

Effective sanitation practices mitigate coffee berry borer, *Hypothenemus hampei* (Ferrari, 1867) (Coleoptera, Curculionidae) infestation in robusta coffee in Indonesia

Wilyus^{1*}, Wilma Yunita¹, Fadila Amelia Putri¹ and Ravindra C. Joshi^{2,3*}

¹Agriculture Faculty, Universitas Jambi. Jl. Jambi - Muara Bulian No.KM. 15, Mendalo Darat, Kec. Jambi Luar Kota, Kabupaten Muaro Jambi, Jambi, Indonesia.

²Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija 3119, Philippines.

³Centre for Agriculture and Bioscience International – Malaysia, Building A19, 43400 MARDI Serdang, Selangor, Malaysia.

Email: wilyus@unja.ac.id; rcjoshi4@gmail.com

ABSTRACT: The coffee berry borer, *Hypothenemus hampei* (Ferrari, 1867), is a major pest responsible for substantial economic losses in global coffee production. This study investigated the impact of field management, particularly sanitation practices, on controlling *H. hampei* infestations in robusta coffee (*Coffea canephora*). Field observations were conducted in both maintained and non-maintained plantations to assess pest populations at different fruit development stages. Results showed that well-maintained fields had significantly lower pest populations across all developmental stages compared to non-maintained fields. Statistical analysis confirmed the effectiveness of sanitation measures in disrupting the pest's life cycle. Mature cherries were found to be highly susceptible to infestation, emphasizing the importance of timely field management. Additionally, healthy coffee plants in managed fields showed greater resilience to pest attacks. The research underscores the vital role of consistent field management in mitigating pest damage and enhancing the sustainability of coffee production systems.

© 2025 Association for Advancement of Entomology

KEY WORDS: *Coffea canephora*, pest populations, field management, pest's life cycle, sustainability

INTRODUCTION

The coffee berry borer, *Hypothenemus hampei* (Ferrari, 1867) (Coleoptera, Curculionidae), is a devastating pest causing significant economic losses in global coffee production (Johnson *et al.*, 2020; Pereira *et al.*, 2021; Abewoy, 2022; Fotso *et al.*, 2023; Myrie *et al.*, 2023). In Indonesia, a major coffee-producing nation, *H. hampei* inflicts severe damage at all stages of berry development, leading

to reduced yields and quality (Avelino *et al.*, 2015; Hayata, 2016; Aristizábal *et al.*, 2017). Global economic losses due to *H. hampei* are estimated at USD 500 billion annually (Infante, 2018). Indonesia experienced a 30 per cent decline in coffee production in 2013, partly attributed to *H. hampei* infestations (Rosiana *et al.*, 2017). Regions like Modayag suffered from high pest damage due to poor plant maintenance (Langkai *et al.*, 2023). The pest also inflicts damage on stored beans,

* Author for correspondence

further degrading quality (Novianti *et al.*, 2023; Aristizábal *et al.*, 2017). High infestation levels have been reported in Sulawesi, Sumatra, and the Kerinci Regency of Jambi Province, where up to 64.32 per cent of coffee plants were affected (Arifin *et al.*, 2022; Nadiawati *et al.*, 2023; Langkai *et al.*, 2023).

Environmental factors, such as temperature, altitude, and humidity, significantly influence *H. hampei* populations. The pest thrives at altitudes between 400 and 1,000m, where optimal conditions accelerate its life cycle (Moreira *et al.*, 2020). Warmer temperatures at lower altitudes and cooler temperatures at higher altitudes impact infestation rate (Constantino *et al.*, 2021; Myrie *et al.*, 2023; Hendrival *et al.*, 2024).

Cultural practices, including pruning, sanitation, and removing infested cherries, are essential for managing *H. hampei* (Constantino *et al.*, 2021; Kidanu, 2020). However, smallholder farmers often face challenges in implementing these practices due to limited resources and knowledge (Aristizábal *et al.*, 2023). Integrated pest management (IPM) strategies, which emphasize sanitation, have proven effective, often integrating biological agents like *Beauveria bassiana* (Aristizábal *et al.*, 2017; Rasika, 2021).

