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Insect Diversity of Mangrove Ecosystems in Beras Basah Village, Langkat, North Sumatra, Indonesia

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Abstract

This study aimed to investigate the diversity of insects, including stingless bees (*Heterotrigona*) in the mangrove ecosystem of Beras Basah Village, Langkat Regency, North Sumatra, Indonesia. The mangrove plantation in Beras Basah Village contained 11 species, including *Rhizophora apiculata, Rhizophora mucronata, Rhizophora. stylosa, Avicennia marina, Sonneratia alba, Bruguiera gymnorhizza, Xylocarpus granatum, Excoecaria agallocha, Scyphiphora hydrophyllacea, Lumnitzera racemosa*, and *Nypa fruticans*. Additionally, five flowering plant species were identified in the vicinity: *Antigonon leptopus, Asclepias curassavica, Helianthus annuus, Calliandra grandiflora, Portulaca grandiflora*. Other plant species recorded in the area included *Cocos nucifera, Pandanus amaryllifolius, Leucaena leucocephala, Ziziphus mauritiana, Albizia chinensis*, and *Terminalia catappa*. Insect identification from four observations using sweep nets, yellow sticky traps, and blue pan traps resulted in the collection of 1,525 individual insects belonging to eight orders, 17 families, and 19 genera. These insects included ten predators and pests, comprising five Odonata species (*Neurothemis terminata, Orthetrum sabina, Orthetrum testaceum, Potamarcha congener, Zyxomma obtusum*) and five ant species (*Camponotus* spp., *Crematogaster* spp., *Nylanderia* spp., *Odontoponera denticulate*, *Pheidole* spp.). The insect functional status within the mangrove area was determined to include seven species of scavengers, 12 species of herbivores, two species of pollinators, 19 species of predators, one species of parasitoid, and four species of insect disease vectors. This study provides valuable insights into the insect diversity and ecological roles within the mangrove ecosystem of Beras Basah Village, contributing to a better understanding of the conservation and management of this important habitat.

Keywords: conservation, ecological interactions, insect diversity, mangrove ecosystems, stingless bees

Introduction

Stingless bees, such as *Heterotrigona itama*, commonly known locally as "Kelulut," are eusocial insects belonging to the Apidae family. They are widely distributed across tropical regions, including Africa, Australia, South and Central America, and Southwest Asia. With approximately 600 species recorded globally (Avila et al., 2018; Basari et al., 2018), these bees offer significant economic potential, particularly in Indonesia, due to their pollination services and the production of valuable products such as honey, bee pollen, and propolis. The increasing economic value of these products has fueled the growth of meliponiculture, the cultivation of stingless bees, in Indonesia (Herwina et al., 2021).

Indonesia's vast forested areas, spanning approximately 143 million hectares, provide an ideal environment for beekeeping due to its abundance of flowering plants. This natural resource offers a promising opportunity for honey production, as evidenced by the successful cultivation of stingless

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bees in the country (Novandra and Widnyana, 2013; Djamaluddin, 2018).

Beyond their economic benefits, *H. itama* plays a crucial role in ecosystem conservation. These bees are known to modify floral nectars using salivary and enzymes from their cephalic glands, resulting in honey with unique flavors and potential medicinal properties (Avila et al., 2019). The maturation process within the hive further enhances the honey's characteristics, producing a distinctive blend of sweet and sour tastes (Chuttong et al., 2016; Jalil et al., 2017).

This study investigates the insect diversity within the mangrove ecosystems of Beras Basah Village, Langkat Regency, North Sumatra, Indonesia, and assesses their potential role in supporting *H. itama* populations. We can gain valuable insights into these important habitats' conservation and sustainable utilization by exploring the insect diversity and ecological relationships in mangrove ecosystems.

Materials and Methods

The study was conducted in the mangrove forests of Beras Basah Village, Langkat Regency, North Sumatra Province, Indonesia (4°07'15.7" N, 98°14'30.4" E), located adjacent to the Malacca Strait (Figure 1). Insect sampling was conducted in the mangrove forests of Beras Basah Village, Langkat Regency, North Sumatra Province, Indonesia, from February to April 2024. Stingless bees (*Heterotrigona itama*) were included among the target species. A variety of traps were employed to capture insects: A 40-cm diameter sweep net (SN), made of clear gauze (Figure 2A), was used to capture insects by swinging it 10 times (Gill and Oneal, 2015) within a 3m x 3m area in the morning, between 8:00 AM and 10:00 AM. Five yellow sticky traps (YSTs) were deployed at each of three sampling plots, measuring approximately 15 x 10 m². YSTs consist of yellow paper coated with adhesive and are mounted on wooden poles at a height corresponding to the mangrove canopy (Figure 2B). Insects attracted to the yellow color become trapped by the adhesive. YSTs were installed and collected at 8:00 AM, with this trapping method repeated for seven days for each observation (Sianipar et al., 2015). One blue pan trap (BPT) was placed on each sample tree, filled with a one-third solution of water and detergent (Figure 2C). Trapped insects were filtered and removed using a brush and placed in film bottles containing 70% alcohol for laboratory identification. BPTs were installed and collected at 8:00 AM, with this trapping method repeated for seven days for each observation (Acharya et al., 2021). Samples were preserved and stored in 70-80% ethyl alcohol (EtOH). Captured specimens were stored in jars or bottles and transported to the Pest Laboratory, Faculty of Agriculture, University of Sumatra Utara (USU) for subsequent identification. Detailed examinations of collected insects were conducted using stereo microscopes (Olympus CX 23). When necessary, dissections were performed to facilitate identification. Samples were identified using the taxonomic keys and descriptions provided by Haneda (2018), and Djamaluddin (2018). Consultations were conducted with insect experts and entomologists at various

