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ISoI 2023

5TH INTERNATIONAL SYMPOSIUM ON INSECTS

PROCEEDINGS BOOK

UNVEILING THE HIDDEN PROSPECT OF INSECTS

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5TH INTERNATIONAL SYMPOSIUM ON INSECTS (ISoI 2023)

11 -13 SEPTEMBER 2023
PULLMAN KUCHING, SARAWAK, MALAYSIA

PROCEEDINGS BOOK

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ENTOMA AT A GLANCE

The Entomological Society of Malaysia (ENTOMA) took its inaugural steps on the 22nd of August 1994, driven by a resolute purpose to kindle public awareness about the profound significance of insect studies. Concurrently, we envisioned fostering a global network of entomological researchers that transcends national borders.

ENTOMA's doors are wide open to all who share a passion for insect-related studies and research. Embracing a diverse spectrum, we extend our arms not only to students and researchers but also to hobbyists, policymakers, lawyers, and even those from non-scientific domains. This inclusive approach creates a dynamic platform where we connect, share ideas, present groundbreaking research and cultivate potential collaborations.

Throughout our journey, ENTOMA has orchestrated a symphony of enriching events from enlightening webinars and invigorating conferences to captivating talks, empowering lectures, and engaging quizzes. A pivotal milestone was co-hosting the 4th Asia Pacific Congress on Entomology in 2001, forging a collaborative bond with the Malaysia Plant Protection Society (MAPPS).

In 2012, ENTOMA embarked on a new expedition by orchestrating the debut International Symposium on Insects (ISoI 2012). This pioneering endeavour unfolded from the 3rd to 5th of December at the Mines Wellness Hotel, Kuala Lumpur. This achievement paved the way for subsequent symposia, with the second held at Bayview Hotel, Melaka from 1st to 3rd December 2014, followed by Bayview Hotel, Langkawi from 19th to 21st March 2018.

In response to the extraordinary global situation triggered by the early 2020 onset of the COVID-19 pandemic, ENTOMA embraced innovation. The Society took a bold step by organizing its first-ever virtual conference the 4th International Symposium on Insects (ISoI 2020), themed 'Entomology Beyond 2020'. We were resolute in providing a dynamic platform for entomologists to share their findings and experiences, transcending geographical constraints.

This year, we embark on a fresh chapter as we transport ISoI to the captivating landscapes of Kuching, Sarawak a first for ENTOMA. We're thrilled to host you in this entomologically rich state of Borneo. As we advance into the future, ENTOMA remains steadfast in its commitment to shaping the world of entomology. Together, let's unfold a new chapter of discovery and collaboration.

5TH INTERNATIONAL SYMPOSIUM ON INSECTS (ISoI 2023)

The 5th International Symposium on Insects (ISoI2023) is a renowned event held on September 11th –13th, 2023 at Pullman Kuching, Sarawak, Malaysia. ISoI2023 provides a platform for delegates to interact and highlight knowledge and achievement in worldwide insect studies. Entomology is crucial to understanding human disease, agriculture, evolution, ecology and biodiversity. Insects are the basis for developments in biological and chemical pest control, biological diversity and various other fields of science.

This fifth edition of ISoI is organized by the Entomological Society of Malaysia (ENTOMA). As the social umbrella for local entomologists. ISoI2023 is also co-organized by the Centre for Insect Systematics (CIS), Universiti Kebangsaan Malaysia (UKM), Universiti Teknologi MARA (UiTM) Cawangan Sarawak, and Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS). ISoI2023 is also sponsored by the Business Events Sarawak (BESarawak), Corteva Agriscience, and FMC Corporation.

ISoI2023 is intended to cover 12 scopes of insect studies such as agricultural entomology, behavioural and chemical ecology, biodiversity and conservation, entotourism, entomophagy, and education, insect physiology and biochemistry, insect systematics and evolution, integrated pest management, invasive alien species, forensic, medical, and urban entomology, molecular entomology and biotechnology, pesticide resistance and toxicology, acarology and other topics related to insects. This symposium anticipates more than 150 participants among academics, research scientists, policymakers, and officials from public and private sectors, with thought-provoking keynote lectures and presentations (oral and poster) in the field of Entomology.

Objectives
1. To provide a medium of knowledge exchange for entomologists.
2. To explore the benefits of insects towards humankind and the environment.
3. To foster global networking among entomologists.

ISoI2023 will highlight the theme:
'Unveiling the Hidden Prospect of Insects'

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CONTENTS

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PROCEEDINGS PAPERS

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INSECT DIVERSITY ASSESSMENT IN MARDI ORGANIC TOMATO PLOT, CAMERON HIGHLANDS

Nurin Izzati Mohd Zulkifli[1], Ainnur Arina bt Roslan[1], Hidayah bt Yahya[1] & Nor Ayshah Alia Ali Hassan[2]

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ABSTRACT

The study aimed to assess the abundance and diversity of insects in an organic tomato plot at MARDI Cameron Highland, in the presence of companion crops such as flower strips, onions, and leeks. A total of nine yellow sticky traps (YST) were strategically placed near the flower strips and another nine traps near the onions to collect insect samples. Throughout the season, 2,260 insects were collected. The data were analysed using descriptive statistics, and mean comparisons were conducted using t-tests. The dominant insect order observed was Diptera, constituting 80.35% of the total catch, while Thysanoptera accounted for the lowest percentage at 1.28%. Both the areas covered with flower strips and onions exhibited similar results in terms of diversity index calculation. The Shannon-Weiner diversity index (H'), Simpson Diversity Index (D), and Margalef's Diversity Index (d) for insects in flower strips were 2.86, 0.89, and 16.01, respectively. In comparison, the corresponding values for insects in the onion and leeks plot were 2.87, 0.89, and 18.56. Moreover, the study revealed a high number of beneficial insects, with 363 recorded in the plot as compared to pest of tomato (n=358). Overall, these findings indicate that the presence of flower strips and onions alongside tomatoes in the organic plot positively impacts insect diversity, with both areas showing comparable results. Furthermore, the observed abundance of beneficial insects underscores the potential of companion cropping strategies for promoting natural pest control in agricultural settings.

Keywords: companion crop, beneficial insects, pest, tomato

INTRODUCTION

Solanum lycopersicum, usually referred to as tomato, is a widely popular plant that enjoys significant popularity in both domestic and international markets. Nevertheless, a wide range of arthropod pests have the tendency to infest tomato plants, encompassing both arthropod-vectored diseases and pests. The sustainable management of arthropod pests in tomato cultivation holds significant importance, particularly within the realm of organic farming. This is primarily attributed to the utilisation of biopesticides and other alternative approaches to control of pests. Companion cropping, a sustainable agricultural practice, involves planting two or more different plant species in close proximity, fostering a mutually beneficial relationship that enhances overall crop productivity and ecological balance. Companion cropping, also known as "trap crops" and "intercrops," employs a "push-pull strategy"[1] to utilize the interactions between different crops and their impact on pests, pathogens, and the environment. In this strategy, specific companion plants are strategically planted alongside the main crop to influence pest behaviour and reduce pest infestations. The practice of companion cropping is not new; it has been employed by traditional farmers for centuries in various cultures worldwide [2]. Today, with the growing interest in organic and regenerative agriculture, companion cropping has experienced a revival as an essential component of agroecological farming systems [3,4]. Thus, one of the ultimate goals of research conducted in MARDI Cameron Highland is to identify the most suitable companion crop to be planted alongside tomatoes in efforts to develop a holistic and sustainable organic farm. In this paper we focused on insect assessment, as data collection for the first season has been completed. A more comprehensive conclusion will be drawn after the second season's sampling is finished. The study aims to provide insights into the community-level insect population in the tomato plot with the addition of flower strips and onions as companion crops. The data collected will serve as a baseline for the organic tomato plot at MARDI Cameron Highland, contributing to the establishment of an environmentally friendly and balanced farming system.

MATERIALS AND METHODS

The research was carried out at MARDI Organic Farm located in Cameron Highland, Pahang. A total of nine yellow sticky traps (YST) were strategically placed near the flower strips and another nine traps near the onions to collect insect samples. All YST traps were exposed for 24h. At the time of collection, the traps were covered with a transparent plastic sheet and brought back to the lab for identification purposes. Sampling was conducted three times and for each sampling date, the traps used in combination were counted as sampling replicates. The data were analyzed using descriptive statistics, and mean comparisons were conducted using t-tests using Minitab Version 18. Insect diversity and richness are determined by the Shannon Weiner Index (H') and Simpson Diversity Index (D), Margalef Index (D) and Species Richness (S), referring to the total number of species containing in one area.

