cocoa pod borer (CPB) *Conopomorpha cramerella* Snellen (Lepidoptera: Gracillariidae) is one of the key pests of cocoa that arduous to control due to the natural behaviour that protect them from enemies or control techniques [1–3]. The larvae of CPB live inside the cocoa pod and active to feed on mucilage and placental [4]. CPB attacks on younger pods resulting in malformation and clumped beans, making them unextractable during harvesting [2, 5, 6]. The yield loss caused by CPB can reach up to 80 % [1].

Cocoa is the source of living for more than 2,186 farmers in Langkat District, North Sumatra, with an average area of 1,616 ha, but the yield per ha is ca. 558 kg/ha/year [7], and some farmers can only produce less than 400 kg/ha/year [8]. Most of the farmers failed to control CPB with insecticides resulting in low quality of cocoa beans, which led to decreasing income per capita. Thus, the farmers could not maintain the trees properly using cultural practices such as pruning and fertilizer application. Therefore, total production in these areas reduces more than 90% [8].

Cocoa Black Ants (CBA), *Dolichoderus thoracicus* Smith (Hymenoptera: Formicidae) is known as a biological agent in controlling CPB in Indonesian cocoa plantations [9–

11]. To control CPB attacks, farmers in North Sumatra applied the Integrated Pest Management strategies with an emphasis on biological control, *i.e.*, the establishment of CBA, cocoa mealybug (CM) *Exallomochlus hispidus*, and followed by 7-day harvesting round and buried of cocoa husks [12]. CBA is mutually associated with CM. The high population of CBA and CM required in controlling CPB, and the success rate would be higher if there are at least 70% harvested pods occupied by CBA and CM [13]. CBA also a biological agent for controlling *Helopeltis theobromae*, Miller (Hemiptera: Miridae) in large scale cocoa plantations in North Sumatra and East Java [14–16].

The CBA occurred naturally in cocoa plantations, where 62 % of cocoa trees in shaded areas have been occupied by CBA [8]. CBA build their arboreal nests for their breeding sites. In natural condition, where cocoa is grown under coconut palm, CBA nests can be found under folded coconut palm or cocoa leaves, cocoa leaf litter, within the laterally curled leaflets of dried coconut fronds, underneath the dried sheath that once served to protect the coconut inflorescence and under the proximal ends of live coconut leaflets [9, 17, 18]. The population growth of CBA depends on their nests and food sources, as well as the absence of antagonist ants. Usually, population density is controlled by food resources and breeding sites as well as by predation [19]. Saleh [12] reported that based on CBA preferences to

build nests in cocoa leaf litter and coconut leaflet tubes, he used the materials to construct artificial nests for CBA. The artificial nests made from dried cocoa leaves as practiced in cocoa estates [15] and several types of artificial nests of CBA had been used by planters and researchers in Java, Indonesia, and Malaysia, as reported by Kalshoven [9] that banana or coconut leaves stuffed in bamboo were used in Java cocoa plantations to enhance CBA population. Ho and Khoo [20] made artificial nests from the plastic bag and Saleh [21] reported that the permanent nest made from polyester bag 35 cm x 40 cm with 30 to 40 holes filled with dried cocoa leaves could last more than five years without replacing the dried cocoa leaves and polyester bag.

The CPB control strategies for cocoa farmers in the Bahorok, Langkat District, are not complicated because the CBA population occurs naturally. Thus, very profitable for cocoa farmers. The population of antagonist ants is very low. Therefore, it helps to increase the CBA population. Antagonist ants are issues in some cocoa plantations because it disturbs the CBA population. Despite that, it is necessary to observe the condition of the cacao trees, which infested by CBA and CM. However, there should be special treatments on supporting the development of ant species on cacao without shade. The study was conducted to obtain an efficient strategy to control CPB that can be applied by farmers.

1.1. Materials and Methods

The study was conducted in smallholder cocoa farms at Timbang Jaya village in Bahorok, Langkat District, North Sumatra, from March 2018 to June 2019. The location is 03°03' North and 96°06' East, 92 km from Medan. The annual precipitation in this area is 3,000-4,000 mm per year and the peak of rainfall is in December to the middle of January. The conditions of cocoa trees were varied. Generally, smallholders planted the cocoa trees around houses with a total of 50-300 trees, but some were planted separately in the cocoa plantations with the total number of trees up to 900. The cocoa trees planted with other plants, such as coconut, soursop, and rubber as shade trees, and in some areas, there were no shade trees with most of the cocoa trees had dieback symptoms. There were no fertilizer applications and pest control for more than two years.

