Земледелие и защита растений / Soil Fertility and Plant Protection

Научная статья Original article
DOI: 10.12731/2658-6649-2026-18-1-1397 **EDN:** BPESFT
UDC 633.73:632.937.3

Investigating arboreal ant communities as predators of coffee berry borer (Hypothenemus hampei Ferr.) in Arabica coffee plantations

J. Jauharlina, Icha Destriany, Nihayatul Afifah Husna, Muhammad Sayuthi, Tjut Chamzurni
Universitas Syiah Kuala, Darussalam, Banda Aceh, Indonesia

Abstract

This study investigated the arboreal ant community and evaluated its potential role as a predator of the Coffee Berry Borer (CBB) in Gayo coffee plantations in Aceh Tengah Regency, Sumatra, Indonesia. Four plantations (two organic and two conventional) were studied. Arboreal ants found on coffee trees and CBB-infested berries were also observed. A total of 23 ant species were recorded in conventional plantations and 17 species in organic plantations. Notably, the abundance of ants was three times higher in the organic plantations than in the conventional plantations. The observed ant genera, including *Crematogaster, Pheidole, Tetramorium, Tapinoma, Technomyrmex*, and *Monomorium*, exhibited potential as CBB predators in both cultivation systems. Interestingly, seven ant species found inside CBB-infested berries were the same as those on coffee trees, suggesting that they enter through CBB-made holes and prey on pests within the berries. The absence of pesticide use and the diverse shade plants in the agroforestry system likely contributed to the higher ant abundance in organic plantations. These findings highlight the potential of exploiting arboreal ant communities for sustainable CBB management during Gayo coffee cultivation.

Keywords: biological control; natural enemies; organic coffee; conventional coffee; coffee berry borer

For citation. Jauharlina, J., Destriany, I., Husna, N. A., Sayuthi, M., & Chamzurni, T. (2026). Investigating arboreal ant communities as predators of coffee berry borer (Hypothenemus hampei Ferr.) in Arabica coffee plantations. *Siberian Journal of Life Sciences and Agriculture, 18*(1), 224–243. https://doi.org/10.12731/2658-6649-2026-18-1-1397

Introduction

Coffee is one of the world's most economically significant crops, with Arabica coffee being particularly renowned for its superior taste compared to other varieties, such as Robusta and Liberica. Fadhil et al. [1] highlight that the Gayo region, specifically the Gayo Highlands, includes Bener Meriah, Central Aceh, and Gayo Lues as primary producers of Arabica coffee in Aceh Province. The authors document that these areas play a significant role in Indonesia's coffee production landscape, significantly contributing to regional agricultural practices and economic viability, with a noted productivity range of 700 to 800 kg per hectare across these regencies. However, the coffee berry borer (CBB), *Hypothenemus hampei* Ferr., poses a significant threat to coffee production in these regions [2; 3]. This pest has also been recorded as the most destructive pest in other coffee-producing countries [4-7]. The coffee berry borer is a globally notorious pest, inflicting damages of over $500 million annually in the coffee industry [8]. These beetles directly attack coffee berries by boring into them, where they lay eggs and complete their life cycle inside the infested berries, thereby causing significant damage [9]. The lifecycle of CBB within berries disrupts the development of coffee beans, leading to substantial yield losses and quality degradation. Given its impact, managing CBB is critical for sustaining coffee production and protecting the livelihoods of coffee farmers in affected regions.

Coffee plantations in the Gayo Highlands are characterized by their implementation of agroforestry systems, which integrate coffee plants with a diverse range of trees that provide shade, thereby creating a forest-like environment [10]. This cultivation method is significant for both ecological sustainability and agricultural productivity in the region. Predatory ants are frequently used as biological control agents in agroforestry systems. Several ant species are known to reduce the prevalence of coffee berry borers, either by preventing the borer from boring in coffee berries or by eliminating them once they are within the berries. Ant predators have plenty of opportunities to capture defenceless borers because it takes the adult borer nearly an hour to effectively enter the coffee berry [11; 12]. It has become more apparent over the past ten years that ants are significant CBB natural enemies on coffee plantations. Several studies have shown that ants consume CBB in laboratory experiments [13-15]. Other studies have provided concrete evidence that ants can lessen CBB infestation in coffee plantations [5; 16; 17].

An earlier study revealed that conventionally and organically managed coffee plantations in the Aceh Tengah Regency contain large populations of ants [2]. A later study showed that the ant community in the same area comprises both ground-nesting ants and arboreal ant species [18]. It has been observed earlier in Brazil that several ground-nesting ant species prey on CBB [14]. Ant species that nest and forage on plants above the ground are arboreal ants. A negative correlation exists between fruit attacked by the borer and the prevalence of Azteca instabilis, a prominent canopy ant that frequently forages coffee bushes [12; 17]. Free-roaming CBB adults are prevented from colonizing berries by at least six different ant species that graze on plants in Mexico, according to research by Gonthier et al. [16].

Identification of ant species in Aceh Tengah Regency has only been made from the ground underneath coffee bushes [18], while arboreal ant species, or the group of ants living and soaring above the ground, have not yet been identified. According to Larsen and Philpott [14], arboreal species present in coffee plants can act as effective predators of CBB. Given the size of the present ant population and the frequency with which the ant community is observed on coffee plantations, further identification and research are required to fully understand the potential of arboreal ants as predators and their potential for controlling CBB.

Previous studies have shown that ant populations dominate other arthropod species in both conventional and organic coffee plantations. Identification and observation of ant diversity focused on ant samples found on the ground surface of coffee plantations. The results were promising, and the presence of ants with the potential to be predators of CBB was relatively high in this area [2; 18]. Regarding the trend of organic coffee, the presence of natural enemies in the field is crucial because it can be used to reduce CBB infestation and other pest attacks.

The ant community in coffee plantations is found not only in nesting and foraging on the ground, but also in ant communities that forage on coffee trees (arboreal ants). Their presence in coffee trees can provide ecosystem services in the form of predation against CBBs that attack coffee berries. In the current study, we focused on the ecosystem services provided by arboreal ants as a biological control agent of CBB in the Arabica coffee plantation in Aceh Tengah Regency, Aceh Province. We observed arboreal ant communities, recorded their abundance, and described their predation on CBB in conventionally and organically managed coffee. We also identified ant species communities inside CBB coffee berries in the two types of coffee plantations.