Figure 1. Map of the study site in Beras Basah Village, Langkat Regency, North Sumatra Province, Indonesia (4°07'15.7"N, 98°14'30.4"E).

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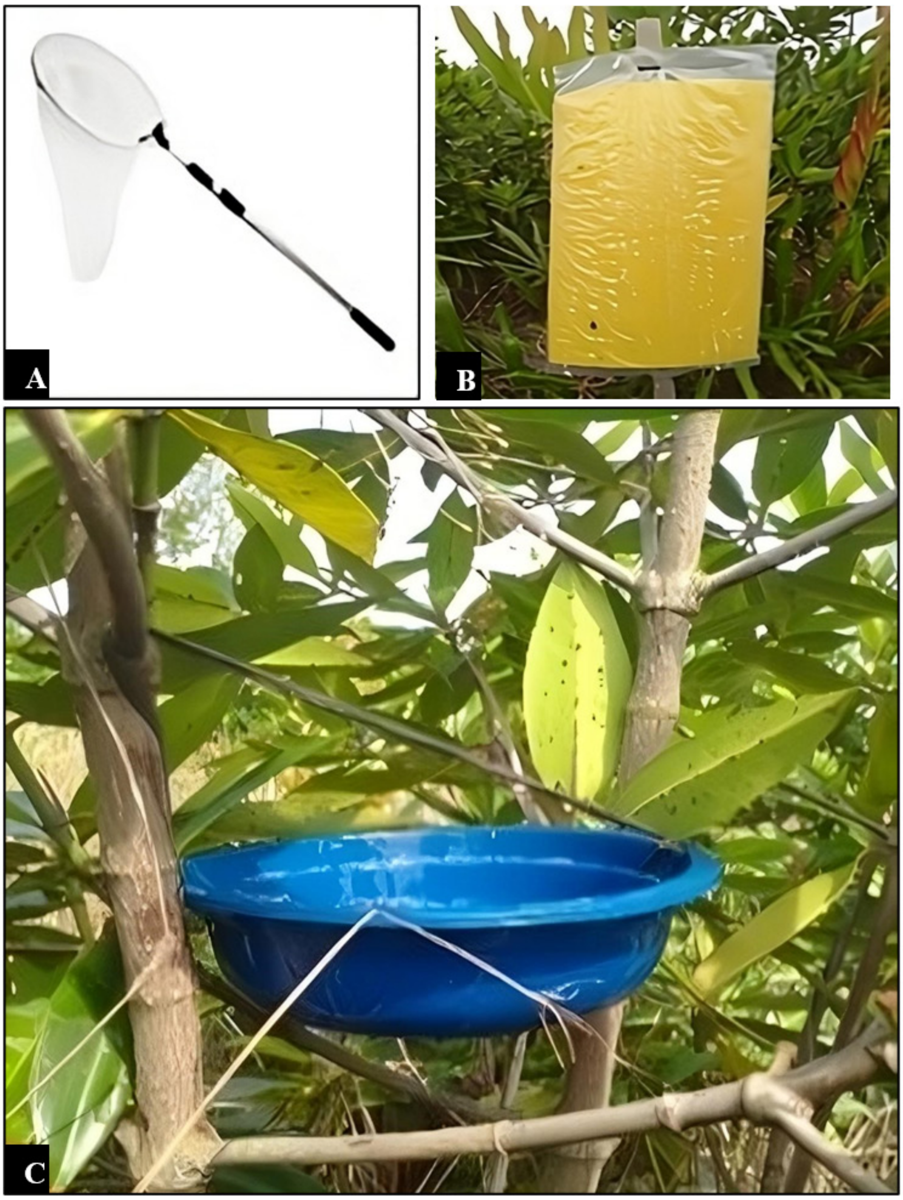

Figure 2. Insect sampling tools used for insect diversity assessment in Beras Basah village, Langkat, Northern Sumatra, Indonesia. (A) sweep net, (B) yellow sticky trap, and (C) blue pan trap. [Photo credits: Amelia Zuliyanti Siregar and Ravindra C. Joshi].

insect museums to further confirm identifications.
A survey of the mangrove plant species present within the study site was conducted. Plant identification was carried out at the Pest Laboratory, Agrotechnology Study Program, Faculty of Agriculture, University of North Sumatra. Morphological characteristics of encountered mangrove species were observed and compared with reference materials, including online resources (https://www.wetlands.or.id/mangrove/mangrove_species.php?id=64) and reference libraries by Giesen et al. (2007), Noor et al. (2012), and Gultoma et al. (2021).