The study was conducted at 10 smallholder cocoa farms. In each farm, we selected 10 sample trees. The total number of cocoa trees colonized by CBA and CM were counted. The presence of CBA and CM were recorded from harvested pods samples as well as CPB infestation. We harvested and separated the ripe pods with and without CBA and CM. All pods were examined to calculate the

damage caused by CPB. The damages were grouped into free (uninfested pods), infested (all pods attacked by CPB), and severe damage pods (pods with > 50% unextractable seeds).

1.2. Our Contribution

This paper presents improvements for the establishment of CBA for controlling CPB in cocoa farmers. This founding could easily be adopted by cocoa farmers. The farmers could select the types of artificial nests of CBA depending on available materials in their location.

1.3. Paper Structure

The structure of the rest of this paper is Section 2 informs the potential of CBA and CM population and interaction with CPB infestation. 2.1. The strategy for controlling CPB is consists of the presence of CBA and CM; trees occupied and without CBA and CM then area of cocoa trees without shade trees. 3. The conclusion of this paper is the need to observe the presence of ants before determining an efficient strategy.

2. RESULTS AND DISCUSSION

Overall, 62% of observed cocoa trees were occupied by CBA and CM (Table 1). Saleh *et al.* reported 14 tree species that act as shade trees and as the host of CBA and CM [7]. Four of 14 species were found in this study, *i.e.*, coconut (*Cocos nucifera*), soursop (*Annona muricata*), kapok (*Ceiba pentandra*), and jackfruit (*Artocarpus heterophyllus*). CBA and CM populations could not be found in cocoa trees without shade. Most of the unshade trees were unhealthy, stressed, and infested by Vascular Streak Dieback caused by air-borne fungal pathogen *Oncobasidium theobromae*. Besides, CM prefers shaded habitats. Cocoa without shade trees has an open canopy with excessive light that penetrates tree parts under the canopy, which limiting the CM population growth. The high population of CM was found mostly in habitats with the intensity of light less than 200 lux [22]. As cocoa mealybug is the primary food source of cocoa black ants [24], therefore its abundance highly depending on the survival of CM. Hence, it is challenging to introduce CBA in cocoa monocultures that using insecticides to control pests, which resulted in a declining mealybug population [10].

Table 1 The survival of cocoa black ant (CBA) and cocoa mealybugs (CM) on the cocoa tree

Location No	Total trees observed	Number of cocoa trees colonized by CBA and CM		Percentage of cocoa trees colonized by CBA and CM (%)
		Occupied by CBA and CM	No CBA and CM	
1	10	3	7	30
2	10	8	2	80
3	10	10	0	100
4	10	9	1	90
5	10	7	3	70
6	10	8	2	80
7	10	5	5	50
8	10	2	8	20
9	10	8	2	80
10	10	2	8	20
Total	100	62	38	62

The ripe pods from the 100 sample trees were harvested (Table 2). There were 179 pods examined with 104 pods occupied by CBA and CM, which 69.3% of pods were healthy, 30.7 % of pods infested by CPB with 4.8% of infested pods were heavily damaged. Meanwhile, 75 pods without CBA and CM have 100 % infested by CPB, and 29.3 % of infested pods were damaged heavily. In order to suppress CPB infestation below than 50% or the percentage of massive damage pod below than 5%, the harvested pods should be occupied by CBA and CM should be above 70 % [12, 22]. These results are in line with the previous study, where the increasing population of CBA in the cocoa plantation significantly decreased the population of CPB [26].

The effectiveness of this biocontrol method of CPB depends on the population of CBA and CM in cocoa plantations, where it should high and sufficient [5, 15, 23]. Saripah [25] states that the control of CPB using black ants offer more promising results in comparison to pesticide and reduce the population of the borer significantly and increase more than 50% of healthy cocoa pods. Despite that, the integration of the biological control using the CBA and good cultural practices such as short harvesting round and burying the cocoa husk will increase the chance to reduce the population of the borer drastically and increase the cocoa yield [16, 22].