Materials and methods

Study Site

This study was conducted in a coffee plantation grown by the Aceh Tengah Regency community, located approximately 300 km from the city of Banda Aceh, Indonesia. Aceh Tengah is one of the three regencies in the Gayo Highlands of Aceh Province, Indonesia. This area spans an altitude range of 200–2600 m above sea level, with rainfall varying from 1082 to 2409 mm per year and 113 rainy days annually. The average daily temperature is approximately 20 ^{o}C. Two organic and two non-organic (conventional) coffee plantations, each with an area of approximately 1 ha, were used as research locations. Four lands were studied, featuring coffee plantations aged 10-15 years, located at 1200-1300 m above sea level (asl), as presented in Table 1.

Table 1.

The study site for arboreal ant sampling on Arabica coffee plantations in Aceh Tengah Regency

Village	Type	Location Coordinate (Range)	Altitude (m asl)
Atang Jungket	Organic	04^{o}35’34”- 04^{o} 36’33”N 96^{o} 47’57”- 96^{o} 48’04”E	1222
Simpang Lukup Badak	Organic	04^{o} 35’41”- 04^{o} 36’25”N 96^{o} 48’05”- 96^{o} 48’05”N	1200
Simpang Uning Niken	Conventional	04^{o}36’10”- 04^{o}37’01”N 96^{o}48’26”- 96^{o}48’33”E	1231
Tebes Lues	Conventional	04^{o}35’59”- 04^{o}36’38”N 96^{o}47’30”- 96^{o}48’18”E	1255

Two distinct cultivation systems were studied. In organic plantations, no chemical pesticides or fertilizers were applied. Instead, growers used compost made from coffee berry skins as the primary fertilizer, with no pest control measures implemented. In contrast, conventional plantations utilized chemical inputs including herbicides for weed control during the early growth phase of coffee trees (less than five years old) and chemical fertilizers applied 1-2 times annually.

Both cultivation systems employed polyculture planting arrangements, incorporating shade trees such as Lamtoro (*Leucaena glauca*), avocado, orange, guava, and persimmon. Banana and chilli plants were intercropped between the coffee trees. For this study, coffee trees with heights between 1.5-2.0 meters were randomly selected from each location for observation and sampling. Data collection was conducted over four observation periods, each at four-week intervals, from July to October 2021.

CBB Infestation in Coffee Berries

One hundred coffee berries were randomly collected from each coffee tree sample to determine the percentage of CBB infestations per tree. The total number of trees used for sampling coffee berries was 20 trees per observation plot. The total number of trees used for sampling coffee berries from the entire plot was 80. All collected coffee berries were placed in plastic bags and taken to the Biological Control Laboratory to count the number of coffee berries attacked by CBB. The percentage of CBB attacks (CBB infestations) was calculated using the formula expressed in Equation 1.

$$I = a/b \times 100\% \quad (1)$$

where *I* represent the percentage of CBB-infested berries, *a* is the number of coffee berries infested with CBB, and *b* is the number of coffee berries observed.

Arboreal Ant Community and Its Abundance

Arboreal ants are a community of ants that nest and forage in trees, specifically in this study, coffee trees. Ant samples were collected from 10 coffee trees from each location. Ants were sampled using the method developed by Larsen and Philphott [14]. The presence of ant communities in the trees was visually observed for two minutes for each sample tree. Visual surveys included shaking branches and observing coffee leaves, stems, and berries. Then, while moving around the coffee tree, the visible ants were collected manually using a small brush for two minutes in each tree sample. The collected ant samples were placed in small plastic bottles containing 70% alcohol and taken to the Biological Control Laboratory of the Faculty of Agriculture, Syiah Kuala University, for identification. Arboreal ant sampling was performed four times at an interval of 3 weeks. The ants were then identified by observing their morphology using a loupe and a microscope. The identification stage was carried out by referring to the results of previous studies [18-20]. The total number of individuals from each ant species was counted and stored in separate collection bottles for each species. The number of ant species per observation plot for the organic and conventional coffee plantations was also calculated.

Community of Ant Species Inside CBB-infested Coffee Berries

All CBB-infested berries were placed separately according to the plant samples at each sampling time. Ants from CBB-infested berries were placed in bottles containing 70% alcohol. The ants were then grouped according to their sampling locations. Ants were identified by examining their morphological characteristics, using the same sources as those for the arboreal ants. The total number of individuals of each identified ant species originating from the infested coffee berries was counted at the Laboratory of Biological Control, Faculty of Agriculture, Universitas Syiah Kuala.

Data Analysis

The identification of arboreal ants is carried out morphologically (morphospecies), at least to the level of their genera. Their role in coffee plantations was determined by referring to the ant species found in previous studies [18] and other studies elsewhere [14, 21]. Infestation of CBB, abundance of each ant species, and species richness between organic and conventional coffee plantations were analyzed using Student's t-test. The same analysis was performed on the ant communities of CBB-infested berries from organic and conventional coffee plantations.

Research Results and Discussion

CBB infestation

The coffee berry borer (*H. hampei*) infested both the organic and conventional coffee plantations. The infestation of CBB on organic coffee plantations ranged between 24.65-27.95% and between 26.47-36.24% on conventional coffee plantations, as demonstrated in Fig. 1. The results of the t-test analysis showed that the average level of CBB infestation in organic and conventional coffee plantations was not significantly different in the first observation (July) ($P = 0.45$, $t = 0.11$, $df = 78$), second observation (August) ($P = 0.20$, $t = 0.84$, $df = 78$), and fourth observation (October) ($P = 0.25$, $t = 0.66$, $df = 78$). In the third observation (September), CBB infestation differed significantly between the two types of coffee plantations ($P = 0.01$, $t = 2.36$, $df = 78$). In general, CBB infestation in conventional coffee plantations tended to be higher than that in organic coffee plantations, despite the non-significant difference in the first, second, and fourth observations. These results are similar to those of previous studies by Husni et al. [3]. They also observed CBB infestation in Aceh Tengah Regency from 2019 to 2021 with four observations: once before the coffee harvest, twice during harvest, and once after harvest. They found no significant difference in CBB infestation between the organic and conventional coffee plantations. CBB infestation was also relatively higher in conventional coffee plantations.