Insect Diversity and Abundance

Sweep Net (SN)

Insect sampling using sweep nets (SN) over four observations from February to March 2024 in Beras Basah Village resulted in the collection of 345 individual insects belonging to eight orders, 17 families, and 19 genera (Table 2). The Hemiptera order and Hymenoptera order exhibited the highest number of individuals, with 132 and 49 individuals, respectively. Within the Hemiptera order, the Largidae family, specifically *Macrocheraia* spp., was the most abundant with 47 individuals (Table 2). This dominance may be attributed to the suitable habitat

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and abundant food sources the mangrove ecosystem provides. In comparison,

Results and Discussion

Food Sources for Stingless Bees (Heterotrigona itama)

A survey of the mangrove plantations in Beras Basah Village identified 11 mangrove species, five flowering plant species in the vicinity of the mangrove forests, and several other plant species such as *Cocos nucifera*, *Pandanus amaryllifolius*, *Leucaena leucocephala, Ziziphus mauritiana*, *Albizia chinensis*, and *Terminalia catappa* (Table 1) (Figure 3 A-E). The food resources utilized by *H. itama* in Beras Basah Village are similar to those reported in Tegal Yoso Village, Purbolinggo District, East Lampung, which include Coral Vine, Tropical Milkweed, Common sunflower, Red Powder-puff, and nectar-producing plants such as Aren palm, Lamtoro, and Bidara (Winarno et al., 2024). This suggests a consistent preference for certain plant species among stingless bee populations in different regions.

Membere et al. (2021) recorded a higher diversity of insects in the Bundu-Ama mangrove ecosystem of the Niger Delta, Nigeria, with eight orders, 20 families, and 35 species identified. Haneda et al. (2013) demonstrated the critical role of distance in shaping the ecological dynamics of insects between oil palm and forest ecosystems, providing valuable insights for developing more effective conservation strategies.

Yellow Sticky Trap (YST)

Insect identification from four observations using yellow sticky traps (YST) yielded a total of 750 individual insects belonging to five orders, 16 families, and 19 genera (Table 3). The Diptera order dominated with the most individuals (380), followed

Figure 3. Representative mangrove plant species found in Beras Basah Village, Langkat, Northern Sumatra, Indonesia. (A) *Rhizophora stylosa*, (B) *Rhizophora mucronata*, (C) *Sonneratia alba*, (D) *Nypa fruticans*, and (E) *Avicennia marina*. [Photo credits: Amelia Zuliyanti Siregar and Ravindra C. Joshi].

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by the Hemiptera order with 184 individuals. The Sarcophagidae family, specifically *Sarcophaga* spp., was the most abundant, indicating a high abundance of decomposing insects in the area (Table 3). Other dominant insects included the Dolichopodidae family (94 individuals) and the Psyllidae family (96 individuals), suggesting variations in food sources and habitats, including Coral Vine flowers, Pandan, Coconuts, and mangrove plants. Despite the diversity of our study compared to Rahaman's 2002 study, it offers valuable insights into the unique insect community of this mangrove ecosystem. Rahaman found greater diversity, with eight orders, 53 families, and 94 species. Lepidoptera and Coleoptera dominated his findings, while our study revealed a prevalence of Diptera and Hemiptera. Future research should investigate the factors contributing to these differences and explore the ecological implications of the observed insect communities.

Blue Pan Trap (BPT)

Insect identification from four observations using blue pan traps (BPT) yielded 430 individual insects belonging to five orders, ten families, and 14 genera (Table 4). The Hymenoptera order, particularly the Formicidae family, dominated with the highest number of individuals, totaling 268. *Camponotus* spp. (Formicidae) was the most abundant species, with 90 individuals indicating a high abundance of ants in the area. Other Formicidae families, such as *Solenopsis* spp. and *Lasius* sp., were also well-represented, with 82 and 89 individuals, respectively (Table 4). The dominance of ants may be attributed to the availability of food sources and suitable habitats within the mangrove ecosystem.

The Diptera order was the most abundant insect group in the mangrove area, with 437 individuals (Table 3 and Figure 4). The results of a study by Fitri et al. (2020), reported the dominance of the Hymenoptera order, comprising three subfamilies (Formicinae, Myrmicinae, and Dolichoderinae) in mangrove environments. Similarly, Haneda et al. (2013), Siregar (2016), and Membere et al. (2021) revealed that Hymenoptera (49.1%) was the most prevalent insect order, followed by Diptera and Homoptera.

