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Infestations of Two Major Pests of Cocoa, *Conopomorpha cramerella* and *Helopeltis* spp. Under Natural Condition

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Abstract

The cocoa pod borer (CPB), *Conopomorpha cramerella* (Snellen) (Lepidoptera: Gracillariidae) and *Helopeltis* spp. (Hemiptera: Miridae) are the major pests of cocoa in the South East Asian region. *C. cramerella* started to infest cocoa pod which more than 7 cm in length, whereas *Helopeltis* spp. started to infest the pod at a very early stage of pod development. The present study aimed to determine the relationship and the degree of damage severity of these two significant pests under natural conditions. No insecticide spraying was carried out throughout sampling occasions; however, other management practices were implemented. Destructive sampling of fifty cocoa pods at various lengths was carried out at a fortnightly basis. Percentage of infestation, number of *C. cramerella* eggs, entry and exit holes were recorded for an individual pod. The results obtained denoted that *Helopeltis* spp. began attacking pods at a young age, and the majority of the pods were infested when they reached 8 cm in length. The percentage of damage severity increased as the pod developed. In contrast to *Helopeltis* spp. incidence, the number of *C. cramerella* eggs were recorded higher when the percentage of *Helopeltis* spp. incidences were low. The highest mean number of *C. cramerella* eggs were recorded when the pod length was more than 150 mm. Although the infestation of the *C. cramerella* was more serious, the management of both pests must be started when the pod length is less than 8 cm. Integrated control approaches must be targeted to both pests at the appropriate time, to reduce significant losses.

Keywords: Cocoa, cocoa pod borer, *Conopomorpha cramerella, Helopeltis* spp., mosquito bug, *Theobroma cacao*

INTRODUCTION

The diversification of cocoa *Theobroma cacao* L. (Malvales: Sterculiaceae) planting systems highly contributed to the biodiversity of cocoa insects. Cocoa insects can be classified due to their roles, either as beneficial insects, pollinator, neutral insects and insect pests which can contribute risk to the yield of cocoa. Entwistle (1972) included more than 1,400 species feeding on cocoa, and more than 200 species have been recorded in Malaysia (Lee *et al.*, 2013; 2014). Among all species, the Cocoa pod borer *Conopomorpha cramerella* (Snellen) (Lepidoptera: Gracillariidae) has become the primary threat to cocoa-growing countries in the Southeast Asia region. This pest becomes one of the significant factors in the declining trends of cocoa production in Malaysia. The yield loss in Indonesia was estimated at USD 500 million (Niogret *et al.*, 2019), and infestation at 16-95% may contribute to 3 to 56% yield loss (Sulistyowati, 2015). Beans from infested pods often clump together and are difficult, if not possible, to extract.

Another economic pest is the mirid, *Helopeltis* spp. (Hemiptera: Miridae) which widely distributed in this region (Saripah *et al*., 2017). *Helopeltis* spp. may cause substantial yield loss if their infestation occurred at the early development stage of cocoa pods. Both nymph and adult infest young shoots, pods, and peduncles on which a single pest can produce approximately 25-35 lesions per day. Fresh lesions are water-soaked and dark green. The lesions will turn dark and slightly concave, whereas the old lesion is usually convex. Young pods, especially those less than three months old, have little chance of surviving. Mirid damage may lead to invasion by secondary pests or disease, and severe infestations will lead the pod to crack. The infestation usually increased, particularly in rainy seasons (MCB, 2013), where rainfall is one of the factors which has a positive effect on the insect population (Khoo *et al*., 1991). Other than cocoa, *Helopeltis* spp. also attacked on the flower buds and fruits of guava, as well as cashew and apples. This mirid also infested tea plantation in India (Sarmah & Phukan, 2004; Bhuyan *et al*., 2017) and Indonesia (Indriarti & Soesanthy, 2014).

