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Original Research

Occurrence and Population Dynamics of the Coffee Berry Borer (*Hypothenemus hampei*) on Coffee Plantations in Tanah Datar, Indonesia

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ABSTRACT

Coffee is an exported commodity that is important in earning foreign exchange. The coffee berry borer (*Hypothenemus hampei*) is the most crucial pest that has a detrimental effect on coffee growers in Indonesia. Research on the incidence of fruit borer on Arabica and Robusta coffee was carried out on smallholder plantations in the Tanah Datar district. The study aimed to determine the extent to which fruit borers infest Arabica and Robusta coffee, and to determine the populations of these pests so that they could be compared. Observation variables included planting conditions and cultivation methods, percentage of coffee plants infested, percentage of coffee cherries, insect identification in the laboratory, and coffee berry borer populations. The results showed that the average incidence of *Hypothenemus hampei* infestation on Arabica coffee plants in Tanah Datar district was 30.00% and 36.66% on Robusta coffee plants. The percentage of the egg stage in Arabica coffee is 37% and 27% in Robusta coffee. The percentage of the larval stage in Arabica coffee is 33%, and in Robusta coffee, it is 28%. Stadia Pupa on 20% Arabica coffee, 11% Robusta coffee. Stadia imago on Arabica coffee 54%, Robusta coffee 49%. This study provides important insights for integrated pest management strategies in Tanah Datar, particularly in optimizing pest control for Arabica and Robusta coffee.

Keywords: *Coffea arabica*, coffee berry borer, *coffea robusta*, *Hypothenemus hampei*, incidence.

INTRODUCTION

As a commodity that has a relatively high economic value, given the significant contribution of coffee to the national economy, it is appropriate that the development of coffee farming is given serious attention. For this reason, the growth and productivity of this coffee plant must be considered and maintained to increase the production of the coffee plant itself. The development of coffee farming significantly impacts national economies and local communities by providing employment, generating income, and fostering community development. Coffee farming is a vital economic driver, particularly in countries like Colombia and Ecuador, where it contributes to household incomes and regional economic stability through export revenues (Fernando, 2024). The development of coffee farming significantly impacts the Indonesian economy through various channels, including export revenues, local employment, and agricultural productivity (Khairifa & Suhendar, 2023).

Coffee farmers suffered substantial losses totalling billions of rupiah. In general, the coffee plantation area in Indonesia during the last 10 years did not experience significant expansion. On the other hand, the quality and productivity of our coffee is still low, reaching an average of only 980 kg/ha, still inferior to Vietnam which reaches 1.5 tonnes per hectare and Colombia 1.22 tonnes per hectare. As many as 30% of coffee plants in Indonesia have reached the age of 20 to 30 years (Angkasa and Gandha, 2019). Currently, the increase in coffee production in West Sumatra is still hampered by the low quality of coffee beans produced. While coffee plays a significant role in Indonesia's economy, its production is often compromised by pest infestations, particularly the coffee berry borer (Hypothenemus hampei), which reduces both yield and quality.

The coffee berry borer (*Hypothenemus hampei*) significantly impacts coffee production in Indonesia by reducing the yield and quality of coffee beans. This pest is a significant concern for coffee producers, as it causes substantial economic losses and affects the export quality of Indonesian coffee. Environmental factors such as humidity and temperature influence the pest's lifecycle and attack patterns, which are crucial for developing effective management strategies. The following sections detail the impact and management of the coffee berry borer in Indonesia. The coffee berry borer is responsible for hollowing out coffee seeds, leading to significant yield losses and reduced bean quality. In Indonesia, the average infestation rate exceeds 20%, resulting in yield losses of more than 10% (Wiryadiputra et al., 2008). The pest's attack intensity varies with altitude, with higher intensities observed at lower altitudes. For instance, in North Sumatra, attack intensities reached 56% for Coffea arabica and 62% for Coffea canephora at altitudes below 1000 meters("Attack Intensity Variety of Coffea arabica and Coffea canephora Hypothenemus hampei Ferrari, 1867 (Coleoptera: Curculionidae: Scolytinae) in North Sumatra", 2023).

There is no information on the incidence and level of attack of this coffee berry borer pest in West Sumatra, so we are interested in conducting this research. The research aimed to describe the events found during this pest attack, and to determine the population of coffee berry borers attacking Arabica and Robusta coffee plantations for comparison.

METHODS

This research has been conducted in one of the centers of Arabica and Robusta coffee production, namely Tanah Datar Regency, and in the Insect Bioecology Laboratory, Department of Pests and Plant Diseases, Faculty of Agriculture, Andalas University. The research locations were determined based on the areas with the largest planted area in Tanah Datar Regency. Samples were taken from as many as 10% of the coffee plants on each land per sub-district. The determination of sample plants was carried out systematically by making diagonal lines, and 5 coffee plants were taken on each diagonal line. So the sample plants that will be used are 10 plants.