RESULTS AND DISCUSSION

The total of insects collected during were 2260 in 41 families and 5 orders (Figure 1). Results shows no significant different between insects collected near the flower strips and onion and leeks (SE=35.43, p=0.83, p>0.05). The dominant orders were Diptera (n= 1,816) followed by Hymenoptera (n=310), Coleoptera (n=53), Hemiptera (n=52) and Thysanoptera(n=29). The results indicate that species richness (S), as well as the Margalef Index (d), are higher in the vicinity of the onion and leeks compared to the tomato plants near the flower strips. The number of species observed was 58 near the onion and leeks, while it was 50 near the flower strips. The Margalef Index, which takes into account both the number of species and the abundance of each species, showed a higher value of 18.56 near the onion and leeks compared to 16.01 near the flower strips. Simpson Index and Shannon-Weiner Index, the values were almost the same for both areas. The Simpson Index was approximately 2.86, and the Shannon-Weiner Index was approximately 0.89 near the flower strips. Similarly, the values were nearly identical near the onion and leeks, with a Simpson Index of around 2.87 and a Shannon-Weiner Index of around 0.89 (Table 1). These indices measure species diversity and evenness in the community. The similar values between the two areas indicate that the diversity and distribution of species are relatively consistent near the flower strips and the onion and leeks rows. Indeed, the limited number of samplings may not provide a comprehensive representation of the true population dynamics of arthropods in the plot. Additionally, heavy outliers in the number of individuals from Mycetophilidae (fungus gnats), Cecidomyiidae (gall midge), and Psychodidae (drain flies) could also influence the results and should be considered as potential contributing factors to the overall arthropod population dynamics in the plot. Mycetophilidae, Cecidomyidae and Psychodidae were consistently high during the sampling time. Larvae of these families basically live and feed on the algae, fungi and bacteria which is obviously plenty in the plot. Their impact to the crop itself, remain understudied. Nevertheless, pollination by fungus gnats is known to occur in eight angiosperm families: Orchidaceae, Liliaceae, Asparagaceae, Araceae, Aristolochiaceae, Polygonaceae, Apocynaceae and Saxifragaceae [5,6,7].

Insect pest, from Agromyzidae family such as *Melanogaster*, *Ophiomyia* and *Liriomyza* sp was also recorded present in both sites. This species is properly known as leaf miners. Their larvae are exclusively internal plant feeders. Infestation of leaf miner on tomato have been described worldwide, which can reduce the value of crop up to 20% [8,9]. One successful mating is enough to fertilize all the eggs, and the females will start ovulation within one to two days of emergence [10]. Study done by Bandara et al. [11] to mitigate the infestation of bean fly revealed that the mixed cropping of beans with leek resulted in a significant reduction in the settling, emergence, and mortality of adult bean fly, as well as the death of bean plants, when compared to a monoculture approach.

Present of beneficial insect (n=363) such as Braconidae, Coccinellidae, Apidae, Encyrtidae and Eulophidae in the plot was recorded slightly high compared to the pest(n=358). The presence of those that can act as biological control agents, highlights the positive impact of companion flower strips and onions alongside tomatoes in the organic plot. These beneficial insects can help naturally manage pest populations, potentially reducing the reliance on chemical pesticides. This finding aligns with previous studies conducted by Fiedler et al. [12] and Landis et al. [13], where they manipulated the landscape of orchards by incorporating flowering plants. This conservation biological control strategy was aimed at enhancing the population of natural enemies and beneficial insects. Companion flower strips and onions in the organic tomato plot may serve as attractive habitats for beneficial insects by providing essential resources such as nectar, pollen, and alternative prey. By offering these resources, the companion plants support and enhance the efficacy of natural enemies, facilitating a more robust and self-sustaining ecological balance.

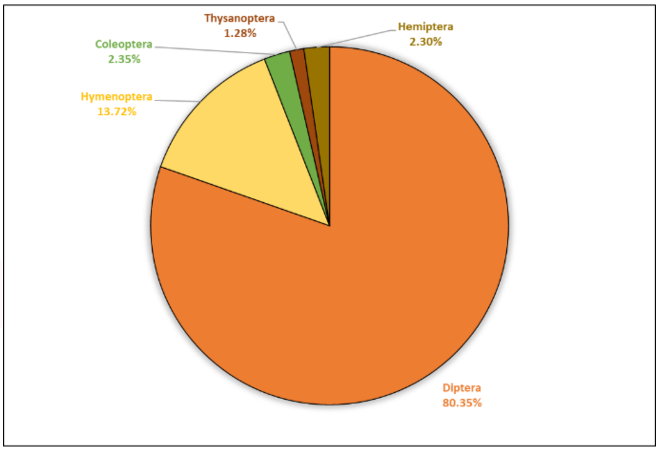

Figure 1. Percentage of insects collected according to Order

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Table 1. Comparison on Species collected (S), Shannon-Weiner Index (H'), Effective Number of Species (ENS), Simpson Index (D) and Margalef Index(d) and Evenness(E') of insects obtained in both plots.

Diversity Indices	Flower Strips	Onion and leeks
Species collected (S)	50	58
Shannon Weiner Diversity Index(H')	2.86	2.87
Effective Number of Species (ENS)	17	17
Margalef Index (d)	16.01	18.56
Simpson's Diversity Index(D)	0.89	0.89
Evenness Index(E')	0.73	0.71

CONCLUSIONS

In conclusion, the use of flowering companion crops in the tomato plot positively impacts insect diversity and encourages the presence of valuable natural enemies and beneficial insects. The findings support the notion that companion cropping, particularly with flower strips and onions, can play a vital role in conservation biological control strategies, ultimately contributing to the reduction of chemical pesticide use and the promotion of ecological harmony in agricultural landscapes. Future study may include the impact of insect diversity on pollination rates and fruit set in tomatoes can reveal the role of beneficial insects in enhancing crop productivity. Examining the influence of insect diversity, including the presence of beneficial insects, on pest control and overall tomato crop health will provide valuable insights for sustainable pest management strategies.

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TERMITE COMPOSITION AND ACTIVITIES IN ALTERED LANDSCAPE: A CASE STUDY FROM UNIVERSITI MALAYSIA SABAH, KOTA KINABALU, SABAH

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ABSTRACT

Human activities and land-use changes can significantly impact termite populations and their ecological roles in ecosystems. This study focuses on termite composition and activities in an altered landscape, using Universiti Malaysia Sabah (UMS) as a case study site. Two belt transects 100 x 2m were used for termite sampling at UMS hill forest while the infestation pattern of termites was examined using direct observation method. Overall, a total of 15 species from 11 genera were recorded. Wood feeders and wood nesters dominated the species assemblages in the area. A total of 37 tree species were infested by termites, with *Acacia mangium* being the most frequently attacked. *Macrotermes gilvus* emerged as the predominant termite species within the UMS campus. Across all three sampled sites, the infestation rates exceeded 70%. Consequently, it is evident that continuous monitoring of termite activities within the UMS campus is essential for effective termite management. This comprehensive assessment of termite infestations underscores the significance of ongoing vigilance to maintain a healthy balance between urban development and preserving the integrity of the ecosystem.

Keywords: termite, diversity, insect pest, Sabah.

INTRODUCTION

Termites are important members of the soil macrofauna in the humid tropics. The dominance of termites in tropical ecosystems is mainly related to their ability to utilize dead plant material rich in cellulose (the most abundant organic matter on Earth) [1]. They play an important role in ecological processes such as decomposing organic matter, improving soil structure, redistributing mineral and organic matter, and promoting the formation of organo-mineral complexes [2, 3]. Termite assemblages are also known as sensitive indicators of anthropogenic habitat disturbance. Human activities and land-use changes have a profound impact on terrestrial ecosystems, including the often-overlooked but ecologically significant termite populations. They show characteristic changes in species richness and functional group composition along disturbance gradients, including those imposed by logging and the conversion of natural forest ecosystems to plantations or subsistence crop fields [4, 5, 2].

This study aimed to uncover the current state of termite populations in the altered landscape and assess their potential implications for ecosystem functioning and management strategies through comprehensive surveys and investigations. The results were subsequently compared with other altered landscapes, including oil palm plantations and disturbed forests. These findings will enhance our understanding of termite responses to landscape alterations and provide valuable insights to guide conservation and management efforts within the UMS campus and similar urbanized areas.

MATERIALS AND METHODS

Termite composition within the UMS Hill Forest (06º 02’ 15.59” N; 116º 06’ 55.26” E) was assessed using two standardized 100 m x 2 m belt transects positioned along designated trails, following the sampling protocol described by Jones and Eggleton [7]. Successive 5 m sections of the transects were sampled by two people for 30 minutes per section. All microhabitats known to harbor termite species were explored. These include carton runways on tree trunks and above-ground vegetation, dead wood in all stages of decay, root mats, tree root systems and buttresses, surface soil, subterranean and epigeal nests, nests inside the wood and arboreal nests up to 2 m above ground level.