Due to the seriousness of both species, it was suggested to implement fortnightly insecticide spraying and targeted on the pod surface as well as young cocoa shoots. It also recommended applying 4P approaches, including pruning, scheduled fertilization, maintenance of field sanitation, and frequent harvesting of mature pods (Saripah & Alias, 2016). A similar concept was adopted in Indonesia (Rahayu & Sulistyowati, 2018) by promoting P3S which include culturally technical controls of pruning (P), fertilization (P), frequent harvest (P), and sanitation (S). To combat *Helopeltis* spp. severe incidence, management must be comprised of environmentally friendly methods. These involved the integration of technical culture, biological control, resistant varieties, botanical, chemical, as well as the implementation of proper integrated pest management (Indriarti & Soesanthy, 2014; Hastuti *et al*., 2015). Therefore, due to the crucial occurrences of *C. cramerella* and *Helopeltis* spp. in Malaysia, this paper aims to provide and information on the infestation of both species under the natural condition, where no control approach had been implemented throughout the observation.

MATERIALS AND METHODS

The study was carried out at the Cocoa Research and Development Center (CRDC), Malaysian Cocoa Board, Jengka, Pahang, Malaysia (Longitude 100^{O} 30’ 31.64" E, Latitude 3^{O} 36’ 59.73^{O} N). This area is located at the central interior of Peninsula Malaysia, with the main characteristic of this zone is the presence of two dry seasons with equal intensity (Azhar *et al*., 2009). The relative humidity is between 85-90%, with a hot, humid climate throughout the year.

The selected mature cocoa area was planted referring to the monoculture planting system under the permanent shade tree of *Gliricidia macculata*. Clonal cocoa trees were planted at 3 m x 3 m on the triangle pattern. No pest management approach had been implemented in this area (six months before the observation until the end of the study) leaving the area under natural condition. On the other hand, management approaches were carried out, including schedule fertilization, field sanitation, weedicide, and pruning every two to three months.

Destructive sampling of 50 cocoa pods from various clones (PBC 123, PBC 140, GS 29, MCBC 1, and KKM 22) at various lengths was carried out at a biweekly basis for 10 consecutive months. No control practice had been implemented throughout the observation, where it leads to the natural condition. In general, cocoa pods more than 70 mm in length were harvested, and the criterion of selection was based on the visible infestation symptoms of Mosquito Bug (*Helopeltis*) on the pod surface. Meanwhile, the number of CPB eggs, entry, exit holes, and the percentage of CPB infestation were recorded for individual pod using the slicing technique. Data obtained from observations were arranged separately based on the pod length in Microsoft® Excel 2007 and were subjected to statistical analysis using Analysis of Variance (ANOVA), SAS software from SAS® Version 8.

RESULTS AND DISCUSSIONS

Helopeltis spp. begin attacking pods at early pod development, which started at the length of 70 mm and onwards. *Helopeltis* spp. symptoms visibly clear when the pod length is more than 85 mm, with the sign of incidence on the pod surface. The percentage of severity increase as the pod size developed and mostly occurred at the range of 85 mm to 150 mm (Figure 1). Meanwhile observation on the infestation based on the pod diameter, it was denoted that *Helopeltis* spp. infestation started from 20 mm, which usually in most clones are at the early age of the development stage. The early infestation of *Helopeltis* spp. might reduce the number of developed pods, if the infestation occurred at the pod peduncle, and by sucking the sap of young pods. The severity risk of infestation is lesser at the older pods, due to pods often tolerate direct damage unless the number of feeding lesions inflicted is high (Khoo *et al*., 1991). The number of *C. cramerella* eggs were recorded low, which most of the pods recorded no egg, even the percentage of *Helopeltis* incidence was increased with the increment of pod length (Figure 2).

