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Research Article

Effectiveness of Attractants for Capturing the Coffee Berry Borer, *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae) in Shade-Grown Robusta Coffee

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ABSTRACT

The coffee berry borer (CBB) is a major pest of coffee plantations worldwide, including in Indonesia. Infestations substantially reduce both the quality and quantity of harvested coffee beans. This study aimed to evaluate the effectiveness of chemical attractants in trapping CBB adults. The experiment was conducted on a coffee plantation divided into two plots differing in the density of *Leucaena leucocephala* shade trees. Plot A had a shade density of 36.85%, while Plot B had a shade density of 31.94%. A 1:2 bioethanol-methanol mixture served as the attractant. Each plot contained nine traps, each filled with 10 ml of the attractant, and the traps were installed on coffee trees for nine sampling periods at 7-day intervals. The results indicated that the bioethanol-methanol attractant effectively attracted female CBBs. Plot A, which had denser shade, recorded the highest proportion of beetles captured (68.88%), compared with 31.12% in Plot B. The captured CBB population varied over time: numbers increased during the first two sampling periods and declined thereafter until the ninth observation. Beetle abundance was influenced by shade density, coffee tree density, and seasonal rainfall. Trap captures contributed to reductions in bean damage by 36.20% in Plot A and 34.03% in Plot B, resulting in healthier coffee berries. Overall, the findings demonstrate that bioethanol-methanol attractant traps can serve as an effective component of CBB management strategies.

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Introduction

Coffee is a plantation crop of high economic importance, serving as a major source of income for farming communities and contributing substantially to national foreign exchange earnings. Several coffee species are cultivated globally, including *Coffea arabica*, *C. canephora* (robusta), *C. liberica*, and *C. excelsa*, with robusta and arabica being the dominant types grown in Indonesia due to their suitability to local climatic conditions. One of the most serious constraints to coffee production is the coffee berry borer (CBB), a beetle that causes substantial yield losses and affects the livelihoods of more than 20 million coffee farmers worldwide (Vega et al., 2003).

Coffee plantations in Indonesia face persistent challenges, particularly low productivity and poor bean quality. Among the major contributing factors is the high incidence of CBB infestation, which significantly reduces yield and degrades coffee quality. In robusta plantations in East Bolaang Mongondow Regency, Indonesia, infestation levels have been reported to range from 70% to 87% (Rimbing et al., 2023). Damage on smallholder farms often exceeds 50%. Attacks on young berries commonly lead to developmental failure, while infestations on mature berries result in considerable quality deterioration. The insect exploits coffee berries and beans for shelter, oviposition, feeding, reproduction, and metamorphosis. Yield losses attributed to CBB in Karo Regency, Indonesia, range from 30% to 40% (Efrata et al., 2023).

CBB population density and infestation severity are strongly influenced by environmental conditions, including temperature, humidity, rainfall, cultivation practices, and shade density. Weather variables, particularly rainfall, play a crucial role in population development due to the beetle's small body size and susceptibility to environmental fluctuations. Shade trees also affect CBB dynamics; in Indonesia, coffee plants are typically shaded by *Leucaena leucocephala* and *Erythrina subumbrans*, which differ in canopy density. Understanding the pest's population dynamics is essential for predicting outbreaks and designing effective management strategies.

The use of synthetic insecticides has been largely ineffective because all developmental stages of CBB are protected within the coffee berry. Attractant traps provide a promising environmentally friendly alternative. These traps can effectively lure adult beetles, thereby reducing bean damage and slowing pest spread. Their use in coffee plantations has demonstrated potential in lowering CBB severity from severe to moderate or low levels (Sasmita, 2023).

Given the importance of attractants in CBB management, the present study was conducted to evaluate the effectiveness of bioethanol-methanol as an attractant for adult CBB. The study assessed population abundance, population dynamics for management decision-making, coffee bean damage, the influence of shade density on CBB populations, and additional factors affecting trap catches. The findings are expected to contribute valuable understandings for developing improved CBB control strategies using bioethanol-methanol attractant systems.

Materials and Methods

Study site

The experiment was conducted in a *Coffea canephora* (robusta) plantation in Indonesia, situated at an altitude of approximately 725 m above sea level, at coordinates 00°72'08.0" N and 124°40'06.8" E. Coffee cultivation in the region involves both monoculture and polyculture systems; however, approximately 95% of the plantations are monoculture.