In this study, most of the coffee berries in observations I (July), II (August), and III (October) were still yellowish-green in both organic and conventional coffee plantations. The coffee berries observed in July and August were the newly developing ones after the big harvest in April, while the berries observed in October were the ones after the September harvest. It has been known that coffee berries' colour and maturity level are two factors that can attract CBB to the berries. CBB usually prefer the almost ripe coffee berries, which are reddish [22]. Another study showed that CBB adults prefer red traps because they resemble ripe coffee berries and are less attracted to yellow devices [23]. The different types of coffee cultivation do not seem to cause significant differences in CBB infestation between organic and conventional coffee plantations, except in observation IV (September). During this time, the CBB infestation showed a preference for conventional coffee compared to organic coffee. The level of CBB infestation is higher on coffee plants with berries that begin to harden and ripen for harvest.

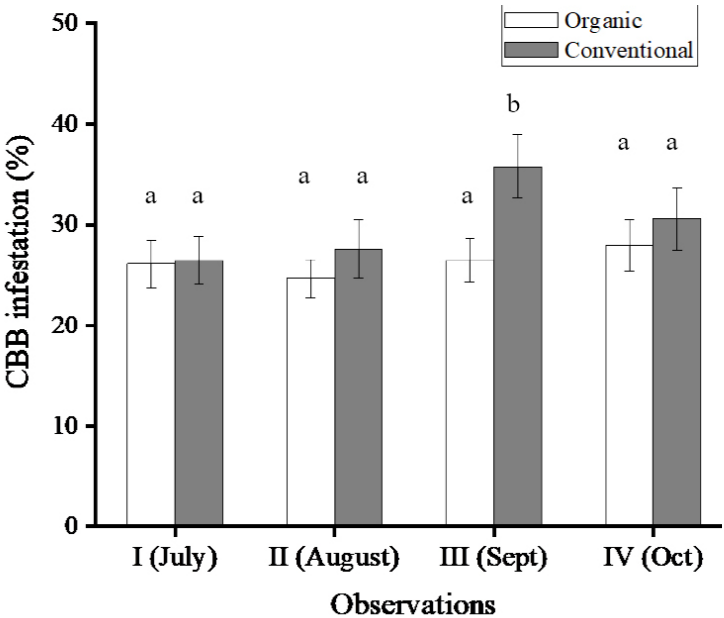


Fig. 1. CBB infestation on organic and conventional coffee plantations in Aceh Tengah Regency, Aceh Province, Indonesia. The letters above the bars indicate a significant difference based on the T-test at the 0.05 level for each observation.

Community of arboreal ants on coffee trees and their ecological roles

As presented in Table 2, the ants sampled from organic and conventional coffee consisted of 4 subfamilies, 11 genera, and 23 morphospecies during the four samplings. All 23 morphospecies were found in organic coffee, whereas only 17 were found in conventional coffee. A previous study by Jauharlina et al. [18] showed that ants found on the ground also contained more ant species in conventional coffee than in organic coffee. It was suspected that this result was influenced by the composition of the soil layer and leaf litter, which was also a nesting place for ants. Conventional coffee plantations were observed to have a lot of leaf litter, rotting wood, and fallen CBB-infested berries scattered around coffee trees. This condition invites more ant species to settle in the habitat [18]. The type of food source determines the foraging activity of ants, which affects their composition in a habitat. Differences in food availability and predation could influence ant species in conventional coffee plantations [24]. In the present study, the relatively higher percentage of CBB infestation in conventional coffee is a significant food source (prey) for predatory ants, allowing it to invite more ant species to occupy the area.

Table 2.

Community of arboreal ant species on organic and conventional coffee plantations in Aceh Tengah Regency, Aceh Province, Indonesia

Subfamily	Genus	Morphospecies	Type of cultivation	
			Organic	Conventional
Dolichoderinae	*Dolichoderus*	*Dolichoderus* sp	✓	✓
	Philidris	*Philidris* sp. 1	✓	✓
		Philidris sp. 2	✓	✓
	Tapinoma	*Tapinoma* sp. 1	×	✓
		Tapinoma sp. 2	✓	✓
		Tapinoma sp. 3	✓	✓
		Tapinoma sp. 4	✓	✓
	Technomyrmex	*Technomyrmex* sp. 1	✓	✓
		Technomyrmex sp. 2	✓	✓
		Technomyrmex sp. 3	✓	✓
Formicinae	*Camponotus*	*Camponotus* sp. 1	✓	✓
Myrmicinae	*Aphaenogaster*	*Aphaenogaster* sp.1	×	✓
		Aphaenogaster sp.1	×	✓
	Crematogaster	*Crematogaster* sp 1	✓	✓
		Crematogaster sp 2	✓	✓
	Pheidole	*Pheidole* sp 1	✓	✓
		Pheidole sp 2	✓	✓
	Tetramorium	*Tetramorium* sp 1	✓	✓
		Tetramorium sp 2	✓	✓
		Tetramorium sp 3	✓	✓
		Tetramorium sp 4	×	✓
	Solenopsis	*Solenopsis* sp	×	✓
Pseudomyrmicinae	*Tetraponera*	*Tetraponera* sp	×	✓
		Number of species	17	23

Note: ✓ = present, × = absent

Table 3 presents the ecological role of arboreal ants found in organic and conventional coffee plantations under study. The arboreal ant species in this study have ecological roles as predators, scavengers, and plant pests. Ant species that act as predators are those that prey on other insects so that they can be used as natural enemies to control pests. Many studies have shown the role of ants of the genus *Dolichoderus* as predators of pests on cocoa plants [25]. Ants from the genera Solenopsis, Pheidole, and Crematogaster have been known as predators of CBB in Colombia [26]. Pheidole synanthropica ants that attack CBB carry their prey to the ant nest [5]. The ant species *Crematogaster curvispinosus* is known to prey on the immature stage of CBB on coffee plantations in Brazil [27]. In contrast, Camponutus species are predators that hunt live insects and insect carcasses for food [28].