Helopeltis spp. began attacking pods more 70.00mm, which pods size of 70.00 to 79.99 mm recorded 40.313% of infestation (Figure 3) and shows no significant difference ($p<0.05$) with other classes except for 90.00 to 99.99 mm (29.307b). Infestations throughout the observation period might denote that *Helopeltis* spp. attacking cocoa pods at various lengths with the almost constant infestation, and it may occur at the very early developmental stage of cocoa pods. Fortunately, even *Helopeltis* spp. infestations can be categorized into moderate, which recorded more than 30%, pods were successfully developed and able to survive. Unlike *Helopeltis* spp. incidence, *C. cramerella* appeared to deposit their eggs at every class of length. The highest mean of eggs was recorded at pod length more than 150 mm (0.400a) and significantly different ($p>0.05$) at pod length of 80.00 to 89.99 mm. Similar results were obtained from *C. cramerella* entry holes, where the highest was recorded at pod length more than 150 mm (3.063) and significantly different ($p<0.05$) with pod length below than 140 mm (Figure 4). Entry holes gradually increased with the pod increment. Similar results were obtained for exit holes, where pods more than 140 mm tend to have more exit holes compared to smaller size pods. This might be due to adult *C. cramerella* repeatedly deposit their eggs at the same pods throughout the developmental stages, thus increased the cumulative number of exit holes through their maturity. It was denoted that if the larvae of *C. cramerella* able to spend more time inside the pod and allows them to complete their larval stages, the risk of successful emergence of pupae is high. The higher number of the successful mature larva to tunneling out from older pods may increase the number of exit holes later on, as found in this study.

The results obtained from this study suggested that the infestation of both pests