Preliminary Survey

This preliminary survey aimed to identify locations or coffee plantations that could fulfill the requirements and criteria to be used as sample land.

Sampling

The sample plants will be randomly taken diagonally as many as 10 plants, then marked with label paper and attached to the sample tree. Then the sample plants are harvested. The harvest of the 10 sample plants was then randomly taken as much as 10% to be used as sample coffee fruit. Samples were taken twice with a span of 14 days.

In the second sampling, 100 coffee cherries were taken randomly (50 young coffee cherries and 50 mature coffee cherries) from each sample tree. Then put in plastic and labelled. So there will be 10 plastics containing 100 coffee cherries each that will be sampled. Then coffee cherries that fall around the sample coffee plants are also taken, both young coffee cherries and old coffee cherries.

Insect Identification in the Laboratory

Identification is done to observe coffee fruit borer pests obtained in the field, to know the characteristics of the order to the species level. Observations were made of: Classification and Morphology of the insect, Percentage of Coffee Plants Attacked, Percentage of Coffee Fruits Infested, and Coffee Fruit Borer Population.

RESULTS AND DISCUSSION

Coffee Planting Condition

Based on observations of the condition of coffee plantations in Tanah Datar District, the types of coffee grown are arabica and robusta coffee. Farmers generally obtain seeds from the seeds of previously harvested coffee cherries, and then conduct their seedlings. Some also get seeds from the Agricultural Extension Centre in the sub-district. The planting distances used by farmers are (2.75 x 2.75) m and (3 x 3) m, but some farms do not pay much attention to planting distances. On and around coffee plantations, there are other plants such as bananas, sweet bark, cocoa, chillies, pokat, lamtoro, rimbang, and surian wood.

Many coffee fields have not been managed optimally by farmers. Farmers do not know the things that need to be considered in coffee cultivation techniques, such as pruning, fertilisation, and pest and disease control, and sanitation have not been done properly. The only fertiliser used is urea fertiliser with erratic doses and timing. Some fields are not even fertilised at all.

In some fields, weeds are allowed to grow wild, leaf litter and pest-infested coffee cherries are scattered on the ground. Coffee farmers have their own ways of controlling coffee pests. Some coffee farmers burn coffee leaf litter at the edge of the field to reduce pest attacks. However, some farmers do not carry out control.

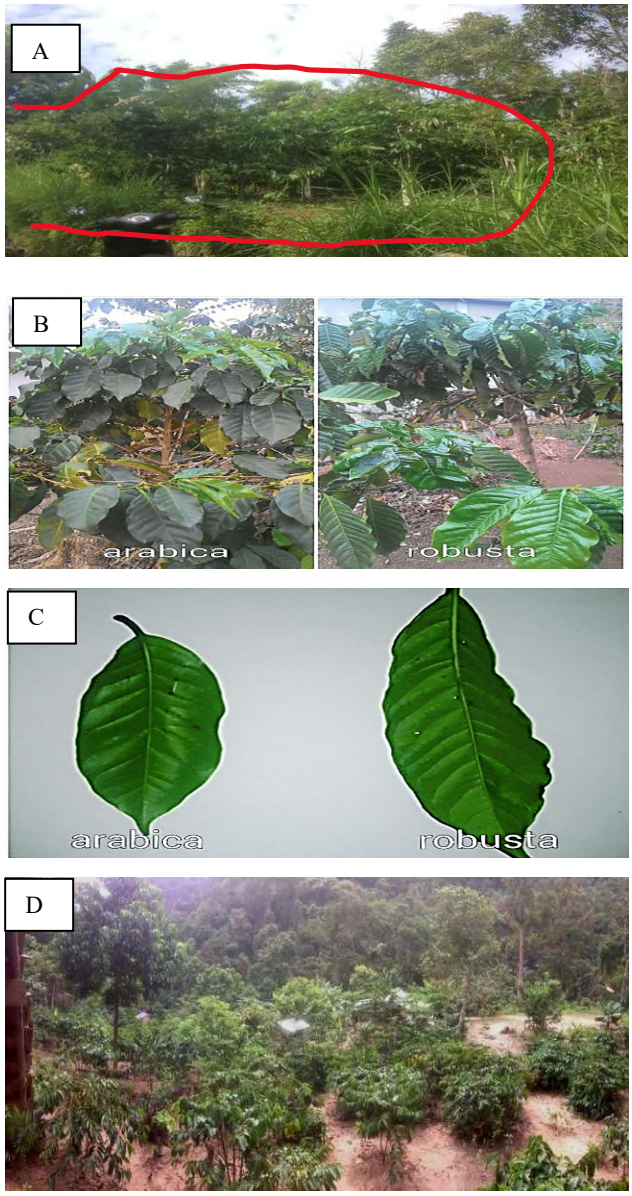

Figure 1. The condition of coffee plantations in several sub-districts, Tanah Datar district (a) arabica coffee plantation in Sungai Tarab sub-district (b) arabica and robusta coffee plants (c) arabica and robusta coffee leaves (d) robusta coffee plantation in X Koto sub-district.