Tamiai Village in Kerinci Regency, with its suitable climate for coffee cultivation, also faces *H. hampei* challenges. Limited pest management practices and minimal fertilizer use contribute to high infestation rates (Novianti *et al.*, 2023; BP3K Batang Merangin, 2023).

Field surveys in Tamiai have revealed high levels of *H. hampei* infestation, leading to significant losses for farmers (Sri *et al.*, 2021). This reflects broader trends in Indonesian coffee regions, where *H. hampei* remains a major threat. This research aims to understand *H. hampei* dynamics under varying environmental conditions and develop effective strategies to mitigate infestation risks.

MATERIALS AND METHODS

This research was conducted in a robusta coffee plantation in Desa Tamiai, Kecamatan Batang

Merangin, Kabupaten Kerinci, Jambi Province, Indonesia. Two distinct plots were studied: a non-maintained plot (2°09'57"S; 101°38'15"E) and a maintained plot (2°10'06.0"S; 101°38'31.3"E). The plantation, approximately 300 hectares in size, consists of 5- to 10-year-old coffee plants intercropped with cinnamon trees, spaced 1.5 meters apart. The research was conducted over a three-month period, from May to July 2024.

Two farmer plots were selected based on their maintenance conditions. Within each plot, coffee plants were further categorized based on weed conditions and topography into non-maintained and maintained groups. Non-maintained plots received neither organic nor inorganic fertilizers and were not subjected to weeding. In contrast, maintained plots were regularly fertilized with NPK fertilizers and underwent weed control using herbicides.

The primary variables observed in this study were the level of attack and population density of *H. hampei*. The level of attack was expressed as the percentage of coffee berries infested by *H. hampei*. This included the attack levels on young, unripe, and ripe fruits. Additionally, the population density of *H. hampei* at various developmental stages (egg, larva, pupa, and adult) was assessed within infested berries at different stages of ripeness (young, unripe, and ripe).

A total of 16 sample plants were selected from both plots to represent various field conditions, with eight plants from each plot. Four productive branches from each sample plant, oriented to the four cardinal directions, were destructively sampled for each observation. The study involved three observation periods over three weeks, with different sample branches selected for each observation to ensure data accuracy. At each observation, all fruits from the four sampled branches were harvested, placed in plastic bags, and stored in a cooler box for subsequent analysis. Each fruit was individually examined for a maximum of 48 hours to record the number of young, unripe, and ripe fruits; the number of young, unripe, and ripe fruits infested by *H. hampei*; and the number of *H. hampei* eggs, larvae, and pupae on young, unripe, and ripe fruits.

The level of *H. hampei* attack was calculated by counting all coffee berries on four branches of each sample plant and then determining the number of infested berries based on observed symptoms. The percentage attack rate was calculated using the following formula:

$$\text{Percentage of attack (A)} = \frac{\text{Number of Infested Berries (a)}}{\text{Total Number of Berries Observed (b)}} \times 100$$

The attack percentages were categorized based on the scale (source-Directorate General of Plantations, 2010): scale 1 (d" 25% as – Light; 2 (25-50% as – Currently; 3 (51-90% as – Heavy) and 4 (e" 90% as Very Heavy).

The population densities of *H. hampei* eggs, larvae, pupae, and adults were calculated for every 100 fruits within three predetermined phenological stages (young, unripe, and ripe). These densities were expressed as the number of *H. hampei* individuals per 100 coffee berries. The data on attack levels and *H. hampei* populations were analyzed statistically using a t-test to compare the means between the two study plots. Descriptive analysis was employed to further interpret the results. Supporting environmental data, such as temperature and humidity, were used to contextualize the findings.

RESULTS AND DISCUSSION

Attack Level: Field observations revealed significant differences in *H. hampei* attack rates between maintained and non-maintained coffee fields across various fruit development stages (young, unripe, and ripe). Maintained fields, which received regular management practices, exhibited significantly lower infestation. The average attack rates were 9.51 ± 4.82 , 14.23 ± 6.17 and 11.35 ± 3.13 per cent, for young, unripe and ripe fruits, respectively, categorizing the overall infestation level as "Light." In contrast, non-maintained fields showed higher infestation. The average infestation was 25.55 ± 8.14 , 34.91 ± 15.35 and 38.07 ± 19.36 per cent for young, unripe, and ripe fruits, respectively, categorizing the overall infestation level as "Currently." There were significant differences between maintained and non-maintained coffee

fields across various fruit development stages (*significantly different according to the paired t-test* ($\alpha = 0.05$), emphasizing the effectiveness of regular cultural practices, such as pruning and sanitation, in mitigating *H. hampei* impacts and promoting healthier coffee crops.