Sampling method

The study consisted of two coffee plantation plots that differed in shade tree density. Based on field measurements, Plots A and B had shade densities of 36.85% and 31.94%, respectively. The plots were located 600 m apart, with each plot covering an area of 0.5 ha.

Each plot was treated with a bioethanol-methanol attractant designed to capture CBB. The attractant mixture consisted of 50% bioethanol and 99% methanol in a 1:2 ratio. Three attractant traps were placed in each row, with 10 m spacing between traps and 10 m between rows. The experiment was replicated three times, resulting in a total of 18 traps (3 rows × 3 traps × 2 plots).

Captured insects were collected and recorded at seven-day intervals across nine observation periods (days 7, 14, 21, 28, 35, 42, 49, 56, and 63). The traps were hung on coffee trees at a height of 1-1.25 m above ground level. All CBB and non-target insects caught in the traps were counted to evaluate population dynamics. Specimens were subsequently counted in the laboratory, and non-target insects were identified.

Coffee fruit damage

The first coffee berry collection was conducted on day 0, immediately after trap installation, followed by additional collections on days 35 and 56. The first two collections largely consisted of green berries, whereas the third collection primarily comprised ripe orange and red berries.

Coffee berries were sampled from four designated points within each plot, spaced 10 m apart. At each point, 0.2 kg of berries was collected, resulting in a total of 0.8 kg per plot per collection (4 points × 0.2 kg). Samples at each point were taken from 3-4 coffee trees with abundant fruit, selected to represent berry damage within the plot.

Damage assessment was performed by slicing berries from the disc region toward the beans. Observations indicated that although CBB occasionally bored into green berries, bean damage was often absent. The percentage of bean damage was calculated using the formula:

$Ps = A/A + B \times 100\%$

Where Ps = Percentage of damage, A = Number of infested beans, and B = Number of healthy coffee beans.

Attractant trap procedure

The bioethanol used in the experiment was produced by farmers in North Sulawesi Province, Indonesia, through distillation of fermented *Arenga pinnata* palm sap. The fermented sap was heated to produce vapor, which was condensed to yield bioethanol. The bioethanol concentration used was 50%, as measured with a digital alcohol meter. The methanol used was synthetic and commercially sourced.

The trap consisted of a 1.5-liter plastic bottle modified with two openings (5 cm × 5 cm) on opposite sides to allow CBB entry. The bottom of the bottle contained 200 ml of water mixed with 2 ml of liquid detergent to serve as the insect collection reservoir. A small 25-ml bottle containing the bioethanol-methanol attractant was suspended inside the larger bottle. Each trap received 10 ml of the attractant.

Insect identification

Non-target insects preserved in 70% ethanol were sorted by group and identified based on their morphological characteristics following Kerruish and Unger (2010) and Wedad et al. (2019).

Statistical analysis

Differences in CBB population and coffee bean damage between treatments were analyzed using independent-samples t-tests. Data from all nine observation periods were subjected to statistical comparison. The t-test was selected because it is appropriate for determining significant differences between two independent group means. A significance level of $P \leq 0.05$ was used to determine treatment effects. Statistical analyses were performed using SPSS software version 22.

Results and Discussion

The bioethanol-methanol mixed attractant trap had a positive effect on capturing the CBB population. The attraction occurs because volatile chemical compounds rapidly evaporate and disperse into the air, influencing insect behavior and guiding them toward the source. All captured CBB individuals were females, as males were not trapped. Male CBBs remain inside the coffee berries and are unable to fly due to their underdeveloped wings. In contrast, female CBBs and non-target insects are attracted to the volatile compounds and enter the mineral bottle traps.

Non-target insects caught in the bioethanol-methanol traps belonged to eight insect orders: Coleoptera, Lepidoptera, Blattodea, Neuroptera, Diptera, Hymenoptera, Hemiptera, and Orthoptera. Diptera and Coleoptera were the dominant groups. Important captured Coleopteran species included *Carpophilus* sp. (Nitidulidae), Curculionidae (ambrosia beetles), and Coccinellidae. *Carpophilus* sp. is known as a plant pest and a vector of *Phytophthora palmivora* and *Ceratocystis* spp. in plantation crops. Among Diptera, *Bactrocera* sp., a major pest of chili, was recorded, along with various decomposer species associated with organic matter.