Table 3.

The ecological role of arboreal ants found in organic and conventional coffee plantations in Aceh Tengah Regency based on their genera

Genus	Ecological role
Dolichoderus	Predator
Philidris	Scavenger
Tapinoma	Scavenger, pest, predator
Technomyrmex	Scavenger, pest, predator
Aphaenogaster	Scavenger
Crematogaster	Predator
Pheidole	Predator
Tetramorium	Scavenger, predator
Solenopsis	Predator
Tetraponera	Predator

Ants of the Technomyrmex genus are insects that consume plant nectar or sugar as an energy source. *Technomyrmex albipes* species are generally considered secondary pests in agriculture because they protect honeydew-producing insects, such as aphids and mealybugs, which benefit them [29]. Another study showed that the relationship between *T. yamanei* ants and *Coccus viridis* had a positive effect on coffee plants, as *T. yamanei* also attacked CBB [11]. Thus, the *Technomyrmex* ants found at the study site also potentially become predators of CBB.

Dolichoderinae and Myrmicinae are subfamilies with the dominant number of ant morphospecies compared to subfamilies formicinae and pseudomyrmicinae. *Tapinoma* (Dolichoderinae) and *Tetramorium* (Myrmicinae) were the genera with the highest number of species found, as shown in Table 3 and illustrated in Fig. 2. Both genera are classified as groups of ants that show predation behaviour. Worker ants of the species *Tetramorium acuelatum* attack their prey with a sting; therefore, they are classified as aggressive predators [30]. One species of *Tapinoma* was reported to be a predator of CBB in Mexico by foraging in coffee fruits and preying on CBB [31].

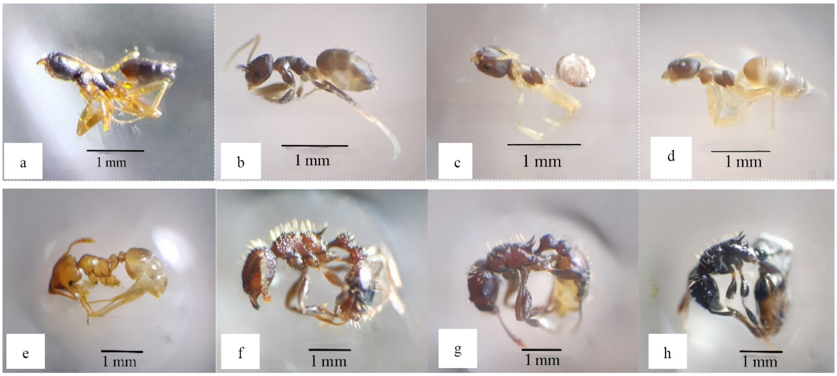
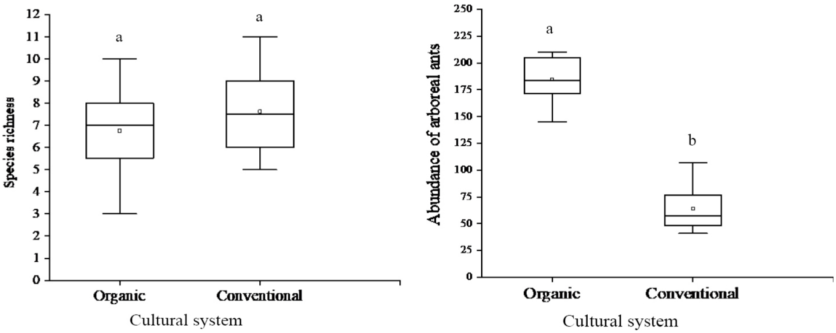


Fig. 2. The genera of *Tapinoma* and *Tetramorium*. The highest number of arboreal ant species recorded in organic and conventional coffee plantations in Aceh Tengah Regency, Aceh Province, Indonesia: *Tapinoma* sp.*1* (a), *Tapinoma* sp. 2 (b), *Tapinoma* sp.3, (c), *Tapinoma* sp. 4 (d) and *Tetramorium* sp 1. (e), *Tetramorium* sp. 2 (f), *Tetramorium* sp. 3 (g), *Tetramorium* sp. 4 (h)

Species richness and abundance of arboreal ants on coffee trees

Fig. 3 shows the species richness and abundance of arboreal ants in organic and conventional Arabica coffee plantations in the study area. Despite the higher number of arboreal ant species in conventional coffee (species richness) in the overall observations, the species richness per plot in each observation did not differ significantly between the two types of cultivation ($P = 0.21$, $t = 0.82$, $df = 14$). During each observation, we found various ant species in the conventional coffee, resulting in a higher number of ant species across the four observations. In contrast, we found 1476 individual ants in organic coffee plantations and 512 individual ants in conventional coffee plantations. The abundance of arboreal ants in the organic coffee plantations was three times greater than that in the conventional coffee plantations. The T-test results showed that the abundance of arboreal ants in each plot was significantly higher in organic coffee plantations than in conventional coffee plantations ($P < 0.0001$, $t = 10.92$, $df = 14$).



(a) (b)

Fig. 3. Species richness (a) and abundance (b) of arboreal ant morphospecies per plot in organic and conventional Arabica coffee plantations in Aceh Tengah Regency, Aceh Province, Indonesia.

In organic coffee plantations, a higher abundance of ants was found on the genera *Dolichoderus, Philidris, Camponotus,* and *Crematogaster*. In conventional coffee, as demonstrated in Fig. 4, the dominant ants were the genera *Dolichoderus, Tetramorium* sp. 2, and Technomyrmex sp. 1. Many studies have shown that particular dominant ant species can control the availability of food sources and plant canopies for nesting. Therefore, the dominant ant species is a determining factor in the structure of the ant community in a habitat [32].