Population density: Field observations revealed significant differences in the population density of eggs, larvae, pupae and adults between maintained and non-maintained fields (Table 1, Fig. 1). The data revealed a significant reduction in *H. hampei* populations across all life stages in maintained fields compared to non-maintained fields. Regular management practices, such as pruning and sanitation, implemented in maintained fields effectively suppressed the development and proliferation of *H. hampei* at all stages of the coffee berry borer's life cycle.

A significant difference in egg counts was observed between the two field conditions. Non-maintained fields exhibited higher average egg populations (29.07 ± 7.176 per 100 fruits) compared to maintained fields (10.47 ± 2.54 per 100 fruits). This trend persisted across all fruit development stages: young fruits (22.84 ± 10.66 vs. 9.71 ± 3.68), unripe fruits (30.92 ± 10.661 vs. 11.73 ± 6.73), and ripe fruits (33.45 ± 8.00 vs. 9.96 ± 3.74). These findings demonstrate that effective field maintenance practices can significantly reduce *H. hampei* egg populations and subsequent infestations.

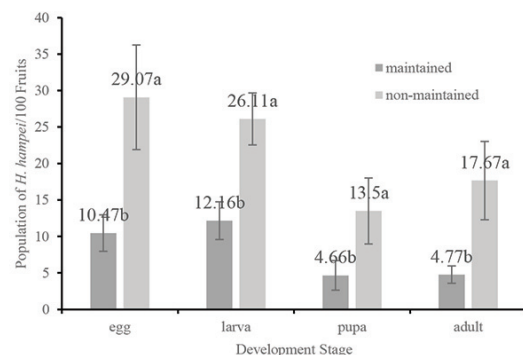


Fig. 1 Comparison of *H. hampei* population dynamics in maintained and non-maintained field conditions. Numbers followed by different letters in the same *H. hampei* development stage are significantly different (paired t-test, $\alpha = 0.05$).

Table 3. Population density at different developmental stages in Maintained and Non-Maintained fields

Field conditions	Young fruit	Unripe fruit	Ripe fruit	Average
Eggs $\pm$ SD/ 100 Fruits				
Maintained	9.71 $\pm$ 3.68b	11.73 $\pm$ 6.73b	9.96 $\pm$ 3.74b	10.47 $\pm$ 2.54b
Non-maintained	22.84 $\pm$ 10.66a	30.92 $\pm$ 10.661a	33.45 $\pm$ 8.00a	29.07 $\pm$ 7.176a
Larvae $\pm$ SD/ 100 Fruits				
Maintained	9.38 $\pm$ 4.24b	16.53 $\pm$ 4.17b	10.56 $\pm$ 2.77b	12.16 $\pm$ 2.58b
Non-maintained	13.57 $\pm$ 6.30a	34.28 $\pm$ 7.45a	30.50 $\pm$ 3.69a	26.11 $\pm$ 3.57a
Pupae $\pm$ SD/ 100 Fruits				
Maintained	2.56 $\pm$ 1.30b	7.39 $\pm$ 5.59b	4.03 $\pm$ 1.82b	4.66 $\pm$ 2.02b
Non-maintained	7.89 $\pm$ 2.00a	15.16 $\pm$ 9.23a	17.01 $\pm$ 4.53a	13.50 $\pm$ 4.52a
Adults $\pm$ SD/ 100 Fruits				
Maintained	4.67 $\pm$ 1.84b	3.68 $\pm$ 1.60b	5.95 $\pm$ 1.90b	4.77 $\pm$ 1.20b
Non-maintained	16.33 $\pm$ 9.58a	14.93 $\pm$ 8.03a	21.75 $\pm$ 3.92a	17.67 $\pm$ 5.37a
Total population				
Maintained	26.35 $\pm$ 8.71b	39.35 $\pm$ 14.76b	30.51 $\pm$ 6.30b	32.07 $\pm$ 7.34b
Non-maintained	60.64 $\pm$ 17.63a	95.75 $\pm$ 22.45a	102.72 $\pm$ 14.33a	86.37 $\pm$ 15.61a