Data in Figure 1 show that the abundance of the CBB population captured during the nine observation periods differed markedly between plots A and B. A t-test revealed a significant difference at $\alpha = 0.05$ ($t = 3.665$; $p = 0.006$). Overall, 68.88% of CBB individuals were captured in plot A and 31.12% in plot B. This difference in population abundance was influenced by shade density, with plot A exhibiting denser shade than plot B. Dense shade positively affected beetle capture, consistent with previous findings that shaded Arabica coffee systems show higher CBB trap captures (Rimbing et al., 2024a). In plot A, shade trees were dense, nearly covering the coffee plantation and reducing light penetration, which lowered air temperature and increased humidity. These environmental conditions influence insect survival, fecundity, physiology, and reproductive activity. In contrast, shade trees in plot B were regularly pruned, allowing greater sunlight penetration.

Lower shade density in plot B likely reduced captures because volatile compounds from the attractant dispersed more extensively both horizontally and vertically, making it more difficult for beetles to locate the source. Coffee plants under more than 40% shade tend to have higher CBB populations (Marino et al., 2016; Oliva et al., 2023). Temperature variations associated with shade density also affect CBB activity; lower temperatures and higher humidity can enhance CBB flight. Shade density can therefore be used as an indicator of coffee berry susceptibility or resistance to CBB infestation. Furthermore, bioethanol-methanol traps pose no negative environmental impact.

Besides shade conditions, coffee plant maintenance contributed to population differences. Coffee trees in plot B were pruned regularly, whereas those in plot A were infrequently pruned, resulting in denser vegetation. A previous study in the same location during the dry season of 2022 recorded 3,212 female CBBs captured using five traps over five observation periods (Rimbing et al., 2024b). In contrast, the present study recorded 2,370 individuals captured using nine traps over nine observation periods (Figure 1). The lower capture numbers in the present study were likely due to rainy-season conditions, which reduced trap effectiveness. Rainfall decreases air temperature, thereby slowing attractant evaporation. In dry conditions, higher temperatures accelerate volatilization and increase beetle attraction. High rainfall reduces the volatilization rate of attractant compounds and suppresses Scolytinae flight activity (Sanguansub et al., 2020).

Across both plots, the mean number of CBB captured exceeded the standard error over the two-month observation period (Table 1). Despite the rainy season, the first two observations showed increased captures in both plots A and B, likely due to drier conditions and the initial placement of the attractants. From the third observation onward, captures declined gradually. This reduction corresponded with the relatively low rainfall during the study, averaging 6.35 mm per 14-day interval. Rainfall data from the Passi Agricultural Extension Center (May-July 2024) indicated a total of 495.10 mm across 56 days (8.89 ± 11.09 mm), with 41 rainy days. Abiotic factors, particularly rainfall, temperature, and humidity, are therefore essential for predicting infestation dynamics and designing effective CBB management strategies.

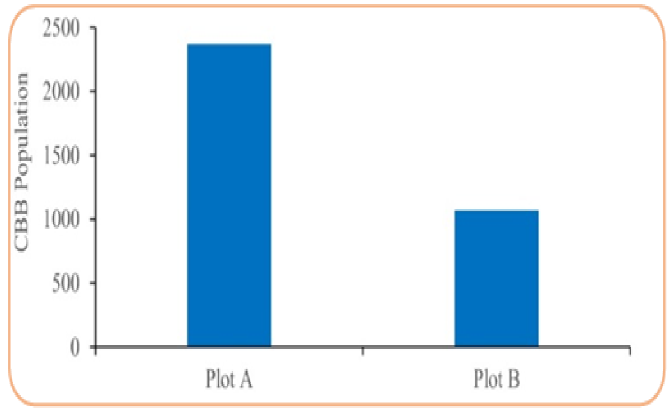

Figure 1. Total number of female CBBs captured in Plots A and B.

Table 1. Number of CBB adults captured using a bioethanol–methanol attractant at 7-day intervals.

Plot	Observation								
	I	II	III	IV	V	VI	VII	VIII	IX
A	61.00±43.65	56.00±17.95	34.55±25.51	24.22±13.01	22.11±15.6	12.0±09.50	18.78±12.08	10.11±07.08	24.56±20.68
B	19.67±14.89	26.44±20.04	11.44±05.65	07.44± 4.19	10.56±3.39	08.89±4.83	14.33±06.81	06.67±02.92	13.56±09.58

The total number of female beetles captured over the nine observations showed fluctuations (Figure 2), consistent with trends reported in Arabica coffee (Rimbing et al., 2024b). Rainfall, humidity, and temperature strongly influenced these fluctuations. Cumulative rainfall exceeding 100 mm is known to suppress female flight activity (Johnson and Manoukis, 2021). In this study, rainfall negatively affected CBB captures by reducing beetle activity. Field observations showed that 3-6 ml of the initial 10 ml attractant remained after seven days. In contrast, during the 2022 dry season, the attractant evaporated more rapidly, leaving 0-2 ml after five days (Rimbing et al., 2024b), which resulted in higher beetle captures. Overall, CBB population dynamics are strongly linked to climatic conditions and the physiological status of coffee trees (Mendesil et al., 2004; Jaramillo et al., 2013).