Insect Identification in the Laboratory

Based on coffee fruit samples obtained in the field and then identified in the laboratory, it is known that the type of coffee fruit borer pest found in Tanah Datar district is *Hypothenemus hampei*. The classification of this type is as in the following table 1.

Table 1. Classification of *Hypothenemus hampei* (Coffee berry borer) found in coffee plantations in Tanah Datar District

Class	Ordo	Famili	genus
Insecta	Coleoptera	Curculionidae	Hypotenemus

Table 2. Morphology of *Hypothenemus hampei* Stadia Colour Size

Stadia	Colour	Size
Eggs	clear as crystal	(1,0 – 1,9) mm
Larva	White	(2,2 – 4,0) mm
Pupa	yellowish	(1,0 – 2,0) mm
imago	Dark brown - Black	Female: (1,4 – 2,2) mm Male.: 1,4 mm

The eggs of this coffee fruit borer pest are clear crystal-like oval-shaped with a size of 1.0 mm - 1.9 mm, the eggs hatch into larvae which are white and at the end near the head are brownish with a size of 2.2 mm - 4.0 mm. Eggs have a high % fertility rate of 99.2%, leading to rapid population growth(Fernández & Cordero, 2007). Then the larva turns into a pupa, the pupa is yellow with a size of 1.0 mm - 2.0 mm. Larvae are the primary feeding stage, causing direct damage to coffee berries by boring into them, which can lead to significant crop losses (Noriega et al., 2019).

Furthermore, the pupa turns into an adult insect called an imago. The female imago is larger than the male imago and blacker in colour. The female imago measures 1.4 mm - 2.2 mm and is solid black in colour, while the male imago measures 1.4 mm and is brownish in colour. Adult females emerge to infest new berries, with their emergence pattern influenced by temperature, affecting the timing of infestations (Jaramillo et al., 2010). The adult stage is critical for reproduction, with a high fecundity rate of 43 eggs per female, and a skewed sex ratio favoring females, which exacerbates the pest problem (Fernández & Cordero, 2007).

The life cycle of the coffee berry borer, *Hypothenemus hampei*, consists of several stages: egg, larva, pupa, and adult. Each stage plays a significant role in the pest's impact on coffee production. The egg stage lasts approximately 4.21 days, followed by the larval stage, which spans about 11.15 days and includes two instars. The pre-pupal and pupal stages last 2.66 and 5.29 days, respectively, while the adult stage can last over 100 days, with females being particularly long-lived and prolific in reproduction(Fernández & Cordero, 2007). The pest's development is temperature-dependent, with optimal development occurring between 18°C and 30°C, allowing for multiple generations per year, especially in warmer climates(Giraldo-Jaramillo et al., 2018).

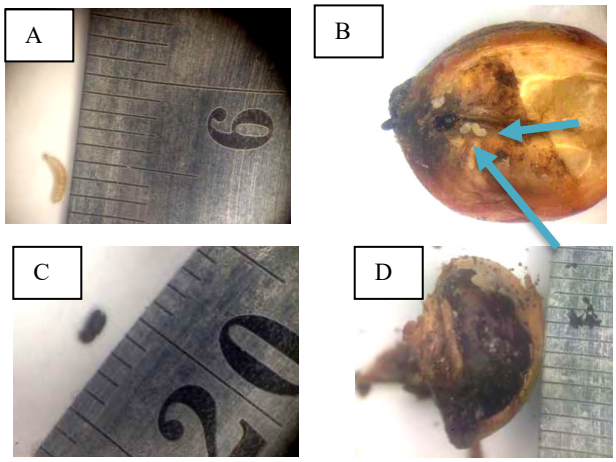

Figure 2. (a) *Hypothenemus hampei* larvae, (b) Hypothenemus hampei pupae, (c) imago Hypothenemus hampei, (d) infested coffee fruit. Image taken using 40 x 10 magnification

Percentage of Coffee Plants Attacked

Based on the observations that have been made, the percentage of infested coffee plants can be obtained as follows:

Table 3. Percentage of Coffee Plants Infested in Tanah Datar District

District	Arabica (%)	Robusta (%)
Batipuh Selatan	30	30
X koto	45	55
Sungai Tarab	20	45
p-value (two-tailed)		0.25

The average percentage of infested arabica coffee plants in Tanah Datar Regency is 31.66%, while robusta coffee plants are 43.33%. The problem of coffee berry borers is more prevalent in robusta coffee plantations than in arabica coffee. The percentage of infested

arabica coffee plants in Tanah Datar District did not exceed 50%. It can be said that arabica coffee farmers in Tanah Datar District have done a little better maintenance and care of the garden although not yet fully perfect. Observations and questionnaires in the field evidence this. Based on the Wilcoxon signed-rank test, the difference in infestation rates between Arabica and Robusta coffee across the three districts is not statistically significant ($p = 0.25$). This suggests that while Robusta shows higher infestation percentages in two out of three locations, the difference is not strong enough to rule out chance variation with the current sample size.