Table 1. Plant Species Observed in Beras Basah Village, Langkat, Northern Sumatera, Indonesia

English Name/ Vernacular Name	Botanical Name
Tall-stilt Mangrove, True Mangrove, “Bakau minyak”	*Rhizophora apiculata* Blume
Red mangrove, Loop-root Mangrove, “Bakau bakau hitam”	*Rhizophora mucronata* Poir.
Small stilted mangrove, “Bakau merah”	*Rhizophora stylosa* Griff.
Grey Mangrove, White Mangrove, “Api-api Jambu”	*Avicennia marina* (Forssk.) Vierh.
Mangrove Apple, “Pepada”	*Sonneratia alba* J. Smith
Large-Leafed Orange Mangrove, “Tanjang”, “Bakau”	*Bruguiera gymnorhiza* (L.) Lam.
Cannonball Mangrove, “Nyiri”	*Xylocarpus granatum* J. Koenig
Milky Mangrove, “Buta-buta”	*Excoecaria agallocha* L.
Yamstick Mangrove, “Cingam”	*Scyphiphora hydrophylacea* C.F. Gaertn.
Black Mangrove, White Teruntum	*Lumnitzera racemosa* Willd. Cadena de amor
Mangrove Palm, “Nipah Palm”	*Nypa fruticans* Wurmb
Coral Vine, “Cadena de amor”	*Antigonon leptopus* Hook. & Arn.
Tropical Milkweed, Bloodflower, “Kapas cinde”	*Asclepias curassavica* L.
Common Sunflower, “Bunga Matahari”	*Helianthus annuus* L.
Red Powder-puff, Fairy duster,	*Calliandra grandiflora* (L'Hér.) Benth.
Japanese Rose, Moss Rose, Ten o'clock, “Bunga Pukul Sembilan”	*Portulaca grandiflora* Hook.
Coconut, “Kelapa”	*Cocos nucifera* L.
Pandan, “Pandan rampeh”	*Pandanus amaryllifolius* Roxb. ex Lindl.
Coffee bush, Wild tamarind, “Lamtoro”	*Leucaena leucocephala* (Lam.) de Wit
Indian jujube, Chinese date, “Bidara”	*Ziziphus mauritiana* Lam.
Silk tree, Chinese albizia, “Sengon”, “Sengghung”	*Albizia chinensis* (Osbeck) Merr.
Singapore Almond, “Jelawai Ketapang”	*Terminalia catappa* L.

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Table 2. Diversity of Insects insects trapped by sweep net (SN) in Beras Basah Village, Langkat Regency, North Sumatra, Indonesia, from February to April 2024

Order	Family	Genus	Sampling Dates[1/]				Total
			01 March 2024	08 March 2024	15 March 2024	22 March 2024	
Coleoptera	Coccinellidae	*Coccinella* spp.	4	10	8	12	34
Coleoptera	Coccinellidae	*Curinus* spp.	0	12	14	8	34
Diptera	Muscidae	*Musca* spp.	0	4	4	0	8
Hemiptera	Coreidae	*Acanthocephala* spp.	3	0	6	0	9
Hemiptera	Dictyopharidae	*Dictyophara* spp.	2	0	6	7	15
Hemiptera	Largidae	*Macrocheraia* spp.	7	20	16	4	47
Hemiptera	Psyllidae	*Acizzia* spp.	0	0	28	0	28
Hemiptera	Pyrrhocoridae	*Dysdercus* spp.	10	7	4	12	33
Hymenoptera	Apidae	*Xylocopa* spp.	1	1	6	5	13
Hymenoptera	Crabronidae	*Cerceris* spp.	2	1	4	8	15
Hymenoptera	Ichneumonidae	*Enicospilus* spp.	0	1	0	2	3
Hymenoptera	Pompilidae	*Pepsis* spp.	0	0	0	7	7
Hymenoptera	Vespidae	*Vespa* spp.	7	4	0	0	11
Lepidoptera	Nymphalidae	*Acraea* spp.	3	0	0	0	3
Mantodea	Hymenopodidae	*Odontomantis* spp.	1	0	8	6	15
Odonata	Coenagrionidae	*Ischnura* spp.	4	2	0	8	14
Odonata	Libellulidae	*Diplacodes* spp.	8	0	8	12	28
Orthoptera	Acrididae	*Camnula* spp.	5	6	3	5	19
Orthoptera	Acrididae	*Acrida* spp.	1	1	4	3	9
Total			58	69	119	99	345

Notes: [1/] Sampling was conducted between 8:00 AM and 10:00 AM on each observation day.