Previous studies have shown similar dominance of arboreal ants in coffee plantations. Ants of the genus *Tapinoma* and *Crematogaster* were the dominant ants in the study conducted in southern Mexico [16]. The genera *Tapinoma* and *Crematogaster* were also the dominant ants found on a coffee plantation in Thailand [12]. Meanwhile, the study conducted in a coffee plantation in Sukabumi, West Java, recorded the dominance of the genus *Dolichoderus* [25]. This study's dominant arboreal ant species belong to the subfamily of ants known to be dominant in various habitats. *Dolichoderus, Philidris, Technomyrmex*, and *Tapinoma* belong to the Dolichoderinae subfamily, which often achieves ecological dominance in different habitats [33]. The genus *Philidris* exhibits aggressive behaviour that can reduce the richness of other ant species in trees. *Crematogaster* and *Tetramorium* belong to the subfamily Myrmicinae, the second-largest ant subfamily worldwide [34]. The ant genus Camponotus comes from the Formicinae subfamily, which is also widely distributed worldwide. *Camponotus* ants are often found in organic coffee plantations because they generally live nesting in the tree canopy and rotting old tree trunks [35].

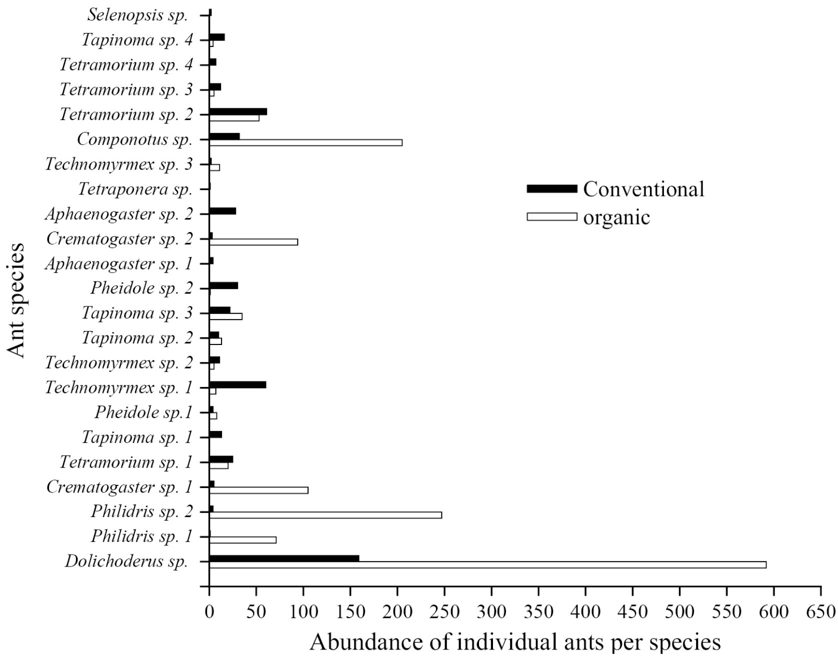


Fig. 4. The abundance of arboreal ants per species in organic and conventional Arabica coffee plantations in Aceh Tengah Regency, Aceh Province, Indonesia.

Factors affecting the presence of insects in agricultural habitats include cultivation practices and pesticides [25]. The higher abundance of arboreal ants in organic coffee plantations suggests that organic cultivation systems are crucial for sustaining insect populations in coffee plantations. Organic plantations contain more soil organic matter and nutrients, which are essential for the survival of organisms [36]. Ant populations were more abundant in locations where insecticides were not used to control CBB. The application of various synthetic pesticides in conventional coffee plantations has a negative impact on arthropods, which serve as natural enemies of coffee plants. Broad-spectrum pesticides interfere with the presence of various beneficial insects, such as natural enemies, and can even lead to the emergence of secondary pests [37].

Vegetation composition can also influence the presence of ant species and their populations [38]. The composition of vegetation affects the presence of ant species because it affects food availability in a habitat [39]. Vegetation can determine the type of insects found in a habitat. The abundance of arboreal ants in organic coffee plantations suggests that the diverse vegetation used for shading in these cultivation systems influences the ant population.

Community of arboreal ants and their abundance inside CBB-infested berries

Observations of CBB-infested berries showed that there were 26 coffee berries in the presence of individual ants from a total of 9613 CBB-infested berries. The ant community consisted of nine species from six genera and two subfamilies, as shown in Table 4. Seven of the nine species found were the same ant species as the arboreal ants in coffee plants. The abundance of ants inside coffee berries was higher in organic coffee than in conventional coffee (Table 5).

Table 4.

Ant community inside CBB-infested berries in organic and conventional coffee plantations in Aceh Tengah Regency (n=26).

Subfamily	Genus	Morphospecies	Type of cultivation	
			Organic	conventional
Dolichoderinae	*Tapinoma*	*Tapinoma* sp. 1	✓	-
	Technomyrmex	*Technomyrmex* sp.1	✓	✓
		Technomyrmex sp. 2	×	✓
Myrmicinae	*Crematogaster*	*Crematogaster* sp 1	✓	✓
		Crematogaster sp 2	×	✓
	Pheidole	*Pheidole* sp 1	✓	✓
	Monomorium	*Monomorium* sp. 1	✓	✓
		Monomorium sp. 2	✓	-
	Tetramorium	*Tetramorium* sp 2	×	✓

Note: ✓ = present, × = absent

All ant species observed from CBB-infested berries are potentially CBB predators that enter the berries through the CBB-made tunnel. Ants of the genus *Monomorium*, as shown in Fig. 5, were the most common ants in CBB-infested coffee berries (Table 5). Still, these species were not found in arboreal ant sampling in coffee plantations. Presumably, because the size of *Monomorium* is minimal (less than 2 mm in length) and moves very quickly, therefore they were not collected when sampling using the hand-picking method (manual). According to Gathalkar and Sen [40], ants of the genus *Monomorium* are tiny predatory ants that are often used as biological agents to control various pests in agriculture. *Monomorium* worker ants such as *M. destructor* and *M. minimum* attack the early instar larvae of the insect pest *Antheraea mylita* on *Terminalia* *arjuna* by entering the pupa and then eating the pupa. *Monomorium* ants can also attack when prey insects moult on trees [40]. In this study, *Monomorium* ants found inside CBB-infested berries are thought to prey upon the CBB larvae.