The study of termite infestation patterns was conducted through direct observation at three sites: the UMS Hill Forest, along all main roads, and within all faculties at UMS. A total of 300 trees were randomly sampled. The observation was based on the presence of mud tunnels, epigeal mounds and arboreal nests. The tree species with the presence of termite sign was identified and recorded.

All termite samples were preserved in 90% alcohol and subsequently identified to species or assigned to morphospecies by referring to Thapa [8]. The feeding and nesting groups were allocated according to Eggleton *et al.* [4] and Jones and Brendell [6].

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RESULTS AND DISCUSSION

Termite Composition

A total of 15 species of termites, belonging to 11 genera from three families (Kalotermitidae, Rhinotermitidae and Termitidae), were recorded within UMS (Table 1). This represents 14.56% of the total termite species recorded in Sabah. Termitidae (10 species) was the dominant family, with the subfamily Termitinae comprising seven species followed by two species for Nasutitermitinae and single species for Macrotermitinae. The subfamilies Termitinae, Macrotermitinae and Nasutitermitinae are common in most tropical forests and disturbed habitats. However, the species compositions within the subfamilies depend very much on the habitat conditions. This variation in species composition is a common phenomenon in ecological studies, reflecting the adaptability of different termite species to their respective habitats.

The family Rhinotermitidae represented by four species, is the most important family of lower termites and is very common in the rainforest of the Oriental region. Some of the important genera commonly found in Malaysian forests, recorded in this study, *Coptotermes* and *Schedorhinotermes*. Rhinotermitidae is also known to be abundant in areas where there are plenty of damp logs. However, only a few colonies were encountered within UMS as there were not many damp logs or the logs are too dry. *Coptotermes curvignathus* is well known as a plantation pest due to its habit of feeding on live trees. The family Kalotermitidae was represented by single species, *Cryptotermes* sp, commonly referred to as Dry Wood Termites, are typically recognized by their pale-yellow-brown coloring. Unlike some other termite species, Dry Wood Termites do not build mounds; instead, they establish their nests inside trees, stumps, or wood that may be buried underground. *Cryptotermes* species are often more prevalent in and exhibit a preference for drier climatic conditions.

Prohamitermes mirabilis and *Macrotermes gilvus* demonstrated the highest frequency of occurrence in this study. Both of these species are notably adaptable to disturbed environments, which may explain their prevalence. In addition to these common species, rare termite species, *Amitermes minor* and *Malaysiocapritermes prosetiger* were also recorded.

Table 1: Termite species recorded using single standardised transect: Feeding groups, l = litter feeders, epy = micro-epiphyte feeders, s/w = soil/wood interface feeders, w = woodfeeders, (f) = fungus growers. Nesting groups, a = arboreal, e = epigeal, h = hypogeal, w = in dead wood.

Family Species	Feeding Group	Nesting Group
Family: Kalotermitidae		
Cryptotermes sukauensis (Thapa)	w	w
Family: Rhinotermitidae		
Sub-family: Coptotermitinae		
Coptotermes curvignathus (Holmgren)	w	w
Sub-family: Rhinotermitinae		
Schedorhinotermes javanicus (Kemner)	w	w
Schedorhinotermes brevialatus (Haviland)	w	w
Schedorhinotermes sarawakensis (Holmgren)	w	w
Family: Termitidae		
Sub-family: Termitinae		
Prohamitermes mirabilis (Haviland)	s/w	h
Microcerotermes dubius (Haviland)	w	e
Microcerotermes serrula (Desneux)	w	w
Dicuspiditermes santschii (Silvestri)	s	e
Termes propinquus (Holmgren)	s/w	e/w
Malaysiocapritermes prosetiger (Ahmad)	s	h
Amitermes minor (Holmgren)	w	e
Sub-family: Macrotermitinae		
Macrotermes gilvus (Hagen)	w/l	e
Sub-family: Nasutitermitinae		
Nasutitermes havilandi (Desneux)	w	a
Nasutitermes matangensiformis (Holmgren)	w	a
Number of species = 15		

Functional and Nesting Groups

The termite feeding groups in this study were classified into four distinct categories. The largest group, dominated by wood feeders, included 10 species, collectively making up 67% of the total. The wood-feeding termites were common in the study area similar to any disturbed habitats. A clear dominance of wood-feeding species was seen at this site, relatively like any disturbed forest. Additionally, there were two species each of soil-feeders and soil-wood interface feeders, each contributing 13.3% to the composition. The fungus grower was represented by one species, accounting for 9% of the overall termite feeding groups observed in this study. Overall, a similar trend of wood-feeding termites dominating the assemblage in disturbed habitats is still evident in the present and previous studies.

Four distinct nesting groups were identified among the termite species studied. Wood nesters were the most prevalent, represented by six species, accounting for 40% of the total. Following closely were the epigeal nest-builders, comprising of five species, which constituted 33.3%. Notably, species from the Kalotermitids (dry wood termite) and Rhinotermitids (damp wood termite) families were primarily associated with wood nesting behaviors. In contrast, both hypogeal nesters and arboreal nesters each comprised 13.3%, with two species belonging to each category, forming essential components of the termite assemblages in the ecosystem. This classification offers insights into the diverse nesting strategies employed by these termite species within the studied habitat.

Termite Infestation and Presence Signs on Trees

A total of 259 trees exhibited signs of termite infestation, as evidenced by the presence of mud tunnels and epigeal mounds. Among the 43 recorded tree species, 37 were found to be infested by termites. Notably, *Acacia mangium* was the most heavily targeted species, with 33 trees (86.84%) affected, followed by *Tabebuia* sp. (100%), *Delonix regia* (81.48%), *Elaeocarpus pedunculatus* (91.30%), and *Peltophorum pterocarpum* (100%). *Cinnamomum iners* and *Samanea saman* both had 18 trees infested, with infestation rates of 85.71% and 90%, respectively. Additionally, *Andira inermis* (92.86%) and *Lagerstroemia speciosa* (100%) were also prominently affected.

Interestingly, six tree species remained entirely uninfested by termites: *Syzygium oleina*, *Rapanea* sp., *Livistona chinensis*, *Leucaena leucocephala*, *Ficus* sp., and *Casuarina equisetifolia*. This comprehensive assessment highlights the varying degrees of susceptibility among tree species to termite infestation within the studied area. These findings provide valuable insights into the preferences and infestation patterns of termites across various tree species in the studied ecosystem.

A total of nine termite species were observed infesting trees within the UMS area, with five of these species being potential pests. Among them, Macrotermes gilvus emerged as the most prevalent termite species, followed by Nasutitermes havilandi. Additionally, wood feeders like Microcerotermes dubius, while recorded with lower occurrence, are also recognized as potential pest species.

CONCLUSIONS

In general, termite species richness appeared relatively lower, with wood feeders dominating the overall assemblage. All three sampled sites within the UMS campus, including the hill-forested area, faculties and institutes, and along the main roads, exhibited termite infestation rates exceeding 70%. Among the identified species, Macrotermes gilvus emerged as a major species associated with trees within the campus, warranting focused management efforts. It is strongly recommended that continuous monitoring of termite species at UMS be prioritized to enhance termite management and proactively address potential escalation. Additionally, the six tree species untouched by termite infestations present intriguing avenues for further investigation. This integrated approach, combining targeted management of pest species and the exploration of natural resistance in specific tree species, offers the potential for a more comprehensive and effective termite management strategy.

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ABUNDANCE AND DIVERSITY OF AQUATIC INSECTS IN RELATION TO THE PHYSICO-CHEMICAL PARAMETERS IN SUNGAI PENG, JERTEH, TERENGGANU

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ABSTRACT

Aquatic insects are widely used for freshwater monitoring worldwide, but their inclusion in health and water quality assessment in Malaysia has been relatively limited. This study aimed to investigate the diversity, abundance, and correlation of aquatic insects with physico-chemical parameters in Sungai Peng, Jerteh, Terengganu, that may be affected by human activities. Two methods were used to collect aquatic insects: kicking bottom of aquatic D-net method and collection of substratum method. Six water physico-chemical parameters were recorded: water velocity, temperature, pH, Biological Oxygen Demand (BOD), Total Suspended Solid (TSS) and Dissolved Oxygen (DO). A total of 1215 individuals from 12 orders of aquatic insects were identified in the stream. The analysis of insect diversity using the Shannon Index (H') and Evenness Index (E) revealed that the river displays a moderate diversity, with an H' value of 1.83 and an unstable community with an E value of 0.74. The dominant order recorded was Hemiptera, followed by the sensitive EPT community, Trichoptera, Plecoptera, and Ephemeroptera. Based on the data obtained on BOD, pH and TSS, Sungai Peng was classified as Class I according to the National Water Quality Standard for Malaysia (NWQS). The analysis indicates that the insect abundance is positively correlated with temperature and TSS but negatively correlated with BOD, pH, and water velocity. These results provided the first insight of the diversity and abundance of aquatic insects, and their relation with the water quality in Sungai Peng for a better conservation approach of insects of Terengganu streams.