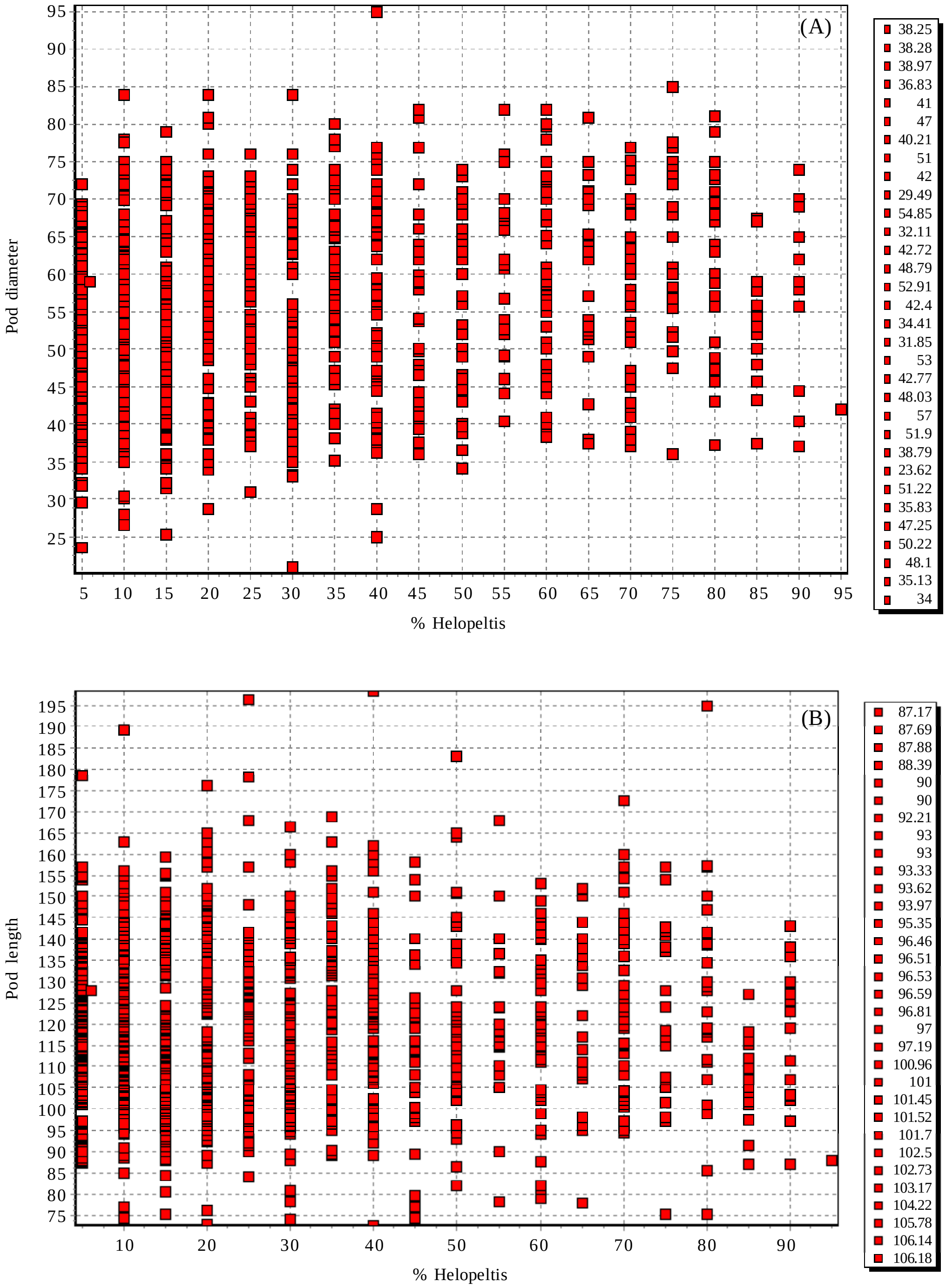

Figure 1. Relationship between *Helopeltis* spp. infestation with pod diameter (A) and length (B)