Table 5.

The abundance of ants inside CBB-infested berries, organic and conventional coffee plantations in Aceh Tengah Regency (n=26 CBB-infested coffee berries)

Morphospecies	Type of cultivation	
	Organic	conventional
Crematogaster sp 1	3.0	1.0
Crematogaster sp 2	163.0	0.0
Pheidole sp 1	23.0	65.0
Monomorium sp 1	18.0	241.0
Monomorium sp 2	0.0	22.0
Tetramorium sp 2	10.0	0.0
Tapinoma sp 1	0.0	1.0
Technomyrmex sp 1	2.0	26.0
Technomyrmex sp 2	19.0	0.0
Total abundance	238.0	356.0

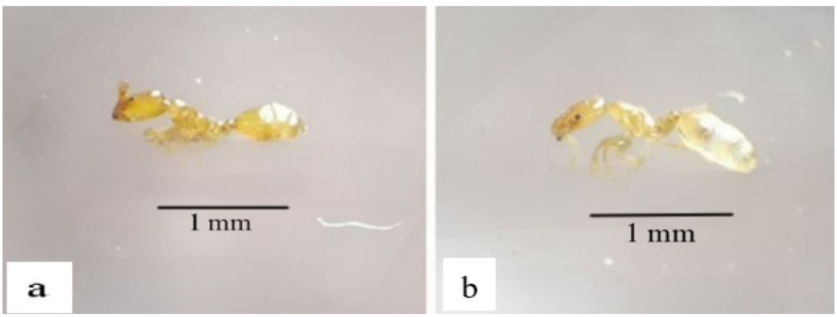


Fig. 5. Ants species of *Monomorium* sp 1 (a) and *Monomorium s*p 2 (b) found in coffee berries attacked by CBB in organic and conventional coffee plantations in Aceh Tengah Regency, Aceh Province, Indonesia

We observed that the ants emerged from CBB-infested coffee berries through a CBB-made hole 3-7 days after sampling. Ants could prey on CBB by entering CBB-infested berries. Tiny ants enter through the holes made by CBB, attack the larvae and CBB adults, and may bring CBB to their nests [14]. Ants can also prevent the spread of CBB by waiting outside the coffee berries and catching CBB adults as they leave the berries to look for new hosts [15, 41]. The ants that enter the CBB-infested berries are the species that have a smaller head size compared to the diameter of the CBB-made tunnel on the berries. Therefore, not all arboreal ants with the potential to be predators can be found inside CBB-infested berries [15]. We found that most coffee berries attacked by CBB and containing ants inside contained no CBB individuals. Of the 26 CBB-attacked berries observed, only seven coffee berries contained one or two CBB adults. This finding suggests that arboreal ants that enter CBB-infected coffee berries have significant potential to become predators of CBB. Based on their ecological roles, six genera of arboreal ants have great potential as predators of CBB: *Crematogaster, Pheidole, Tetramorium, Tapinoma, Technomyrmex,* and *Monomorium* (Table 4). Ants of the genera *Monomorium*, *Crematogaster,* and *Pheidole* are a genus of ants with the highest abundance (Table 5).

Conclusion

The arboreal ant communities found in coffee plantations are potential predators of CBB in both organic and conventional coffee, particularly the following six genera of arboreal ants: *Crematogaster, Pheidole, Tetramorium, Tapinoma, Technomyrmex,* and *Monomorium*. Ants of the genera *Monomorium, Crematogaster,* and *Pheidole* had the highest abundance of individuals found in this study. A small portion of CBB-infested berries contained ants, mainly of the same species as those observed on coffee plantations, except for the genus *Monomorium*. These tiny ants were missed during hand-picking sampling of the coffee trees. Despite the small percentage of CBB-infested berries that contained ants, this study has shown that ant communities do enter the CBB-infested berries and presumably attack the CBB inside them. A higher abundance of ant individuals in organic coffee indicates that coffee farm management can influence the arboreal ant population that nests and forages coffee plantations.

Sponsorship information. This research was made possible through financial support from Universitas Syiah Kuala, Ministry of Education, Culture, Research, and Technology, Indonesia, as stated in the Letter of Assignment Agreement contract number 145/UN11/SPK/PNBP/2022 dated February 11, 2022.

References

1. Fadhil, R., Nurba, D., & Sukmawati, E. (2021). Sensory assessment of Gayo Arabica coffee taste based on various varieties and manual brewing devices. *Coffee Science*, *16*, 1–9. https://doi.org/10.25186/.v16i.1918. EDN: https://elibrary.ru/UONIRN