Keywords: Aquatic insects, water quality, bioindicators, conservation, Terengganu stream.

INTRODUCTION

Aquatic insects have a distinctive function within aquatic habitats with approximately 76,000 species, these arthropods have effectively adapted to a wide range of aquatic environments, from the permanent ponds to the large rivers. Despite being noticeable absent from the ocean, their existence is critical in a variety of habitats [1]. In addition to their vast numbers, they function as ecological fundamental aspect, affecting the dynamics of their habitats and acting as important indicators of environmental health. Their importance goes beyond just how many of them there are.

Aquatic insects, in particular, are extremely sensitive to changes in water quality [2]. These insects exhibit this occurrence in the instance of Sungai Peng, which is located in Jerteh, Terengganu. The water quality of this river is influenced by anthropogenic activity, notably recreational activities which introduce organic and inorganic waste into its flow. These may disrupt the river's physicochemical balance, in turn, affecting the diversity and abundance of its aquatic insects. The aquatic insects of Sungai Peng must adapt to these environmental changes, with their various levels of pollution tolerance explaining their dispersal throughout the river's ecosystems [3]. As a result, knowing the complex relationships between the aquatic insects and Sungai Peng's fluctuating water quality is critical.

This study aims to determine the diversity and abundance of aquatic insects in Sungai Peng, Jerteh, Terengganu, and understand their interaction with the river's physicochemical characteristics. It attempts to discover the ecological implications of human activities on water quality and their consequent influence on the river's aquatic inhabitants in a similar way. This research also assists in understanding the ecological behavior of aquatic insects in Terengganu, Malaysia, while providing valuable insights into the freshwater ecosystems of the region.

MATERIALS AND METHODS

Materials

Handheld Water Parameter Aqua-DP tools were used to measure the level of Dissolved Oxygen (DO) (mg/L), temperature (°C), and pH of the water. The amount of Total Suspended Solids (TSS) (mg/L) in water samples was assessed using a Multiparameter Portable Colorimeter (DR 900). Biochemical Oxygen Demand (BOD) (mg/L) in water samples was identified Ex-Situ. To determine water velocity, a ping pong ball and stopwatch were used. For aquatic insect sampling, an Aquatic D-net (sized at 45.72 cm X 22.86 cm with a mesh size of 900 μm) was used to collect specimens from Sg. Peng. These collected insects were carefully preserved in vials containing 70% alcohol and subsequently transported to the Entomology Laboratory within the Faculty of Bioresources and Food Industry for precise identification.

Methods

The research was conducted at Sungai Peng in Jerteh, Terengganu, Malaysia, near the coordinates 5°30'53"N 102°32'09"E. The river is impacted by anthropogenic activities including recreational area, residential land development, and palm oil plantation. Six sampling stations were established and data were collected from 1st March 2023 to 29th March 2023. Several instruments were used to gather physico-chemical data such as temperature, pH, Dissolved Oxygen (DO), Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and water velocity. Aquatic insects were sampled using an Aquatic D-net by using kicking bottom method and disturbance-removal sampling. Collected specimens were preserved in alcohol and identified in the Entomology Laboratory, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin. Statistical analyses included the Shannon-Wiener Index and Evenness Index to assess insect diversity and distribution consistency while one-way ANOVA and Pearson Correlation Analysis explored relationships between physico-chemical parameters and insect abundance. The water quality was also assessed against National Water Quality Standards (NWQS) to evaluate the water quality status by classifying the water quality into several water classes.

RESULTS AND DISCUSSION

Diversity of Aquatic Insects

The analysis of the recorded aquatic insect population revealed a total of 1,215 individuals from 12 different orders, with Hemiptera being the most abundant (39%), followed by Trichoptera (14%) and Plecoptera (14%). The lower abundance of Diptera suggested clean water conditions [4]. The calculated Shannon Diversity Index (H') of 1.83 indicated moderate diversity, while the Evenness Index (E) of 0.74 pointed to an unstable community, possibly due to environmental disturbances [5][6]. Hemiptera's dominance and its potential association with anthropogenic activities signify the importance of understanding and conserving Sungai Peng's ecosystem health and stability.

Abundance of Aquatic Insects

This study also found significant differences in aquatic insect abundance with Hemiptera most abundant and Lepidoptera the least which was determined as an intrusion. Hemiptera's dominance suggested pollution tolerance due to constant water flow [7]. Ephemeroptera, Plecoptera, and Trichoptera (EPT) presence indicates a cleaner upstream ecosystem making them potential bioindicators [8]. The initial week had the fewest insects, likely due to holiday-related human disturbances, aligning with past research on holiday impacts on insect abundance [9].

Water Quality Classification Based on Physico-Chemical Analysis

Throughout the five-week sampling period, water quality parameters consistently met Class I standards according to the National Water Quality Standard for Malaysia (NWQS). Total Suspended Solid (TSS) levels remained well below the 25 mg/L threshold, with values ranging from 0.834 to 1.335 mg/L. The pH levels consistently fell within the 6.5 to 8.5 range, ranging from 6.88 to 7.71. Biochemical Oxygen Demand (BOD) measurements were consistently below 1 mg/L, ranging from 0.0005 to 0.0028 mg/L. Water temperature fluctuated between 22.20°C and 23.85°C, all within Class I criteria. Department of Environment Malaysia suggests that Sungai Peng maintains a good water quality despite nearby anthropogenic activities. Water velocity fluctuated between rapid and slow flowing conditions during the study with the fifth week displaying the most rapid flow.

Correlation of Aquatic Insect Abundance and Water Quality

The Sungai Peng study showcasing significant correlations between environmental factors and aquatic insect abundance. Biochemical Oxygen Demand (BOD) had a negative correlation with insect abundance indicating that higher BOD negatively impacted the insect populations, attributed to increase in recreational activities that aligned with previous research showing that such activities can introduce pollutants into the water, leading to higher BOD levels and influencing the distribution and abundance of aquatic insects [10]. Total Suspended Solids (TSS) showed a positive correlation, suggesting that elevated TSS levels attracted more insects in this river because it ranges within Class 1 as well as it may predominantly consist of organic matter, which serves as a food source for the aquatic insects [11]. The relationship between pH levels and insect abundance was inconsistent, while water temperature exhibited fluctuating positive correlations. Water velocity had an inconsistent negative correlation with insect abundance, implying that other factors may also influence insect populations. The study emphasized Hemiptera's adaptability with neustonic adaptations for thriving on the water surface [12]. However, further investigations are needed to understand these complex relationships.

CONCLUSIONS

In conclusion, this study identified a diverse range of aquatic insects in Sungai Peng, Jerteh, Terengganu, encompassing 12 orders, with a total of 1223 individuals. The research highlighted the significance of Biochemical Oxygen Demand (BOD) in influencing insect abundance, while factors such as pH, Total Suspended Solid (TSS), temperature, and water velocity were found to be insignificant in this regard. To enhance future research, increasing the sample size is recommended to improve statistical power and detect more significant correlations or differences. Moreover, exploring additional relevant variables is crucial for gaining a more comprehensive understanding of the relationships under investigation and uncovering potential contributing factors to observed variations.

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DIVERSITY OF JACKFRUIT INSECT PESTS AND THEIR POTENTIAL PREDATORS IN ORGANIC ECOSYSTEM

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ABSTRACT

In Malaysia, jackfruit is commonly cultivated on a big scale or as a mixed commodity with other important commercial crops, but cultivation using organic management is still limited. Organic farming may improve agricultural biodiversity more than conventional farming, particularly in terms of predator species richness and abundance. The objectives of this study were to determine the occurrence of jackfruit pests and to identify potential predators of these pests at organic jackfruit farm. The diversity and abundance of insect pests and predator were surveyed in organic jackfruit farm in MARDI, Serdang, Selangor for 11 months from October 2022 (4-month-old plant) to June 2023 (11-month-old plant). All trees in the 1.3-acre research area were selected for sampling. A total of 1986 individuals of fourteen (14) species from ten (10) families of insect pests and natural enemies (predators) were recorded in organic jackfruit farm. The leaf hopper (Hemiptera: Cicadellidae), mealybugs (Hemiptera: Pseudococcidae), scale insects (Hemiptera: Diaspididae), moths (Lepidoptera: Crambidae and Erebidae) and ants (Hymenoptera: Formicidae) were the most abundant pests throughout the observation period. The survey found that spiders (Araneae), lacewings (Neuroptera: Chrysopidae), and mantids (Mantodea: Mantidae) were the most common predators of insect pests encountered in the studied area. The diversity and number of insect pests and predators were also determined in different growth stages of the jackfruit in organic management

Keywords: Jackfruit, pests, predators, organic.