Table 3. Diversity of insects trapped by yellow sticky trap (YST) in Beras Basah Village, Langkat Regency, North Sumatra, Indonesia, from February to April 2024

Order	Family	Genus	Sampling Dates[1/]				Total
			01 March 2024	08 March 2024	15 March 2024	22 March 2024	
Blattodea	Ectobiidae	*Blatella* spp.	4	0	8	0	12
Coleoptera	Anthicidae	*Anthicus* spp.	2	14	6	20	42
Coleoptera	Dytiscidae	*Laccophilus* spp.	0	0	4	8	12
Diptera	Anthomyiidae	*Delia* spp.	9	0	0	0	9
Diptera	Calliphoridae	*Calliphora* spp.	3	0	0	0	3
Diptera	Culicidae	*Aedes* spp.	20	12	10	20	62
Diptera	Culicidae	*Culex* spp.	0	8	0	14	22
Diptera	Dolichopodidae	*Sciapus* spp.	22	29	20	23	94
Diptera	Muscidae	*Musca* spp.	22	27	12	30	91
Diptera	Muscidae	*Stomoxys* spp.	2	0	0	0	2
Diptera	Sarcophagidae	*Sarcophaga* spp.	20	22	27	28	97
Diptera	Tabanidae	*Tabanus* spp.	2	11	28	8	49
Hemiptera	Cicadellidae	*Orientus* spp.	24	23	17	20	84
Hemiptera	Psyllidae	*Acizzia* spp.	23	24	29	20	96
Hemiptera	Ricaniidae	*Ricania* spp.	0	0	0	4	4
Hymenoptera	Pompilidae	*Pepsis* spp.	0	6	12	8	26
Hymenoptera	Formicidae	*Solenopsis* spp.	25	0	0	15	40
Hymenoptera	Sphaecidae	*Sceliphron* spp.	0	0	0	3	3
Hymenoptera	Pompilidae	*Auplopus* spp.	0	0	0	2	2
Total			178	176	173	223	750

Notes: [1/]Trapped insects were collected at 8:00 AM every week.

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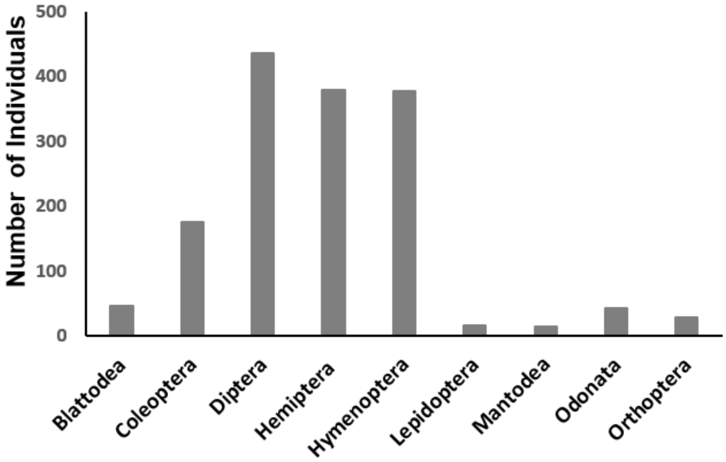

Figure 4. Diversity of insect orders in the sampling area

Environmental Factors and Insect Diversity

The optimum temperature range for stingless bees (*Trigona* spp.) is between 30.5°C and 33.1°C, with a pH of 40.6-49.3. These conditions are conducive to their survival and activity. Tautz et al. (2008) and Hidayatullah (2016) have explained that honeybees generally function optimally at temperatures between 18°C and 35°C, with the ideal temperature being 26°C. Deviations from this temperature range can disrupt their activity.

The favorable environmental conditions in the Beras Basah mangrove area, including suitable temperatures and adequate food sources, create an ideal environment for cultivating stingless bees. It is hypothesized that the environmental conditions within the mangrove ecosystem, with a temperature range of 30.5°C-33.1°C and humidity of 40.6%-49.3%, support the breeding process of insects, thereby influencing their diversity and abundance. This hypothesis is supported by the findings of Su et al. (2021), which demonstrated that temperature (15°C, 25°C, 37°C) and pH (6-8) significantly impact mangrove ecosystems and insect diversity in Taiwan. Each insect species has specific environmental requirements, and the physical factors of the environment play a crucial role in their distribution and abundance. As documented by Yadav et al. (2019) and Iswara et al. (2022), climate change is a primary driver of shifts in arthropod diversity, abundance, population dynamics, and the activity and abundance of natural enemies. While insect populations tend to increase as the harvest season approaches, they typically remain moderate. Conversely, insect abundance declines at the end of the planting season due to the onset of dry conditions and plant senescence.

The environmental factors measured in this study were temperature and humidity. These measurements provide valuable insights into the physical conditions influencing insect diversity and abundance within the mangrove ecosystem. The average temperature recorded in the study was 31.5°C, ranging from 30.5°C to 33.1°C. The average humidity was 46.95%, ranging from 40.6% to 49.3%. These environmental conditions are within the optimal range for stingless bee activity, suggesting they are suitable for survival and reproduction in the Beras Basah mangrove ecosystem.

Insect Predators and Pests of Stingless Bees

Field observations in Beras Basah Village revealed a diverse insect community, including ten species identified as potential predators or pests of *H. itama*. Four species were categorized as pests, while six were classified as predators (Table 5). The two-hour observation period, from 1:30 PM to 3:30 PM, documented at least five species of ants belonging to the Formicidae family and five species of dragonflies belonging to the Libelluilidae family. Although this was a limited observation, the presence of non-stingless bee species in the apiary area suggests a potentially higher insect diversity in the region, warranting further investigation.