Rainfall lowers air temperature in coffee plantations, influencing attractant persistence. Cooler temperatures prolong the active duration of volatile compounds, whereas higher temperatures accelerate evaporation. As temperatures rise, volatile compounds evaporate more rapidly and disperse widely, making them easier for female CBBs to detect. Under such conditions, the number of individuals captured increases, thereby reducing the overall CBB population within the coffee agroecosystem. Volatile compounds can be detected by insects over long distances and are widely used in pest management (Rowan, 2011).

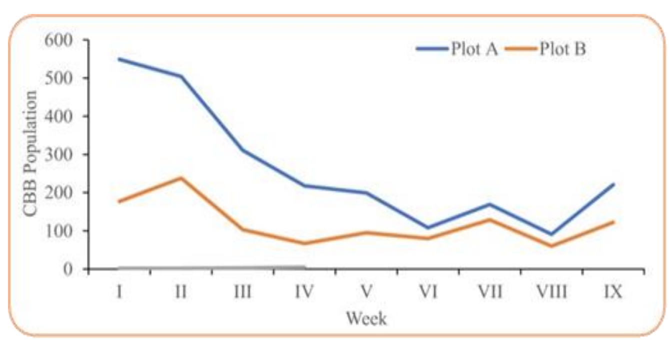

Figure 2. Population dynamics of female CBBs captured in attractant traps from the first to the ninth week in Plots A and B.

Statistical analysis showed no significant difference in coffee berry damage between the two plots (α = 0.05; t = 0.421; p = 0.719). Bean damage was reduced by 34.03% in plot B and 36.20% in plot A. Effective CBB control is generally indicated when infestation levels exceed 10% (Peres-Lachand et al., 2002; Vega et al., 2012). However, the two-month experiment duration was insufficient to produce statistically significant reductions in damage. CBB attacks all coffee types and cultivars; for example, the AGK-1 Arabica cultivar has reported infestation levels of 51.25% (Soesanthy et al., 2016). In this study, the application of attractants increased the proportion of healthy beans, defined as berries without CBB entry holes. Initial numbers of uninfested berries were low, but increased progressively from day 35 to day 56 (Table 2). As no resistant coffee varieties have yet been identified, attractant traps remain a key method in CBB suppression efforts. Previous studies have shown that attractant use can reduce damaged berries by up to 57% (Fernandes et al., 2014).

Table 2. Application of bioethanol–methanol attractant traps for capturing CBB beetles.

Plot	Coffee bean damage/days			Coffee bean without damage /days		
	0	35	56	0	35	56
A	61.02	53.36	38.91	38.97	46.64	61.09
B	64.68	49.23	42.68	35.81	50.74	54.28

Conclusion

The bioethanol-methanol attractant was effective in attracting CBB within the coffee plantation. Shade density and plant vigor strongly influenced capture rates, with the highest captures occurring in the more densely shaded plot A (68.88%). The CBB population fluctuated across the nine observation periods, showing an initial increase followed by a gradual decline, largely driven by high rainfall and frequent rainy days. The attractant also contributed to a reduction in coffee bean damage, 36.20% in plot A and 34.03% in plot B, and increased the proportion of healthy beans. The bioethanol-methanol attractant is effective, economical, environmentally safe, and suitable for sustainable CBB control. Its application is not limited to this study site and has broader potential for adoption across coffee-producing regions.

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Authors' Contributions

JR, RE, and FR designed the study, formulated the methodology, conducted all experiments, and revised the entire manuscript. LSK assisted with data collection and data analysis.

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Conflict of Interest

The authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger

SDG 12 – Responsible Consumption and Production

SDG 15: Life on Land

References

Efrata, E., Hidayat, P., Harahap, I.S., 2023. Coffee berry borer population on the arabica coffee beans from three different cropping patterns in Karo, North Sumatera. IOP Conf. Series: Earth Environmental Science. 1160. 012049.