INTRODUCTION

In Malaysia, jackfruit is commonly cultivated on a large scale or in combination with other significant commercial crops, but the use of organic farming practices is still limited. Pesticide use in conventional farming can have a substantial impact on agricultural ecosystems and insect populations [3]. Organic ecosystem is considered an environmentally sustainable agriculture method since it does not involve the use of synthetic pesticides or mineral chemical fertilizers [6]. It also may promote agricultural biodiversity, particularly in terms of predator species richness and abundance, as a tool for pest management [4]. Based on some literature, managing insect pest is the primary concern for organic farmers. Thus, determining the diversity of pest species and their natural enemies is vital as an initial effort in developing strategies for managing pests in organic ecosystems. The objectives of this study were to determine the occurrence of jackfruit pests and to identify potential predators of these pests during the vegetative stage of an organic jackfruit farm.

MATERIALS AND METHODS

Materials
Insect traps were used in this research. Insect sampling tool such as brush, forceps, and insect vial specimen bottles. Early vegetative stages of jackfruit tree aged four to 11 months old were used in the sampling process.

Methods
The diversity and abundance of insect pests and predators were surveyed in organic jackfruit farm in MARDI, Serdang, Selangor during vegetive stage for 8 months from October 2022 (4-month-old plant) to June 2023 (11-month-old plant). All of the plants in the 1.3-acre research area were selected for in-situ sampling at monthly intervals.

RESULTS AND DISCUSSION

Insect Pest Diversity
A total of 1986 individuals of fourteen (14) species from ten (10) families of insect pests and natural enemies (predators) were recorded in organic jackfruit farm. The findings of this study show that various orders and families of insects are abundant in organic jackfruit farm with the order Hemiptera dominating the number of insect pests. The leaf hopper (Hemiptera: Cicadellidae), mealybugs (Hemiptera: Pseudococcidae), scale insects (Hemiptera: Diaspididae), moths (Lepidoptera: Crambidae and Erebidae) and ants (Hymenoptera: Formicidae) were recorded the most common pests throughout the observation period (Figure 1 a-l). Figure 2 shows the mean population of most common insect pests in organic jackfruit farm in different cultivation phases. Pest population fluctuations in organic systems are possible due to pest management and the capacity of natural enemies.

From the list of identified insect pests, recommended common pest management practices for organic farms include plowing on sunny days to expose eggs to natural enemies and sun heat, as well as removing and burning all weeds that serve as alternate hosts for mealy bugs[2]. Application of crude garlic oil (1%) on tree trunk below the band to kill the bug and conserve natural enemies such as Coccinellids and spiders by avoiding broad-spectrum pesticide application during peak activity period **[5]** .

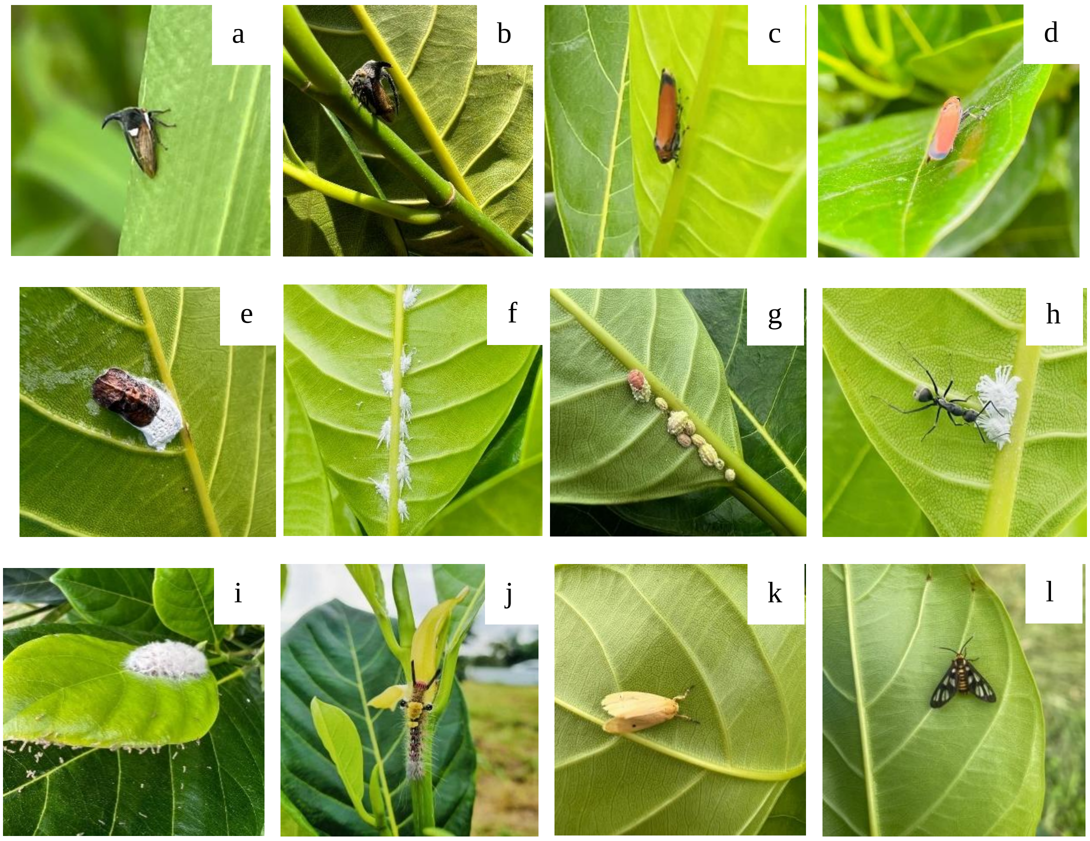

Figure 1: Insect diversity in the early vegetative stages of an organic jackfruit farm. (a-d) Hopper. (a&b) *Leptobelus* sp (Hemiptera:membracidae), (c&d) *Bothrogonia addita* (Hemiptera: Cicadellidae), (e) Scale insects (Hemiptera: Diaspididae); (f&g) Mealybugs (Hemiptera: Pseudococcidae); (h) *Camponotus* ant associated with mealybugs; (i-l) Moths. (i) moth egg mass; (j) Tussock moth, Orgyia spp. (Lepidoptera: Erebidae); (k) Crambids moth (Lepidoptera: Crambidae) and (l) Hubners wasp moth, *Amata hubneri* (Lepidoptera: Erebidae)

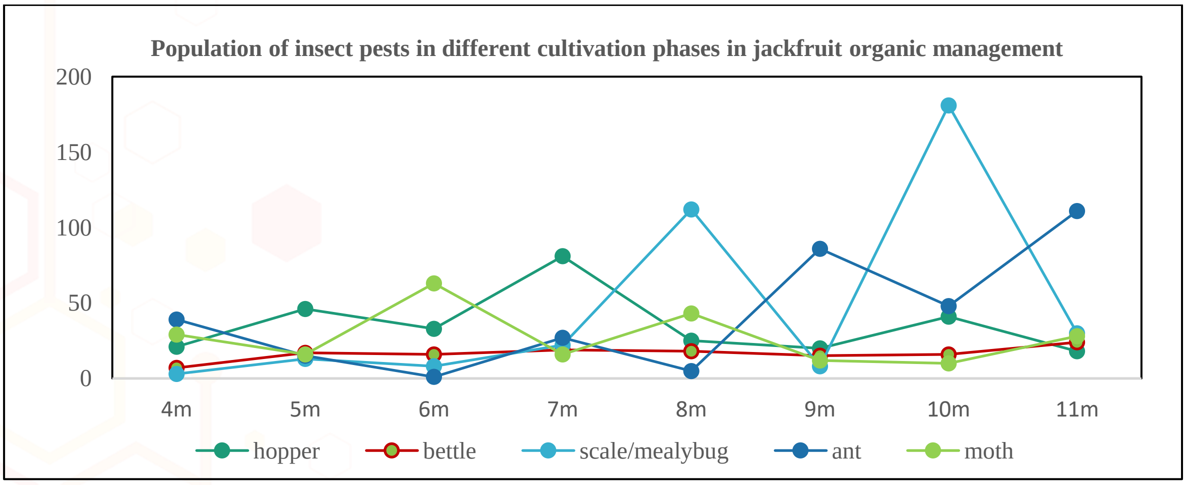

Figure 2: Population dynamic of insect pests recorded in different cultivation phases in organic jackfruit farm

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Predator Diversity
The survey found that the most dominant predatory insect found on organic jackfruit farming system were spiders (Araneae), lacewings (Neuroptera: Chrysopidae), long leg fly (Diptera: Dolichopodidae), weaver ants (Hymenoptera: Formicidae) and mantids (Mantodea: Mantidae) (Figure 3). The most common predator of insect pests encountered in the research area was *Condylostylus* sp. (long-leg fly), which had the highest abundance of predators from every month of observation and assessment. According to Cicero et al. [1] *Condylostylus* sp. (Diptera: Dolichopodidae) has been observed and proven preying on jackfruit pests such as dark-winged fungus gnats, leaf-miner flies, aphids, leafhoppers, thrips, whiteflies, psyllids and mites.