While no direct predation activity by bird species on stingless bees was observed, the presence of dragonfly species indicates the potential for predation. Afriyanto (2015) has reported that dragonfly species can prey on stingless bees. Dragonflies, predatory insects from the Libellulidae family (Anisoptera suborder), were observed during field trips in Beras Basah Village. Five species of dragonflies were recorded (Table 5). These dragonflies were commonly found perched on plants on the ground or tree canopy branches around the *H. itama* farms. The Libellulidae family is characterized by its large size and sensitive compound eyes, which enable them to detect the

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movement of prey such as mosquitoes, flies, aphids, butterflies, bees, or smaller dragonflies. The predation ability of dragonflies is positively correlated with their body size, allowing larger species to consume comparatively larger prey insects or prey on a greater number of smaller insects. This has been observed in the mangrove forests of Lagos State, Nigeria (Alafia et al., 2023). Given that dragonflies from the Libellulidae family are generally larger than individual stingless bees, predation incidents are highly likely to occur. Dragonflies typically ambush their prey, using their agility and speed to capture their targets.

While five species of dragonflies were observed as potential predators of stingless bees, the primary threats to these bees appear to come from ants. The carnivorous Odontoponera denticulata poses the most significant risk of the four ant species recorded. The remaining ant species, *Camponotus* spp., *Crematogaster* spp., *Nylanderia* spp., and *Pheidole* spp., are more generalist feeders and may not pose a direct threat. Stingless bees have developed behavioral mechanisms to protect themselves and their nests from ant attacks (Fitri et al., 2020). However, recent evidence suggests that *Ectatomma tuberculatum* (Olivier) ants can ambush stingless bees, *Tetragonisca angustula* (Latreille) at the entrance of their nests (Ostwald et al., 2018).

Ants from the Formicidae family can be considered pests or competitors of *H. itama*, as several species are known to consume flower nectar, a primary food source for these bees. The presence of these ants in the area may threaten the survival and success of stingless bee colonies (Priawandiputra, 2020). While ants can threaten stingless bee colonies, the risk of invasion and infestation of *H. itama* nest boxes by ants is relatively low. Many types of stingless bees live alongside ants and termites in nature. These insects can benefit from the holes created by ants and termites in trees, which can be used as nesting places. Additionally, stingless bees can take advantage of the digestive microorganisms present in the stomachs of termites (Roubik, 2006; Carrijo et al., 2012). The symbiotic relationship between ants and *H. itama* nesting in the same location can be observed in natural environments. This inventory of potential predators and pests for stingless bee colonies complements the findings of Afriyanto (2015), who recorded ten pests on *Apis cerana* honeybee farms. It is reasonable to assume that these animals may also threaten stingless bees, especially smaller species than the common honeybee.

Mangrove Ecosystem Function for Cultivating Stingless Bees

The presence of insects in mangrove areas is closely linked to the availability of flowers in the local flora. Mangrove flowers provide excellent insect resources, including bees, beetles, flies, and butterflies that utilize nectar or pollen as food. Nectar is a sweet liquid produced by flowers from plants' nectar glands, attracting pollinators such as insects. Pollen is a product made by the male genital organs of plants located in the anthers. The mangrove ecosystem in Beras Basah Village is characterized by a diverse flora that includes flowering plants with varying blooming periods, ensuring a continuous supply of nectar and pollen throughout the year (Harjanto et al, 2020). This abundance of food sources allows various insects to thrive in this location. Mangrove ecosystems have significant ecological and economic functions that humans can utilize. The diverse fauna and flora within the Beras Basah mangrove ecosystem interact with abiotic factors such as temperature, creating a favorable environment for cultivating *H. itama*. Trigona bees are particularly suitable for cultivation due to several advantages. Individuals can increase honey production by cultivating these bees compared to relying solely on natural sources, thereby generating economic benefits for the local community.

Insect Functional Status and Importance Value Index (IVI)

Functional analysis of the identified insect genera revealed a diverse community within the mangrove ecosystem. The community comprised seven scavenger genera, twelve herbivore genera, two pollinator genera, sixteen predator genera, one parasitoid genus, and four disease vectors, as outlined in Table 6.

The largest number of individuals belonged to predatory insects (547 individuals). Predators play a crucial role in the mangrove ecosystem as natural controllers of other insect populations, including herbivores and potential pests for mangrove plants. The presence of predators helps maintain ecosystem balance by reducing pressure from herbivorous insect populations that can damage mangrove vegetation. This aligns with research by Membere et al. (2021) and Siregar et al (2022), which highlighted the importance of predators and parasitoids in preventing population explosions and suppressing the growth rate of pest populations.