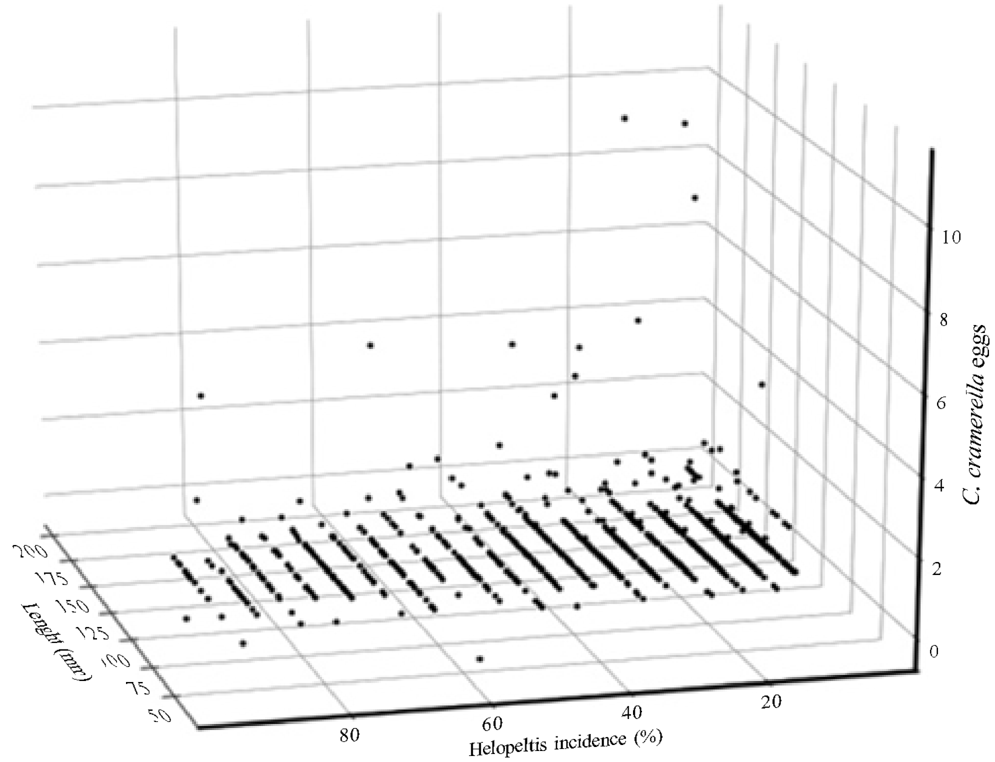

Figure 2. Relationship between *Helopeltis* spp. and *C. cramerella* infestation

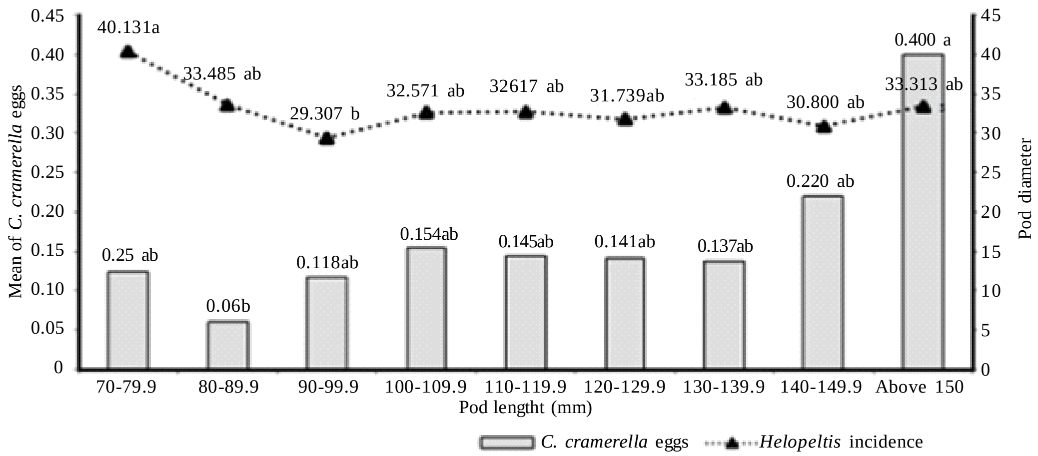

Figure 3. *C. cramerella* eggs and *Helopeltis* incidence

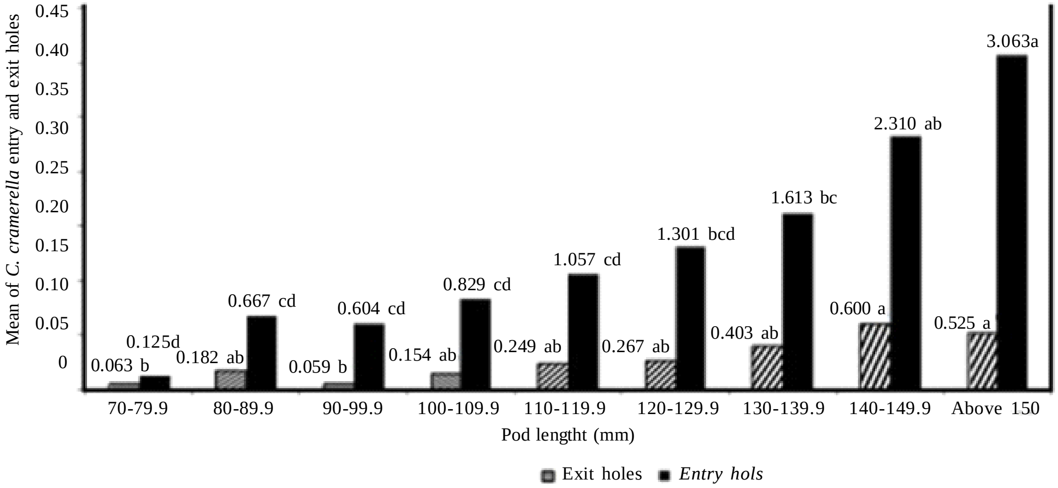

Figure 4. Mean of *C. cramerella* entry and exit holes

can be considered as high under natural conditions. Since there was no control approach had been implemented six months prior to the sampling occasions, and throughout the study, both pests successfully become a nuisance to this area. *Helopeltis* spp. incidence occurred at early development and may contribute to the incidence of cherelle wilt. High cherelle wilt incidence may reduce the number of developing pods later on. *C. cramerella* eggs were found even until cocoa pods reached maturity stages (more than 150 mm length). This will influence the increment of damage severity in terms of visible entry and exit holes. Understanding the behavior of *C. cramerella* and *Helopeltis* spp. is vital for cocoa production, due to their immense ability in affecting pod development, as well as cocoa yield. Although the infestation of the former pest was more severe and led to significant yield losses compared with the latter, the management of both pests is suggested when the pod length is less than 8 cm.

CONCLUSIONS

C. cramerella and *Helopeltis* spp. were infested cocoa pods at the beginning of pod development if there is no control approach had been carried out. Therefore leaving the cocoa block without any effort may contribute to significant yield loss and affecting the quantity and quality of cocoa beans. As part of the control, integrated approaches must be targeted to both pests at the appropriate time, with proper maintenance of the cocoa block is a must. Pest surveillance systems that enable early detection of localized infestations must be carried out, to reduce the risk of more significant yield loss later on.

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