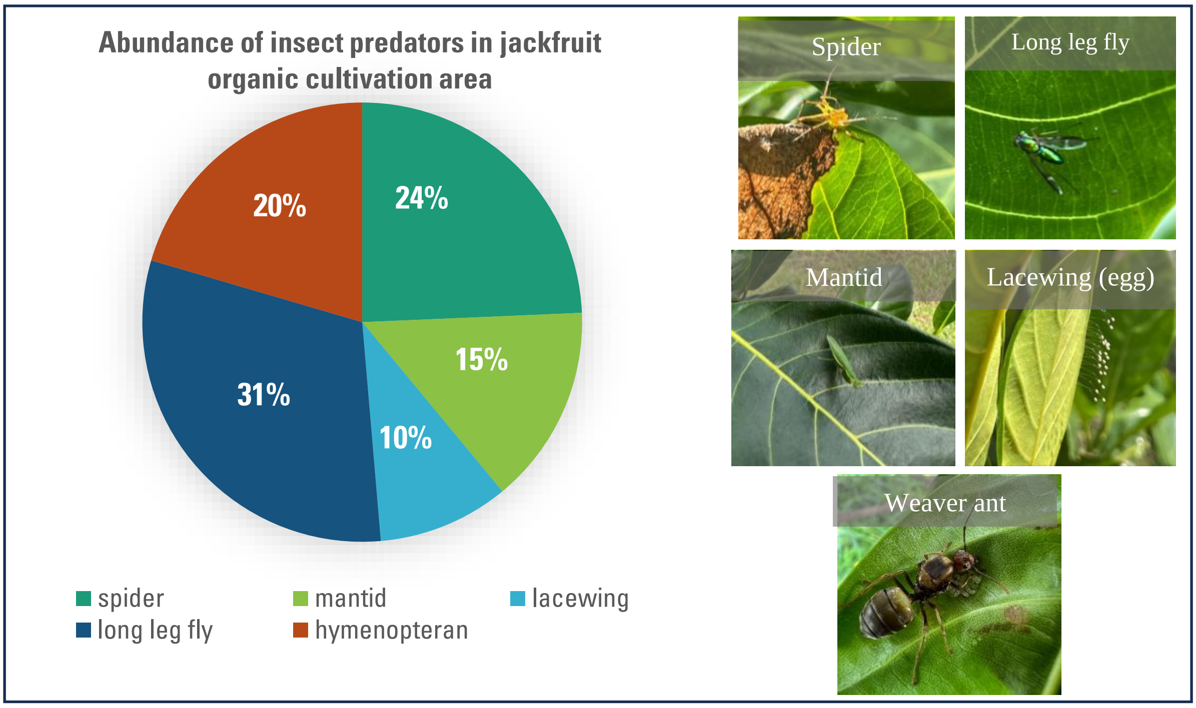

Figure 3: The abundance of the most common predators in jackfruit organic farm

CONCLUSIONS
The findings of this study provide basic and essential data for future pest management development in jackfruit cultivation, particularly in organic farming systems.

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HYMENOPTERAN PARASITOIDS FAMILY DIVERSITY IN ORGANIC DURIAN CULTIVATION

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ABSTRACT

Hymenopteran parasitoid wasps are a diverse group estimated to have over 350,000 species worldwide. Parasitoids provide an important role in biological control services on the farm. However, their diversity and abundance in the agricultural ecosystem were less explored. Organic agriculture ecosystems in Malaysia with zero chemical insecticide application were believed to promote natural enemies' conservation and positively influence their function in the environment. Initial data for parasitoid family richness and population in the early establishment of an organic durian farm, located at MARDI Serdang, Selangor, were assessed in this study. A total of 16 yellow sticky traps were placed randomly in the field for 24 hours. Data were collected biweekly for 7 weeks. From the observation, a total of 2042 individual parasitoids consisting of 16 families in 6 superfamilies were recorded. The parasitoid superfamily of Platygastroidea was the major parasitoids recorded followed by Chalcidoidea, Ceraphronoidea, Cynipoidea, Proctotrupoidea and Ichneumonoidea. Results show that *Telenomus sp.* (Hymenoptera: Scelionidae) was the dominant species in the area with a total of 681 individuals recorded. This species was found to parasitize on *Spodoptera sp.* eggs. These hymenopteran parasitoids provide natural regulation of insect pest populations such as durian psyllids, scales, and lepidopteran pests in the field. The Shanon diversity index of the hymenopteran parasitoid is 1.54. These data provide an early estimation of parasitoid population initial data for parasitoid family richness and population in the early establishment of an organic durian farm, located at MARDI Serdang, Selangor. Data obtained can be used to evaluate the effects of landscape modification aimed at conserving and enhancing the natural enemy population in the organic durian farm.

Keywords: Natural enemies, organic farming, parasitoids.

INTRODUCTION

Organic farming systems encourage sustainable agriculture, ecologically friendly and enhanced ecosystem services in the farm [1]. Organic durian farming is a new emerging industry due to the increasing demand for safer and high-quality durian. The biggest challenge in organic durian farming is pests and disease management. The organic farming system focuses on preventive strategies for pests and diseases by practicing cultural, physical, mechanical, and biological control. Early stage of durian (vegetative stage) attack by several pests including durian psyllid, scale insect, mealybug, lepidopteran pest, plant-eating beetles and grasshopper. It is crucial to monitor these pest populations to avoid an outbreak. These pests can be naturally regulated by their biological control agent such as parasitoids and predators that are available in the field.

Hymenopteran parasitoid wasps are a diverse group estimated to have over 350,000 species worldwide [2]. Parasitoids play a major role as natural enemies in agro ecosystems. Parasitoids are the most widely used for classical biological control programmes worldwide [3]. In Malaysia, there were three major parasitoids namely *Diadegma semiclausum*, *Cotesia vestalis* and *Diadromus collaris* proved to provide effective management against diamondback moth, *Plutella xylostella* L. pest of crucifers in Cameron highland [4]. Parasitoid diversity and abundance in the agricultural ecosystem were influenced by many factors including temperature, humidity, rainfall, host intensity [5], crop management and farming system [6]. Recent studies showed that the planting of perennial flowers as companion plants positively enhanced natural enemies' abundance in the field [4]. Therefore, this study aimed to estimate the parasitoid population by collecting initial data for parasitoid family diversity, richness and density in the early establishment of an organic durian research plot, located at MARDI Serdang, Selangor.

MATERIALS AND METHODS

Study site
The study was conducted at 1 ha organic durian research plot located at Integrated Organic Farm MARDI, Serdang, Selangor.

Parasitoid survey
A total of 16 yellow sticky traps (YST) were placed randomly in the field for 24 hours. Data was collected biweekly from 3 November 2021 until 27 January 2022. Each trap was put inside a transparent zip-lock plastic bag and brought back to the laboratory for observation. All YST were observed under a stereoscopy microscope (Leica-M80), and the number of

parasitoids trapped on the YST was recorded. Parasitoids observed were identified as superfamilies and families based on their morphological and physical characteristics. The Hymenoptera of The World handbook was used for identification.*Analysis of data*

The percentage of each hymenopteran family was calculated to measure their abundance throughout 7 weeks of observation. The Shannon-Weiner Diversity Index and Margalef's Richness Index were used to analyze the diversity, richness, and evenness of the parasitoids.