Herbivorous insects, constituting the second-largest insect population (435 individuals), represent a significant pest threat to the mangrove ecosystem.

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The genus *Acizzia* (Hemiptera: Psyllidae), with an IVI of 15.38%, was identified as the most prominent herbivore, demonstrating its substantial impact on mangrove health. Wahyuningsih et al. (2021) reported that these herbivore insects exhibit diverse feeding behaviors, targeting various plant parts, including roots, stems, flowers, leaves, and fruits. Furthermore, their lifestyles vary, with some species inhabiting the plant surface, others residing within plant tissues, and others dwelling in the surrounding soil.

While the number of scavenger insects identified was 345 individuals and pollinator insects were 16 individuals, these groups still play important roles in the ecosystem. Scavenger insects, also known as decomposers, are essential for decomposing rotting animals and plants, preventing the spread of disease (Arceo-Carranza et al., 2021; Alfianingsih et al., 2022). Pollinator insects are crucial for maintaining the existence of plant species and indirectly support the availability of food and habitat for other insects.

Field surveys conducted in Beras Basah Village, Langkat Regency, North Sumatra, identified four prominent disease vector species belonging to the Diptera order: *Aedes* spp., *Culex* spp., *Stomoxys*

Table 4. Diversity of insects trapped by blue pan trap (BRT) in Beras Basah Village, Langkat Regency, North Sumatra, Indonesia, from February to April 2024

Order	Family	Genus	Sampling Dates[1]				Total
			01 March 2024	08 March 2024	15 March 2024	22 March 2024	
Blattodea	Ectobiidae	*Blatella* spp.	0	0	10	4	14
Blattodea	Ectobiidae	*Parcoblatta* spp.	6	10	4	0	20
Coleoptera	Chrysomelidae	*Monocesta* spp.	5	0	0	0	5
Coleoptera	Coccinellidae	*Coccinella* spp.	0	0	8	0	8
Coleoptera	Coccinellidae	*Curinus* spp.	5	3	0	6	14
Coleoptera	Melolonthidae	*Amphimallon* spp.	3	5	0	11	19
Hemiptera	Dictyopharidae	*Dictyophara* spp.	0	2	0	0	2
Hemiptera	Psyllidae	*Acizzia* spp.	0	21	31	10	62
Hymenoptera	Formicidae	*Solenopsis* spp.	20	26	17	19	82
Hymenoptera	Formicidae	*Lasius* spp.	20	21	28	20	89
Hymenoptera	Formicidae	*Camponotus* spp.	15	22	28	25	90
Hymenoptera	Pompilidae	*Auplopus* spp.	5	0	0	0	5
Hymenoptera	Formicidae	*Polyrhacis* spp.	7	0	0	0	7
Lepidoptera	Pyralidae	*Plodia* spp.	5	1	5	2	13
Total			91	111	131	97	430

Notes: [1/]Trapped insects were collected at 8:00 AM every week.

Table 5. Diversity of insect predators and pests of stingless bees (*H. itama*) in Mangrove Forests

Order	Family	Species	Status	Habitat/Diet
Hymenoptera	Formicidae	*Camponotus* sp.	Pest	Terrestrial ants (Carpenter ants)
Hymenoptera	Formicidae	*Crematogaster* sp.	Pest	Arboreal ants
Hymenoptera	Formicidae	*Nylanderia* sp.	Pest	Arboreal ants (Parrot ants)
Hymenoptera	Formicidae	*Odontoponera denticulata* (Smith)	Predator	Terrestrial ants (Toothed ants)
Hymenoptera	Formicidae	*Pheidole* sp.	Pest	Terrestrial ants (Big-headed ants)
Odonata	Libellulidae	*Neurothemis terminata*	Predator	Carnivore
Odonata	Libellulidae	*Orthetrum sabina*	Predator	Carnivore
Odonata	Libellulidae	*Orthetrum testaceum*	Predator	Carnivore
Odonata	Libellulidae	*Potamarcha congener*	Predator	Carnivore
Odonata	Libellulidae	*Zyxomma obtusum*	Predator	Carnivore

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Table 6. Insect functional status and importance value index (IVI) in the Mangrove Ecosystem of Beras Basah Village, Langkat Regency, North Sumatra, Indonesia