Fernandes, F.L., Picanco, M.C., Da Silva, R.S., Da Silva, I.W., Fernandes, M.E.S., Ribeiro, L.H., 2014. Mass control of coffee berry borer using red PET-bottle traps in coffee crop. Pesquisa Agropecuaria Brasileira 49, 587-594.

Kerruish, R.M., Unger, P.W., 2010. Plant protection 1- pests, diseases and weeds. 4th edition. Published by Root Rot Press-ACT, Australia 2605.

Jaramillo, J., Torto, B., Mwenda, D., Troeger, A., Borgemeister., C., Poehiling, H-M., Francke, W., 2013. Coffee berry borer joins bark beetles coffee klatch. Plos One. 8(9), e74277.

Johnson, M.A., Manoukis, N.C., 2021. Influence of seasonal and climatic variables on coffee berry borer (*Hypothenemus hampei* Ferrari) flight activity in Hawaii. PLos One. 16(12), e0257861.

Mariño, Y.A., Pérez., M.E., Gallardo, F., Trifilio, M., Cruz, M., Bayman. P., 2016. Sun vs. shade affects infestation, total population and sex ratio of the coffee berry borer (*Hypothenemus hampei*) in Puerto Rico. Agriculture Ecosystems and Environment 222, 258-266.

Mendesil, E., Jembere, B., Seyoum, E., 2004. Population dynamics and distribution of the coffee berry borer, *Hypothnemus hampei* (Ferrari) (Coleoptera: Scolytidae) on coffee arabica in South western Ethiopia. SINET: Ethiopian Journal of Science 27(2), 127-134.

Oliva, M.,. Rubio, K.B., Chinguel, D., Carranza, J., Bobadilla, L.G., Leiva, S., 2023. Coffee berry borer infestation and population per fruit relationship with coffee variety, shade level, and altitude on specialty coffee farms in Peru. International Journal of Agronomy Volume 2023, ID 6782173.

Peres-Lachand, G., Hardy, I.C.W., Paul, L.J., 2002. Insect gladiators: competitive interactions between three species of bethylid wasps attacking the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae). Biological Control 25, 231-238.

Rimbing, J., Engka, R., Dumalang, S., Rorong, F., 2023. Response of the coffee berry borer (*Hypothenemus hampei*) to attractant traps in robusta coffee plantations. Indian Journal Agricultural Science 93, 544-548.

Rimbing, J., Pelealu, J., Lumowa,S., Rorong, F., Engka, R., Kandowangko, S., 2024a. Efficacy of a bioethanol-metanol mixture for trapping coffee berry borer in arabica coffee plantations in Indonesia. Plant Protection 8(4), 649-659.

Rimbing, J., Engka, R, Rorong, F., 2024b. Types of attractan traps for coffee berry borers (*Hypothenemus hampei* Ferr) in robusta coffee plants (*Coffea canephora*). AGRIVITA. Journal Agriculture Science 46, 320-329.

Rowan, D.D., 2011. Review volatile metabolites. Metabolites 1, 41-63.

Sanguansub, S., Buranapanichpan, S., Beaver, R.B., Saowaphak, T., Tanaka, N., Kamata, N., 2020. Influence of seasonality and climate on captures of wood-boring Coleoptera (Bostrichidae and Curculionidae (Scolytinae and Platypodinae)) using ethanol-baited traps in a seasonal tropical forest of northern Thailand. Journal Forest Research 25, 223-231.

Sasmita, S., 2023. Intensity of coffee berrine pest attacks (*Hypothenemus hampei* Ferr) and control efforts. AGRIBIOS; Journal Science 21, 52-56.

Soesanthy, F., Randriani, E., Syafarudin., 2016. Evaluation of berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae) attack arabica cultivar of AGK-1. Journal TIDP 3, 167-174.

Vega, F.E., Blackburn, M.B., Kurtzman, C.P., Dowd, P.F., 2003. Identification of a coffee berry borrer associated yeast: does it break down caffein. Entomologia Experimentalis et Applicata 107, 19-24.

Vega, F.E., Davis, A.P., Jaramillo, J., 2012. From forest to plantation? Obscure articles reveal alternative host plants for the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Curculionidae). Biological Journal of the Linnean Society 107, 86-94.

Wedad, A.A., Manal, E.A.E., Hala, M.K., 2019. Taxonomic key to the egyptian genera and species of sap beetles (Carpophilinae: Nitidulidae: Coleoptera). Al-Azhar Bulletin of Science 30, 1-7.