Note: Numbers followed by different letters in the same row are significantly different ($\alpha = 0.05$)

Similar to egg populations, larval populations of *H. hampei* also exhibited significant differences across all fruit stages between maintained and non-maintained fields. The average larval population in non-maintained fields was 26.11 ± 3.57 per 100 fruits, compared to 12.16 ± 2.58 in maintained fields. The highest larval densities were observed in unripe fruits, with 34.28 ± 7.45 larvae per 100 fruits in non-maintained fields and 16.53 ± 4.17 in maintained fields. Even in ripe fruits, non-maintained fields had significantly higher larval counts (30.50 ± 3.69) compared to maintained fields (10.56 ± 2.77). These findings further highlight the importance of maintenance practices in controlling larval populations, which are crucial for limiting subsequent adult emergence and infestation.

A similar trend was observed for pupal populations of *H. hampei*. Non-maintained fields exhibited significantly higher pupal densities compared to maintained fields. The average pupal population in non-maintained fields was 13.50 ± 4.52 per 100 fruits, while in maintained fields, it was significantly lower at 4.66 ± 2.02 . The highest pupal densities were found in ripe fruits (17.01 ± 4.53 in non-

maintained vs. 4.03 ± 1.82 in maintained fields), followed by unripe fruits (15.16 ± 9.23 vs. 7.39 ± 5.59) and young fruits (7.89 ± 2.00 vs. 2.56 ± 1.30). These findings suggest that maintenance practices disrupt the pupal developmental stage, thereby limiting adult emergence and subsequent infestation.

Adult *H. hampei* populations also exhibited significant differences between maintained and non-maintained fields. Non-maintained fields had a higher average adult population of 17.67 ± 5.37 individuals per 100 fruits compared to 4.77 ± 1.20 in maintained fields. The highest adult densities were observed in ripe fruits, with 21.75 ± 3.92 adults per 100 fruits in non-maintained fields and 5.95 ± 1.90 in maintained fields. Unripe and young fruits in non-maintained fields also harbored higher adult populations (14.93 ± 8.03 and 16.33 ± 9.58 , respectively) compared to maintained fields (3.68 ± 1.60 and 4.67 ± 1.84 , respectively). These findings underscore the effectiveness of maintenance practices in limiting adult populations and, consequently, reducing the overall infestation potential of *H. hampei*.

Total population density in maintained fields exhibited significantly lower total *H. hampei* population across all fruit development stages (32.07 ± 7.34 individuals per 100 fruits). While non-maintained fields showed higher total *H. hampei* population (86.37 ± 15.61 individuals per 100 fruits). The population increased from 60.64 ± 17.63 in young fruits to 102.72 ± 14.33 in ripe fruits (Table 1).

This study emphasizes the pivotal role of sanitation practices in controlling *Hypothenemus hampei* infestations in Robusta coffee (*Coffea canephora*). In fields where infested plant debris was consistently removed, pest populations across all life stages were significantly reduced. By disrupting the pest's life cycle, sanitation measures limited the breeding and survival of *H. hampei*, demonstrating their effectiveness as a core pest management strategy.

The findings align with Dufour *et al.* (2021), who reported that mature coffee cherries, due to their higher nutrient content and softer texture, are more vulnerable to *H. hampei*. Similarly, Aristizábal *et al.* (2016, 2017, 2023), Kidanu (2020) and Constantino *et al.* (2021) have underscored sanitation as a cornerstone of Integrated Pest Management (IPM) in coffee production, emphasizing its role in targeting critical stages of the pest's life cycle to mitigate its impact on yield and quality. Regular field maintenance not only curtails pest populations but also promotes overall plant health. Healthier coffee plants are better equipped to synthesize natural defense compounds, which reduce their attractiveness to *H. hampei* (Rasika, 2021).