2. Husni, H., Jauharlina, J., & Saifullah. (2019). Composition and structure community of arthropods in organic and conventional Arabica coffee plantation. In *IOP Conference Series: Earth and Environmental Science* (Vol. 260, Article 012158). IOP Publishing. https://doi.org/10.1088/1755-1315/260/1/012158
3. Husni, H., Jauharlina, J., Sayuthi, M., Mulyadi, E., Yulianda, P., & Maulidia, N. (2022). Consistency of attack level of coffee berry borer (*Hypotenemus hampei* Ferr.) on organic and conventional Arabica coffee plantation in Aceh Tengah District, Aceh Province, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 951, Issue 1, Article 012108). IOP Publishing. https://doi.org/10.1088/1755-1315/951/1/012108. EDN: https://elibrary.ru/XTEDWE
4. Jaramillo, J., Muchugu, E., Vega, F. E., Davis, A., Borgemeister, C., & Chabi-Olaye, A. (2011). Some like it hot: The influence and implications of climate change on coffee berry borer (*Hypothenemus hampei*) and coffee production in East Africa. *PLoS One*, *6*, e24528. https://doi.org/10.1371/journal.pone.0024528
5. Jiménez-Soto, E., Cruz-Rodríguez, J. A., Vandermeer, J., & Perfecto, I. (2013). *Hypothenemus hampei* (Coleoptera: Curculionidae) and its interactions with *Azteca instabilis* and *Pheidole synanthropica* (Hymenoptera: Formicidae) in a shade coffee agroecosystem. *Environmental Entomology*, *42*(5), 915–924. https://doi.org/10.1603/EN12202
6. Trible, W., & Carrol, R. (2014). Manipulating tropical fire ants to reduce the coffee berry borer. *Ecological Entomology*, *39*, 603–609. https://doi.org/10.1111/een.12139
7. Vega, F. E., Infante, F., Castillo, A., & Jaramillo, J. (2009). The coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae): A short review, with recent findings and future research directions. *Terrestrial Arthropod Reviews*, *2*, 129–147.
8. Vega, F. E., Infante, F., & Johnson, A. J. (2015). The genus *Hypothenemus*, with emphasis on *H. hampei*, the coffee berry borer. In F. E. Vega & R. W. Hofstetter (Eds.), *Bark beetles: Biology and ecology of native and invasive species* (pp. 427–494). Elsevier Inc. https://doi.org/10.1016/B978-0-12-417156-5.00011-3
9. Damon, A. (2000). A review of the biology and control of the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae). *Bulletin of Entomological Research*, *90*(6), 453–465. https://doi.org/10.1017/s0007485300000584
10. Abubakar, Y., Alya, M. R., Karim, A., & Fazlina, Y. D. (2024). Effect of variety and farm altitude on chemical content of Arabica coffee (*Coffea arabica*) grown in Gayo highland, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1356, Issue 1, Article 012030). https://doi.org/10.1088/1755-1315/1356/1/012030. EDN: https://elibrary.ru/MDEMYP
11. Perfecto, I., & Vandermeer, J. (2006). The effect of an ant-hemipteran mutualism on the coffee berry borer (*Hypothenemus hampei*) in southern Mexico. *Agriculture, Ecosystems and Environment*, *117*, 218–221. https://doi.org/10.1016/j.agee.2006.04.007

12. Onishi, Y., Jaitrong, W., Suttiprapan, P., Buranapanichpan, S., Chanbang, Y., & Ito, F. (2016). Ant species diversity in coffee plantations in Chiang Mai province, northern Thailand. *The Thailand Natural History Museum Journal*, *10*(1), 33–48.
13. Armbrecht, I., & Gallego, M. C. (2007). Testing ant predation on the coffee berry borer in shaded and sun coffee plantations in Colombia. *Entomologia Experimentalis et Applicata*, *124*, 261–267. https://doi.org/10.1111/j.1570-7458.2007.00574.x
14. Larsen, A., & Philpott, S. M. (2010). Twig nesting ants: The hidden predators of the coffee berry borer in Chiapas, Mexico. *Biotropica*, *42*(3), 342–347. https://doi.org/10.1111/j.1744-7429.2009.00603.x
15. Philpott, S. M., Pardee, G. L., & Gonthier, D. J. (2012). Cryptic biodiversity effects: Importance of functional redundancy revealed through addition of food web complexity. *Ecology*, *93*(5), 992–1001. https://doi.org/10.1890/11-1431.1
16. Gonthier, D. J., Ennis, K. K., Philpott, S. M., Vandermeer, J., & Perfecto, I. (2013). Ants defend coffee from berry borer colonization. *Biological Control*, *58*, 815–820. https://doi.org/10.1007/s10526-013-9541-z. EDN: https://elibrary.ru/RIHWXP
17. Morris, J. R., Vandermeer, J., & Perfecto, I. (2015). A keystone ant species provides robust biological control of the coffee berry borer under varying pest densities. *PLoS One*, *10*(11), e0142850. https://doi.org/10.1007/s10526-013-9541-z
18. Jauharlina, J., Husni, H., Halimursyadah, H., Rizali, A., & Febrian, T. A. (2021, February). Diversity of ants (Hymenoptera: Formicidae) in organic and conventional Arabica coffee plantations in Aceh Tengah Regency, Sumatra, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 667, Issue 1, Article 012036). IOP Publishing. https://doi.org/10.1088/1755-1315/667/1/012036. EDN: https://elibrary.ru/MGOOEV
19. Hashimoto, Y. (2003). Identification guide to the ant genera of Borneo. In Y. Hashimoto & R. Homathevi (Eds.), *Inventory and collection — Total protocol for understanding of biodiversity* (pp. 89–162). UMS Press.
20. Nazaretta, R., Buchori, D., Hashimoto, Y., Hidayat, P., Scheu, S., & Drescher, J. (2021). *A guide to the ants of Jambi (Sumatra, Indonesia): Identification key to ant genera and images of the EFForTS collection*. LIPI Press. https://doi.org/10.14203/press.273
21. Morris, J. R., & Perfecto, I. (2016). Testing the potential for ant predation of immature coffee berry borer (*Hypothenemus hampei*) life stages. *Agriculture, Ecosystems & Environment*, *233*, 224–228. https://doi.org/10.1016/j.agee.2016.09.018
22. Ruiz-Cárdenas, R., & Baker, P. S. (2010). Life table of *Hypothenemus hampei* (Ferrari) in relation to coffee berry phenology under Colombian field conditions. *Scientia Agricola*, *67*(6), 658–668. https://www.scielo.br/j/sa/a/NNTn9FTNJMxpHW8GPswn3Fg/?lang=en&format=pdf