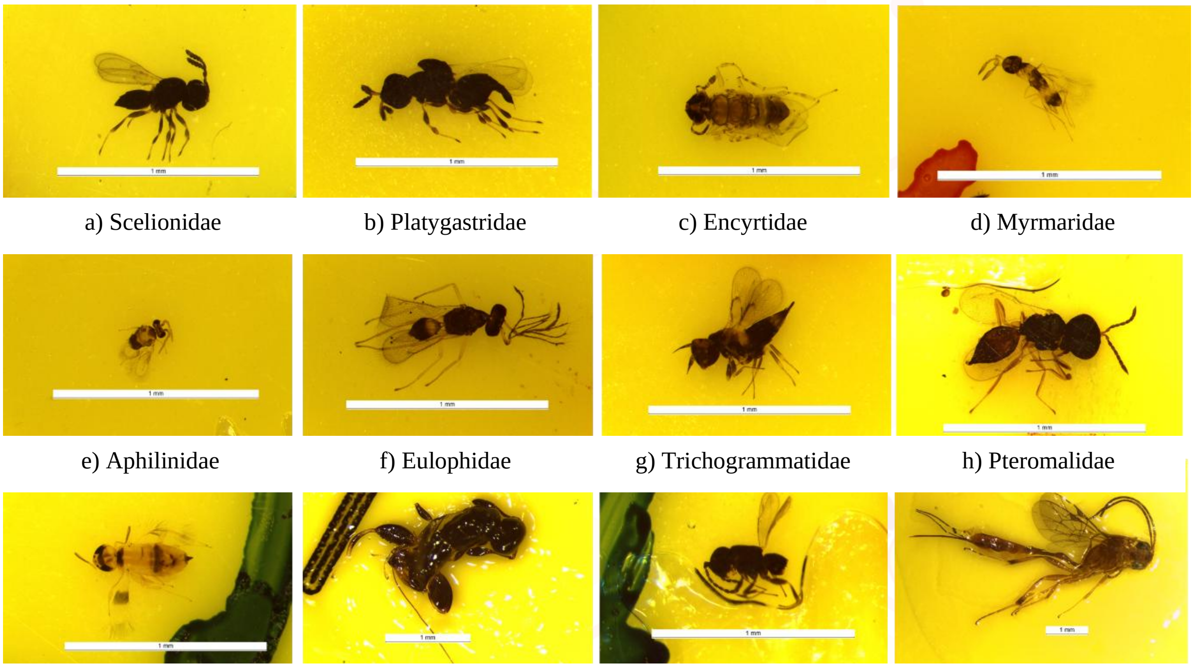
RESULTS AND DISCUSSION

Parasitoid survey

From the observation, a total of 2042 individual parasitoids consisting of 16 families in 6 superfamilies were recorded. The parasitoid superfamily of Platygastroidea was the major parasitoids recorded followed by Chalcidoidea, Ceraphronoidea, Cynipoidea, Proctotrupoidea and Ichneumonoidea (Table 1, Figure 1). These hymenopteran parasitoids reported to provide natural regulation of insect pest populations such as durian psyllids, scales, and lepidopteran pests in the field. Results showed that *Telenomus sp.* (Hymenoptera: Scelionidae) was the dominant species in the area with a total of 681 individuals recorded. This species was found to parasitize on *Spodoptera sp.* eggs (Figure 2).

Table 1: Total composition of insect abundance in different hymenopteran superfamilies and families on an organic durian farm

Superfamily	Family	Total insect specimen	Percentage
Platygastroidea (1080)	Platygastridae, Scelionidae	1080	52.89
Chalcidoidea (499)	Encyrtidae	251	12.29
	Myrmaridae	68	3.33
	Aphilinidae	68	3.33
	Eulophidae	53	2.60
	Trichogrammatidae	35	1.71
	Pteromalidae	11	0.54
	Signiphoridae	12	0.59
	Chalcididae	1	0.05
Ceraphronoidea (383)	Ceraphronidae	382	18.71
	Megaspilidae	1	0.05
Cynipoidea (35)	Figitidae	35	1.70
Proctotrupoidea (26)	Diapriidae	26	1.27
Ichneumonoidea (19)	Ichneumonidae	11	0.54
	Brachonidae	8	0.39
	Total insects	**2040**	



a) Scelionidae b) Platygastridae c) Encyrtidae d) Myrmaridae

e) Aphilinidae f) Eulophidae g) Trichogrammatidae h) Pteromalidae

i) Signiphoridae j) Chalcididae k) Ceraphronidae l) Ichneumonidae

Figure 1: Diversity of parasitoid families observed on yellow sticky traps.

Diversity index

The result shows that Shannon-Weiner Diversity index, Evenness index and Margalef's richness Index during the vegetative stage of organic durian at MARDI Serdang as follow:

Diversity (H') = 1.54
Evenness (E') = 0.569
Richness (R') = 15

Hymenopteran parasitoid diversity was reported to be greatly influenced by several factors including their microclimate condition particularly air humidity and landscape structure [7]. Therefore, correlations between natural enemies' diversity with several factors including temperature, humidity and rainfall should be considered to observe the changes in the abundance and diversity of natural enemies over time.

Figure 2. *Telenomus sp.* parasitized on *Spodoptera sp.* eggs

CONCLUSIONS

This study provides basic information on the abundance and diversity of parasitoids during the vegetative stage and as early data before the landscape modification in the organic durian plot at MARDI Serdang. Additionally, this data can be used to compare natural enemies' abundance and diversity in conventional durian farming systems.

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INFESTATION RATE OF FRUIT FLY ON MELON MANIS TERENGGANU (*Cucumis melo var. inodorus*) AT DIFFERENT FRUIT MATURITY

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ABSTRACT

Recently, Melon Manis Terengganu (MMT) or scientifically known as *Cucumis melo* var. *inodorus* has become a popular variety of rockmelon among entrepreneurs and local farmers particularly in Terengganu, Malaysia due to its high-profit potential. However, fruit fly infestations have posed a significant challenge, leading to reduced melon yields. Thus, this research aimed to identify the species of fruit flies infesting MMT fruits and determine their infestation rates. The study involved collecting 10 infested MMT fruits over three consecutive weeks prior to harvest at different fruit maturity stages, namely unripe, ripe, and fully-ripe stage. The fruit samples were brought to the laboratory and weighed individually before being placed in plastic containers for the rearing process. The fruits were reared until all larvae transformed into pupae and adult's emergence for identification of fruit fly species and its infestation rates. Results showed that a total of 406 adult fruit flies emerged from 30 infested MMT fruit samples collected. Three species of flies were identified namely *Zeugodacus cucurbitae*, and two species from the family Ephydridae (Species A and Species B). There was no significant difference ($P>0.05$) of the infestation rate among fruit maturity stages but relatively Species A recorded the highest infestation rate at 61 ± 53.87 pupae/kg compared to *Z. cucurbitae* (13.5 ± 5.07 pupae/kg) and Species B (6.82 ± 5.26 pupae/kg) during fully-ripe stage of fruits. The adult emergence, percentage of adult emergence, and male and female emergence also showed no significant difference ($P>0.05$) among the different fruit stages. This study provides valuable insights into fruit fly species attacking MMT and their infestation rates, potentially aiding farmers in better managing and controlling MMT pests.

Keywords: cucumis melo, fruit flies, infestation rate.

INTRODUCTION

Melon Manis Terengganu (MMT) is a melon that belongs to the Cucurbitaceae family and is widely cultivated for its sweet and aromatic flesh. However, MMT is vulnerable to a wide variety of insects from the early stages of crop production to harvesting. [1] reported that several insects have been observed attacking rockmelons, such as the red pumpkin beetle (RPB), aphids, and fruit flies. Particularly in the Indo-Malayan region, the melon fruit fly, *Zeugodacus cucurbitae*, is widely recognized as the most destructive pest for melons and related crops, causing a significant decrease in melon, cucumber, and tomato yields [9]. Over the past five years, the infestation of melon flies has become more severe, posing a further significant problem than before [10]. To address this issue, conducting thorough research on the fruit flies that prevalently attack MMT is crucial for effective pest management. As MMT is a relatively new variety of rockmelon, there is currently a lack of literature on fruit flies specific to this type. Hence, the purpose of this study was to identify the species of fruit flies infesting MMT and assess their infestation rates at various fruit ripening stages. It is hoped that the data collected from this study can contribute to improved pest management strategies for MMT in the future, aiding in better protection against fruit fly infestations.

MATERIALS AND METHODS

Sampling Area and Method

This study was conducted at Melon Manis Terengganu (MMT) farms located in Taman Agropreneur, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, Terengganu (5°75'62.3" N,102°62'42.5" E). The study area consists of two plots of MMT crops planted inside the greenhouses (100x60 ft), where each plot consisted of 11 rows of beds. Ten infested MMT fruits were randomly collected for three consecutive weeks representing MMT at three different ripening stages prior to harvest time. Collected infested MMT were brought to the laboratory for fruit rearing and fruit fly identification.

Fruit Flies Identification and Calculation

All adult fruit flies emerged from infested MMT were sorted and identified according to their species based on DORSALIS LUCID v3.3 software [5, 3]. The samples were examined under a stereoscopy microscope (Olympus SZ51, Japan) based on their external morphological characteristics. Fruit weight, total of pupae recovered, and the infestation rate were measured and analyzed by using MINITAB® 19 software version 2021.

RESULTS AND DISCUSSION

Overall, a total of 406 adult fruit flies emerged from infested MMT identified as *Zeugodacus cucurbitae*, Species A, and Species B (family of Ephydridae). However, Species A and Species B were recorded to emerge only from week three compared to *Z. cucurbitae* that emerged from all weeks of fruit sampled.