Table 2 The presence of cocoa black ant (CBA) and cocoa mealybugs (CM) on harvested cocoa pods and severity of CPB infestation

No	Pods with CBA and CM				Pods without CBA and CM				Total pods observed	Total of heavy damaged Pods
	CPB infestation				CPB infestation					
	Total	Free	Infested	Heavy damaged	Total	Free	Infested	Heavy damaged		
1	5	0	5	0	20	0	20	5	25	5
2	10	7	3	1	3	0	3	0	13	1
3	12	11	1	0	0	0	0	0	12	0
4	9	8	1	0	3	0	3	1	12	1
5	15	12	3	0	5	0	5	2	20	2
6	18	13	5	1	10	0	10	3	28	4
7	8	5	3	0	6	0	6	1	14	1
8	4	0	4	2	10	0	10	2	14	4
9	16	14	2	0	8	0	8	4	24	4
10	7	2	5	1	10	0	10	4	17	5
	104	72	32	5	75	0	75	22	179	27
%		69.3	30.7	4.8		0	100	29.3		15.1

2.1. Strategies for Controlling CPB

The results show that the presence of shaded trees supports the growth of CBA and CM populations. While not all cocoa trees have the advantages to grow under shade trees. Therefore, it is necessary to develop strategies to introduce the CBA and CM into those free shade tree areas and also strategies to maintain CBA and CM population. These are three strategies that can be used by the farmers in accordance with their farm conditions.

2.1.1. Strategy for cocoa trees which occupied by CBA and CM

In order to improve the population of CBA and CM to more than 70 % on harvested pods, it is enough to give each tree one empty artificial nest on the branches. The artificial nest of CBA can be made from 40 dried cocoa leaves and tied with raffia ropes (Figure 1a) or stuffed the 40 dried cocoa leaves to the plastic or polyester bag (Figure 1 b, c, d).



Figure 1 Various materials for CBA artificial nest: (a) artificial nest from dried cocoa leaves, (b) dried cocoa leaves in polyester bag, (c) dried cocoa leaves in transparent plastic bag, (d) dried cocoa leaves in black plastic bag

2.1.2. Strategy for cocoa trees without CBA and CM

The artificial nest of CBA is made as mentioned above. The nest must be placed on trees occupied by CBA for at least two months so the nest will colonize by CBA. Then transfer the nests to trees with no CBA. At the same time,



Figure 2 (a) Slices of cocoa pods with CM, (b) slice of cocoa skin and placed on 5cm cocoa pods, Saleh[11]

transfer two slices of cocoa husk occupied by CM to 5 cm length pods. The cocoa husk should be sliced thinly into V shape (Figure 2 a), and in a few days, CM will move to the fresh cocoa pod where they can suck their food [13, 22] (Figure 2 b).

2.1.3 Strategy for cocoa without shade trees

Follow strategies 1 and 2, then give temporary shade from cocoa twigs with leaves on the branches above the pods and placed the slice of cocoa husk on the pods. One of the common biological control of CPB in the cocoa plantation is the use of the natural enemies, CBA.

In order to increase the population of this beneficiary species in controlling CPB, the ant behaviours were studied by few researchers such as nesting area [25, 27], food sources [24], and their role as natural enemies [28, 29]. Gassa *et al.* [30] suggested that the manipulation of the nesting behaviour of the CBA increase its population. Saripah [25] highlighted that the number of artificial nests introduced in cocoa plantations influenced the ground trails and CBA activities on the cocoa trees. According to

Anshary *et al.* [26] the application of suitable for artificial nest is nipa palm leaves, but it has to be strengthened with synthetic materials that will sustain the CBA colonies in the cocoa plantation. Beside cocoa and coconut leaves, another natural material that suitable for artificial nests is nipa palm leaves, but it has to be strengthened with synthetic materials that will sustain the CBA colonies in cocoa plantation.

3. CONCLUSION

CBA and CM populations occurred naturally in cocoa plantations in Bahorok, so it is enough to install empty artificial nests in cocoa trees. Aside from artificial nests, shade trees also boost CBA and CM populations. These strategies combination will maintain CBA and CM populations so it can suppress CPB attacks. Whereas on trees without a shade where no CBA and CM populations, the farmers can transfer the artificial nests which have been occupied by CBA and CM to cocoa trees.

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