This study highlights the critical role of effective field management, with a particular emphasis on sanitation practices, in mitigating coffee berry borer (*H. hampei*) infestations in Robusta coffee (*C. canephora*) plantations. The findings underscore the importance of disrupting the pest's life cycle to reduce its population at various developmental stages. Moreover, maintaining plant health through proper cultural practices not only enhances the vigor of coffee plants but also bolsters their natural defenses, rendering them less vulnerable to pest attacks. Future studies should focus on integrating

sanitation practices with biological control agents, such as parasitoids and predators, as well as advanced technological interventions like pheromone traps and remote sensing for early pest detection.

REFERENCES

- Abewoy D. (2022) Impact of coffee berry borer on global coffee industry. *International Journal of Novel Research in Engineering and Science* 9(1): 1–8. doi:10.1007/s00191-020-00713-4.
- Arifin R.D.N., Suroto A. and Prakoso B. (2022) Identifikasi tingkat serangan *Hypothenemus hampei* dan musuh alaminya pada tanaman kopi di Pesangkalan, Pegedongan, Banjarnegara. *Jurnal Ilmiah Pertanian* 18(2): 126–133. doi:10.31941/biofarm.v18i2.1710.
- Aristizábal L.F., Bustillo A.E. and Arthurs S.P. (2016) Integrated pest management of coffee berry borer: Strategies from Latin America that could be useful for coffee farmers in Hawaii. *Insects* 7(1): 1–24. doi:10.3390/insects7010006.
- Aristizábal L.F., Johnson M.A., Mariño Y.A., Bayman P. and Wright M.G. (2023) Establishing an integrated pest management program for coffee berry borer (*Hypothenemus hampei*) in Hawaii and Puerto Rico coffee agroecosystems: achievements and challenges. *Insects* 14(7): 96–110. doi:10.3390/insects14070603.
- Aristizábal L.F., Johnson M., Shriner S., Hollingsworth R., Manaukis N.C., Myers R. and Arthurs S.P. (2017) Integrated pest management of coffee berry borer in Hawaii and Puerto Rico: Current status and prospects. *Insects* 8(4): 123. doi:10.3390/insects8040123.
- Avelino J., Cristancho M., Georgiou S., Imbach P., Aguilar L., Bornemann G., Läderach P., Anzueto F., Hruska A.J. and Morales C. (2015) The coffee rust crises in Colombia and Central America (2008–2013): Impacts, plausible causes and proposed solutions. *Food Security* 7(2): 303–321. doi: 10.1007/s12571-015-0446-9.
- BP3K Batang Merangin (2023) Laporan bulanan hasil pengelolaan hama tanaman kopi di Tamiai, Kerinci. BP3K Batang Merangin, Jambi 12(1): 78–85.
- Constantino L.M., Gil Z.N., Montoya E.C. and Benavides P. (2021) Coffee berry borer (*Hypothenemus hampei*) emergence from ground fruits across varying altitudes and climate cycles, and the