23. Wiryadiputra, S., Cilas, C., & Morin, J-P. (2008). Effectiveness of the brocap trap in controlling the coffee berry borer (*Hypothenemus hampei* Ferr.) in Indonesia [PA589]. In *22nd International Conference on Coffee Science* (pp. 1405–1408). ASIC. https://publications.cirad.fr/une_notice.php?dk=550189. ISBN: 2-900212-21-9
24. Vicente, R. E., & Izzo, T. J. (2017). Defining habitat use by the parabiotic ants *Camponotus femoratus* (Fabricius, 1804) and *Crematogaster levior* Longino, 2003. *Sociobiology*, *64*(4), 373. https://periodicos.uefs.br/index.php/sociobiology/article/view/1228. https://doi.org/10.13102/sociobiology.v64i4.1228
25. Susilawati, S., & Indriati, G. (2020). The effect of coffee plantations agroecosystem on diversity and abundance of ants (Formicidae). *Journal of Industrial and Beverage Crops*, *7*(1), 981–989. https://repository.pertanian.go.id/items/d2dfc57b-3460-444e-9f84-da4180571748
26. Bustillo, A. E., Cárdenas, R., & Posada, F. J. (2002). Natural enemies and competitors of *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae) in Colombia. *Neotropical Entomology*, *31*(4), 635–639. https://doi.org/10.1590/S1519-566X2002000400018
27. Benassi, V. L. R. M. (1995). Levantamento dos inimigos naturais da broca do café *Hypothenemus hampei* (Ferr.) (Coleoptera: Scolytidae) no norte do Espírito Santo. *Anais da Sociedade Entomológica do Brasil*, *24*, 635–638.
28. Dejean, A. (1988). Prey capture by *Camponotus maculatus* (Formicidae — Formicinae). *Biology of Behavior*, *13*, 97–115.
29. Sangtow, W., Suttiprapan, P., Jaitrong, W., & Buranapanichpan, B. (2018). Species of ants and their relationship with green scale insects on Arabica coffee trees in northern Thailand. *Agricultural Journal*, *34*(3), 469–480.
30. Djiéto-Lordon, C., Richard, F. J., Owona, C., Gibernau, M., Orivel, J., & Dejean, A. (2001). The predatory behaviour of the dominant arboreal ant species *Tetramorium aculeatum* (Hymenoptera: Formicidae). *Sociobiology*, *38*(3), 765–776.
31. Infante, F., Mumford, J., & García-Ballinas, A. (2003). Predation by native arthropods on the African parasitoid *Prorops nasuta* (Hymenoptera: Bethylidae) in coffee plantations of Mexico. *Florida Entomologist*, *86*(1), 86–88. https://doi.org/10.1653/0015-4040(2003)086
32. Tobin, J. E. (1997). Competition and coexistence of ants in a small patch of rainforest canopy in Peruvian Amazonia. *Journal of the New York Entomological Society*, *105*, 105–112.
33. Ward, P. S., Brady, S. G., Fisher, B. L., & Schultz, T. R. (2010). Phylogeny and biogeography of dolichoderine ants: Effects of data partitioning and relict taxa on historical inference. *Systematic Biology*, *59*(3), 342–362. https://doi.org/10.1093/sysbio/syq012. EDN: https://elibrary.ru/NZEFOX
34. Wielgoss, A., Tscharntke, T., Buchori, D., Fiala, B., & Clough, Y. (2010). Temperature and a dominant dolichoderine ant species affect ant diversity in Indonesian ca-

cao plantations. *Agriculture, Ecosystems & Environment*, *135*, 253–259. https://doi.org/10.1016/j.agee.2009.10.003

35. Ibarra-Isassi, J., Handa, I. T., Arenas-Clavijo, A., Escobar, S., Armbrecht, I., & Lessard, J. (2021). Shade-growing practices lessen the impact of coffee plantations on multiple dimensions of ant diversity. *Journal of Applied Ecology*, *58*(5), 919–930. https://doi.org/10.1111/1365-2664.13842. EDN: https://elibrary.ru/JXCENM
36. Swai, E. (2021). *Ants diversity between organic and conventional farm*. GRIN Verlag.
37. Hill, M. P., Macfadyen, S., & Nash, M. A. (2017). Broad-spectrum pesticide application alters natural enemy communities and may facilitate secondary pest outbreaks. *PeerJ*, *5*, e4179. https://doi.org/10.7717/peerj.4179
38. Hoffmann, B. D., & Andersen, A. N. (2003). Responses of ants to disturbance in Australia, with particular reference to functional groups. *Austral Ecology*, *28*(4), 444–464. https://doi.org/10.1046/j.1442-9993.2003.01301.x. EDN: https://elibrary.ru/ETPPNV
39. Silva, L. F., Souza, R. M., Solar, R., & Neves, F. S. (2017). Ant diversity in Brazilian tropical dry forests across multiple vegetation domains. *Environmental Research Letters*, *12*(3), 035002. https://doi.org/10.1088/1748-9326/aa5f2a
40. Gathalkar, G., & Sen, A. (2018). Foraging and predatory activities of ants. In V. Shields (Ed.), *The complex world of ants* (pp. 51–68). IntechOpen. https://doi.org/10.5772/intechopen.78011
41. Pardee, G. L., & Philpott, S. M. (2011). Cascading indirect effects in a coffee agroecosystem: Effects of parasitic phorid flies on ants and the coffee berry borer in a high-shade and low-shade habitat. *Environmental Entomology*, *40*(3), 581–588. https://doi.org/10.1603/EN11015

DATA ABOUT THE AUTHORS

J. Jauharlina, Professor, Department of Plant Protection, Faculty of Agriculture

Universitas Syiah Kuala
Darussalam, Banda Aceh, 23111, Indonesia
ljauharlina@usk.ac.id
ORCID: https://orcid.org/0000-0002-6166-3831

Icha Destriany, Undergraduate student, Department of Plant Protection, Faculty of Agriculture

Universitas Syiah Kuala
Darussalam, Banda Aceh, 23111, Indonesia

Nihayatul Afifah Husna, Undergraduate student, Department of Plant Protection, Faculty of Agriculture
Universitas Syiah Kuala
Darussalam, Banda Aceh, 23111, Indonesia

Muhammad Sayuthi, Associate Professor, Department of Plant Protection, Faculty of Agriculture
Universitas Syiah Kuala
Darussalam, Banda Aceh, 23111, Indonesia

Tjut Chamzurni, Associate Professor, Department of Plant Protection, Faculty of Agriculture
Universitas Syiah Kuala
Darussalam, Banda Aceh, 23111, Indonesia

Поступила 02.07.2025
После рецензирования 10.08.2025
Принята 25.08.2025

Received 02.07.2025
Revised 10.08.2025
Accepted 25.08.2025