Percentage of Coffee Fruits Infested

100 coffee cherries were taken randomly (50 young and 50 mature cherries) from each sample tree.

Table 4. Percentage of Infested Coffee Fruits in Tanah Datar District

District	Arabica (%)				Robusta (%)			
	YF		RF		YF		RF	
	OT	F	OT	F	OT	F	OT	F
Batipuh selatan	40,2	72,5	28,2	48,6	43,6	88,5	30,8	64,4
X Koto	43,6	93,2	32,5	57,5	46,8	46,6	51,2	35
Sungai tarab	40,2	90,2	43,6	69,5	37	40	20,6	29,9

Infestation of young fruit on the tree is higher than that of ripe fruit in both Arabica and Robusta coffee. Similarly, the attack rate on young fruit was also higher than that of ripe fruit in the case of fallen fruit. The higher infestation of young fruit on Arabica and Robusta coffee trees can be attributed to a combination of biological and environmental factors. The Coffee Berry Borer (CBB), a primary pest, exhibits a clumped distribution pattern, with higher infestation rates observed in the lower parts of the trees where infested berries accumulate (Wiryadiputra, 2014). Additionally, the metabolic responses of the coffee plants to CBB infestation differ between Arabica and Robusta, influencing their susceptibility (Castro-Moretti et al., 2020). Environmental conditions, such as shading, also play a significant role, as shaded coffee systems have shown increased infestation by frugivorous flies, which further impacts fruit quality (Souza et al., 2005).

Coffee Fruit Borer Population

After observations in the laboratory, the following results were obtained

Table 5. Total Population of Each Stadia on Arabica's Coffee Fruit in Tanah Datar District

District	Eggs	Larvae	Pupa	Imago
Batipuh Selatan	68	51	15	87 (82♀;5♂)
X koto	22	20	16	37 (30♀;7♂)
Sungai Tarab	11	27	29	37 (34♀;3♂)

Table 6. Total Population of Each Stadia on Robusta's Coffee Fruit in Tanah Datar District

District	Eggs	Larvae	Pupa	Imago
Batipuh Selatan	30	31	9	14 (14♀;0♂)
X koto	17	7	11	82 (50♀;32♂)
Sungai Tarab	30	45	12	49 (35♀;14♂)

In Arabica coffee, in each sub-district, the highest stadia population was in the imago phase. For robusta coffee, in X koto and Sungai Tarab sub-districts, the largest stadia population is also found in the imago phase. However, it is different from the South Batipuh sub-district, in this sub-district, the largest stadia population is actually in the imago phase, or the final stage of development in Arabica coffee plants, which significantly impacts the yield and quality of coffee beans. This phase is crucial as it encompasses the maturation and harvesting of the coffee cherries, which directly influences the biochemical composition and sensory attributes of the beans (Marie et al., 2020). The imago phase is affected by various factors, including genetic variations, environmental conditions, and post-harvest processing techniques, all of

which contribute to the final yield and quality of Arabica coffee (Aparecido et al., 2018).

The integrated pest management (IPM) strategies for controlling Hypothenemus hampei, or the coffee berry borer (CBB), have shown significant promise in enhancing coffee production and quality. These strategies encompass a combination of cultural, biological, and chemical control methods tailored to specific regional challenges. The following sections outline the most effective IPM strategies and their impacts on the coffee industry. Establishing a robust monitoring program is crucial for timely interventions. This includes using traps and regular inspections to track CBB populations (Aristizábal et al., 2017). Efficient harvesting techniques, such as strip-picking and post-harvest sanitation, help eliminate CBB habitats. Pruning and maintaining optimal shade also contribute to pest management(Benavides et al., 2012)(Aristizábal et al., 2012). The application of Beauveria bassiana, a mycoinsecticide, has effectively reduced CBB populations. This biological agent helps combat insecticide resistance (Benavides et al., 2012; Aristizábal et al., 2023).

CONCLUSIONS

The coffee berry borer pest that attacks arabica and robusta coffee plants in Tanah Datar Regency is *Hypothenemus hampei*. The percentage of Arabica coffee plants attacked shows that this coffee fruit borer pest attacks Robusta coffee plants more than Arabica coffee plants. The percentage of coffee fruit attacked shows that coffee fruit borers attack young coffee fruit more than old coffee fruit. The sub-district with the highest infestation is X koto sub-district.

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