- effect on coffee tree infestation. *Neotropical Entomology* 50(2): 374–387. doi:10.1007/s13744-021-00863-5.
- Dufour B.P., Kerana I.W. and Ribeyre F.F. (2021) Population dynamics of *Hypothenemus hampei* (Ferrari) according to the phenology of *Coffea arabica* L. in equatorial conditions of North Sumatra. *Crop Protection* 146. doi:10.1016/j.cropro.2021.105639.
- Fotso F.Y., Touzeau S., Grogard F., Tsanou B. and Bowong S. (2023) Optimal control of coffee berry borers: synergy between bio-insecticide and traps. *Journal of Optimization Theory and Applications* 196(2): 882–899. doi:10.1007/s10957-022-02151-7.
- Hayata H. (2016) Hubungan persentase serangan hama penggerek buah kopi (*Hypothenemus hampei* Ferr. (Coleoptera: Scolytidae)) dengan dugaan kehilangan hasil di Kecamatan Betara Tanjung Jabung Barat. *Jurnal Media Pertanian* 1(2): 85–90. doi:10.33087/jagro.v1i2.20.
- Hendrival U., Yusuf M.N., Nurdin M.Y., Ahmadika H.M. and Margono (2024) Populasi, serangan dan pola distribusi *Hypothenemus hampei* Ferr. pada kopi Arabika Gayo berdasarkan zona elevasi. *Jurnal Agrikultura* 35(1): 20–29. <https://jurnal.unpad.ac.id/agrikultura/article/viewFile/45701/22728>.
- Infante F. (2018) Pest management strategies against the coffee berry borer (Coleoptera: Curculionidae: Scolytinae). *Journal of Agricultural and Food Chemistry* 66(21): 5275–5280. doi:10.1021/acs.jafc.7b04875.
- Johnson M.A., Ruiz-Diaz C.P., Manoukis N.C. and Verle Rodrigues J.C. (2020) Coffee berry borer (*Hypothenemus hampei*), a global pest of coffee: Perspectives from historical and recent invasions, and future priorities. *Insects* 11(12): 882. doi:10.3390/insects11120882.
- Kidanu S. (2020) Bio-ecological and management studies of coffee berry borer, *Hypothenemus hampei* Ferrari (Coleoptera: Scolytidae), in Ethiopia. *International Journal of Forestry and Horticulture* 6(3): 39–47. doi:10.20431/2454-9487.0603005.
- Langkai H., Rimbing J. and Wanta N.N. (2023) Persentase serangan hama penggerek buah kopi (*Hypothenemus hampei* Ferr.) (Coleoptera: Scolytidae) pada pertanaman kopi Robusta (*Coffea canephora*) di Desa Sumber Rejo Kecamatan Modayag. *Jurnal Entomologi dan Fitopatologi* 3(1): 1–9. <https://ejournal.unsrat.ac.id/v3/index.php/enfit/article/view/51118>.
- Moreira J., Villacres D.A. and Hamilton L. (2020) Effects of altitude on *Hypothenemus hampei* populations and coffee quality. *Journal of Insect Science* 12(4): 322–333. doi:10.1080/09670874.2024.2325346.
- Myrie A., Hall T., Luke D., Chinthapalli B.R., Tennant P. and Robinson D. (2023) Coffee Berry Borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae): Activity and infestation in the high mountain and Blue Mountain regions of Jamaica. *Insects* 14(8): 694. doi:10.3390/insects14080694.
- Nadiawati S., Adrinal A. and Efendi S. (2023) Perbandingan tingkat kerusakan buah kopi oleh hama penggerek (*Hypothenemus hampei* Ferr.) pada perkebunan Kopi arabika (*Coffea arabica* L.) dengan ketinggian berbeda. *Media Pertanian* 8(1): 47–58. doi:10.37058/mp.v8i1.6972.
- Novianti R., Rahayuniati R.F. and Suroto A. (2023) Post-harvest management of Robusta Baseh coffee against plant pests: Review. *Jurnal Agri techno* 16(2): 75–84. doi:10.70124/at.v16i2.1174.
- Pereira A.E., Gontijo P.C., Fantine A.K., Tinoco R.S., Ellersieck M.R., Carvalho G.A., Zanuncio J.C. and Vilela E.F. (2021) Emergence and infestation level of *Hypothenemus hampei* (Coleoptera: Curculionidae) on coffee berries on the plant or on the ground during the post-harvest period in Brazil. *Journal of Insect Science* 21(2): 1–8. doi:10.1093/jisesa/ieab022.
- Rasika S. (2021) Innovation development of coffee berry borer (*Hypothenemus hampei* Ferr.) pest control technology and their effectiveness. *Cropsaver, Jurnal of Plant Protection* 4(2): 62–72. <https://jurnal.unpad.ac.id/cropsaver/article/view/36257>.
- Rosiana N., Nurmalina R., Winandi R. and Rifin A. (2017) The level of comparative advantages of world main coffee producers. *Buletin Ilmiah Litbang Perdagangan* 11(2): 227–246. <https://jurnal.kemendag.go.id/bilp/article/view/274>.
- Sri W., Subroto S. and Gunawan A. (2021) Infestation rates of coffee berry borer in the highfields of West Sumatra. *Journal of Agricultural Science* 12(1): 55–64. doi:10.1016/j.jas.2021.05.011.