Classification			Status function	IVI
Order	Family	Genera		
Blattodea	Ectobiidae	*Blatella* spp.	Scavenger	4.84
		Parcoblatta spp.	Scavenger	4.44
Coleoptera	Anthicidae	*Anthicus* spp.	Predator	5.89
	Chrysomelidae	*Monocesta* spp.	Herbivore	1.11
	Coccinellidae	*Coccinella* spp.	Predator	5.89
		Curinus spp.	Predator	6.81
	Dytiscidae	*Laccophilus* spp.	Predator	2.35
	Melolonthidae	*Amphimallon* spp.	Scavenger	3.60
Diptera	Anthoyliidae	*Delia* spp.		1.37
	Calliphoridae	*Calliphora* spp.	Scavenger	0.98
	Culicidae	*Aedes* spp.	Disease vector	7.21
		Culex spp.	Disease vector	3.79
	Dolichopodidae	*Sciapus* spp.	Predator	9.32
	Muscidae	*Musca* spp.	Scavenger	9.65
		Stomoxys spp.	Disease vector	0.91
	Sarcophagidae	*Sarcophaga* spp.	Scavenger	9.51
	Tabanidae	*Tabanus* spp.	Disease vector	6.35
Hemiptera	Cicadelidae	*Orientus* spp.	Herbivore	8.66
	Coreidae	*Acanthocephala* spp.	Herbivore	2.16
	Dictyopharidae	*Dictyophara* spp.	Herbivore	4.24
	Largidae	*Macrocheraia*	Herbivore	6.22
	Psyllidae	*Acizzia* spp.	Herbivore	15.38
	Pyrrhocoridae	*Dysdercus* spp.	Herbivore	5.30
	Ricaniidae	*Ricania* spp.	Herbivore	1.04
Hymenoptera	Apidae	*Xylocopa* spp.	Pollinator	3.98
	Crabronidae	*Cerceris* spp.	Predator	4.11
	Formicidae	*Solenopsis* spp.	Predator	10.17
		Lasius spp.	Predator	8.99
		Camponotus spp.	Scavenger	9.05
	Ichneumonidae	*Enicospilus* spp.	Parasitoid	1.76
	Pompilidae Sphaecidae	*Pepsis* spp.	Predator	4.52
		Auplopus spp.	Predator	2.02
		Sceliphron spp.	Predator	0.98
	Formicidae	*Polyrhacis* spp.	Predator	2.02
	Vespidae	*Vespa* spp.	Predator	2.29
Lepidoptera	Nymphalidae	*Acraea* spp.	Pollinator	0.98
	Pyralidae	*Plodia* spp.	Herbivore	3.98
Mantodea	Hymenopodidae	*Odontomantis* spp.	Predator	3.33
Odonata	Coenagrionidae	*Ischnura* spp.	Predator	3.27
	Libellulidae	*Diplacodes* spp.	Predator	4.19
Orthoptera	Acrididae	*Camnula* spp.	Herbivore	4.38
		Acrida spp.	Herbivore	3.72

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spp., and *Tabanus* spp. (Table 6). These insects are notorious for their role in transmitting various diseases. *Aedes* spp. transmit diseases such as dengue, Zika, chikungunya, and yellow fever (WHO, 2020; CDC, 2022; Gubler, 2004); *Culex* spp. are vectors for West Nile virus, Japanese encephalitis, St. Louis encephalitis, and lymphatic filariasis (Weaver and Reisen, 2010; Kumar and Sharma, 2014); *Stomoxys* spp. (stable flies) mechanically transmit trypanosomiasis, anthrax, and equine infectious anemia (Mihok and Clausen, 1996; Lehane, 2005); and *Tabanus* spp. (horse flies) are known to spread anthrax, tularemia, equine infectious anemia, and Loiasis (African eye worm) (Baldacchino et al., 2014).

Conclusions

The mangrove plantation in Beras Basah Village demonstrated rich floristic diversity, encompassing eleven mangrove species: *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Avicennia marina*, *Sonneratia alba*, *Bruguiera gymnorhiza*, *Xylocarpus granatum*, *Excoecaria agallocha*, *Scyphiphora hydrophyllacea*, *Lumnitzera racemosa*, and *Nypa fruticans*. Surrounding areas supported five additional flowering plant species: *Antigonon leptopus*, *Asclepias curassavica*, *Helianthus annuus*, *Calliandra grandiflora*, and *Portulaca grandiflora*. A total of 1,525 individual insects, representing eight orders, 17 families, and 19 genera, were collected; ten species were classified as predators or pests, including five species from the Odonata order (*Neurothemis terminata*, *Orthetrum sabina*, *Orthetrum testaceum*, *Potamarcha congener*, *Zyxomma obtusum*) and five ant species (*Camponotus* spp., *Crematogaster* spp., *Nylanderia* spp., *Odontoponera denticulate*, and *Pheidole* spp.). Functional analysis of the insect community revealed various ecological roles within the mangrove ecosystem. Seven species were identified as scavengers, twelve as herbivores, two as pollinators, sixteen as predators, one as a parasitoids, and four as disease vectors. Notably, four Diptera species (*Aedes* spp., *Culex* spp., *Stomoxys* spp., and *Tabanus* spp.) were identified as vectors of various diseases. A comprehensive understanding of insect dynamics in mangrove ecosystems necessitates long-term monitoring, habitat assessments, and detailed investigations of functional interactions, particularly involving key species such as stingless bees. With the escalating threats posed by climate change, future research should focus on its impacts on insect diversity, ecosystem functionality, and the critical roles stingless bees play in pollination and seed dispersal. These insights are crucial for developing targeted conservation strategies to safeguard and sustainably manage these vital ecosystems.

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