Table 1**:** Total of pupae, infestation rate, adult emergence, and adult sex ratio by species at different ripening MMT fruit stages.

Week	Fruit Weight (kg)	Species	Pupae Recovered	Infestation Rate (pupae/kg)	Adult emergence (%)	Adult sex ratio (%)	
						Male	Female
1	0.34 ± 0.04[a]	*Z. cucurbitae*	77.33 ± 16.84	28.24 ±18.58	76.37 ± 23.63	35.43 ± 4.46	40.14 ± 4.93
		A	0	0	0	0	0
		B	0	0	0	0	0
2	0.29 ± 0.03[a]	*Z. cucurbitae*	69.67 ± 17..96	24.47 ± 8.17	74.72 ± 25.65	30.94 ± 6.61	35.10 ± 5.57
		A	0	0	0	0	0
		B	0	0	0	0	0
3	0.51 ± 0.09[a]	*Z. cucurbitae*	27.00 ± 2.11	13.5 ± 5.07[a]	55.73 ± 25.64	14.35 ± 2.46	25.79 ± 4.47
		A	50.83 ± 12.82	61 ± 53.87[a]	20.63 ± 10.63	44.73 ± 4.48	49.45 ± 4.40
		B	7.67 ± 1.40	6.82 ± 5.26[a]	1.65 ± 0.52	9.63 ± 1.29	4.91 ± 0.73

Means with the same letters in different columns were not significantly different (P>0.05) by Tukey's (HSD) test

Table 1 showed that Species A recorded the highest infestation rate on week three at 61 ± 53.87 pupae/kg, accounting for 61.88 % of the total infestation rate, followed by *Z. cucurbitae* at 13.5 ± 5.07 pupae/kg (28.69%). Whilst the lowest infestation rate was recorded by Species B with 6.82 ± 5.26 pupae/kg (9.43%). However, from the analysis, there was no significant difference *(P>0.05*) in the infestation rate among different species. The absence of Ephydridae shore flies in week one and week two might be due to the less odour emitted by infested MMT or the different stages of fruit ripeing where the early stages are not attractive to the shore flies. Fully-ripe MMT from week 3 produces more pungent odour, according to [6], cantaloupe melons produce aroma volatiles that are mostly comprised of a complex mixture of esters, including sulfur-containing esters, as well as saturated and unsaturated aldehydes and alcohols. These chemicals may attract Ephydridae flies to infest the punctured MMT and become a secondary pest.

The Ephydridae infested MMT was considered a secondary pest because this family is intensely attracted to the sweet rotting fruit [7]. Ephydridae had been thought to be a biological material decomposer, with larvae of most species requiring a moist to wet environment to survive. They can be found inside live tissues of plants, decomposing organic materials, parasitoids or parasites of animals, or near water bodies [8]. Since the Ephydroidea superfamily includes the Drosophilidae and Ephydridae families, which are closely related [2], it can be assumed that Species A and B started to lay eggs in melon fruit after *Z. cucurbitae* has punctured it. Nonetheless, *Z. cucurbitae* recorded an infestation rate of nearly 30% and was considered relatively high in the field. This species not only harms the production and commercial viability of fruits and vegetables but also poses a serious threat to quarantine security, resulting in barriers to international trade in fruits and fresh vegetables around the world [4]. The other parameters, particularly, percent of adult emergence, and male and female emergence showed no significant difference (*P>0.05*) among the different species. But it has to be noted that the percentage of adult sex ratio was the highest in female Species A (49.45 ± 4.40%) compared to both male and female sex adult ratios for each species in different MMT ripening stages.

CONCLUSIONS

In conclusion, one species of fruit flies emerged from the infested Melon Manis Terengganu (MMT) namely *Zeugodacus cucurbitae*, and two species shore flies from the family Ephydridae (Species A and Species B). The major species infesting MMT was *Z. cucurbitae* which was observed to invade in three consecutive weeks and contribute 30% of the infestation rate in the third week. However, the highest infestation rate among the three species of flies was from Species A (62%). Both Species A and Species B were considered secondary pests that infest MMT after being punctured by *Z. cucurbitae*. This study provides valuable insights into fruit fly species attacking MMT and their infestation rates, potentially aiding farmers in better managing and controlling MMT pests.

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ASSESSING A LABORATORY TEST ON FOOD PREFERENCES OF THE MELON FRUIT FLY, *Zeugodacus cucurbitae* (DIPTERA: TEPHRITIDAE)

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ABSTRACT

Controlling the Melon fruit fly, *Zeugodacus cucurbitae,* can be achieved by employing food bait trapping techniques to reduce reliance on insecticides. However, the success of this method depends on several factors, including the specific type of foods and other population-affecting factors. As a result, performing preliminary studies becomes crucial in order to observe the behaviour and tendencies of the melon fruit fly towards the host foods. Therefore, this study was conducted to assess the food preferences of melon fruit flies in the laboratory before using food in baited traps for field studies. The study employed a choice experiment, presenting four types of foods: Brewer's yeast, banana, cucumber, and Melon Manis Terengganu (MMT). Each experiment involved releasing a four-day-old female *Z. cucurbitae* fly into a rearing cage containing the four foods, and the fly's foraging behaviour was observed and recorded for a duration of two hours with five replications. The results indicated significant differences *($P<0.05$)* in the duration of food consumption by the flies when exposed to different host foods. Notably, the yeast recorded the longest duration with 19.29 ± 3.73 minutes, followed by banana (11.85 ± 1.96 minutes), MMT (7.47 ± 1.13 minutes), and cucumber (4.73 ± 1.02 minutes). However, there were no significant differences *($P>0.05$)* observed in the number of fruit visits, duration of fruit visits, and number of consumptions across all the food hosts. These findings highlight the importance of using yeast as one of the food baits in the management of melon fruit flies. Its incorporation enhances pest control methods, contributing to a more efficient and environmentally friendly approach to managing this pest.

Keywords: Behaviour, food preferences, laboratory test, melon fruit fly

INTRODUCTION

The melon fly, *Zeugodacus cucurbitae* (formerly known as *Bactrocera cucurbitae*), is a species of fruit fly belonging to the family Tephritidae. It is native to certain regions in Asia and is considered a significant agricultural pest, particularly for plants in the Cucurbitaceae family [1]. The level of losses due to *Z. cucurbitae* varies between 30 to 100% depending on the climatic circumstances and vulnerability of the crop variety [2]. Without a doubt, pesticides have been utilized to control the population of melon fruit fly. While pesticides offer benefits in terms of crop production, excessive usage can result in severe outcomes, including pollution of the environment, such as air, water, and soil, and pose substantial health risks to living beings [3]. Hence, there has been a transition in plant protection strategies from relying on chemicals to adopting integrated pest management (IPM) approaches such as food bait trap [4]. However, food bait trapping effectiveness varies depending on factors such as fruit fly diet, fruit fly species, and other factors influencing fruit fly population [5]. As a result, preliminary research is necessary in order to examine the melon fruit fly's behavior and tendencies for host foods. Therefore, this study was carried out in the laboratory to examine the food preferences of *Z. cucurbitae* before employing food in baited traps for field studies.

MATERIALS AND METHODS

Choice Experiment Methodology
The study was conducted in choice experiment where four types of foods which are Brewer's yeast, banana, cucumber and Melon Manis Terengganu (MMT) were put in the petri dish then placed in a rearing cage (30 x 45 x 30 cm) with distances of 5 cm between them. Then, one prestarved four-day-old female *Z. cucurbitae* fly was released into the cage containing the four foods. The selection of female flies is based on their higher tendency to actively seek out food sources, which is essential for their continuous egg production and the sustenance of their species throughout their lifespan [6],[7]. This prestarved fly was deprived of any food source and only given water-soaked cotton pads for 24 hours before being released into the experimental cage. This process ensures that the fly's natural inclination to find a suitable food host is more accurately assessed.

Behaviours Observation
Fruit fly behaviours were observed for 2 hours (0900-1100 h). The selected time frame was based on the peak activity of the flies, as they are most active during this period [8]. The behaviour parameters recorded were; 1) number of fruit visit, 2) duration of visit, 3) number of consumption and 4) duration of consumption completed. The number of times the fly visit and

consume food were recorded using an electronic hand counter (LINE™, Japan) while the duration of food visit and consumption process completed were recorded using a stopwatch (Diamond, China). The experiment was replicated five times.

Data analysis

Flies behaviour (number of food visit, duration of visit, number of consumption, duration of consumption completed) obtained from the experiment was subjected to One-way of Analysis of Variance (ANOVA) for comparison between different food hosts. Means were separated with Tukey's Range (HSD) Test at 0.05 level of significance. All data analyses were performed using MINITAB® 19 software (2021).

RESULTS AND DISCUSSION

The Table 1 below shows the result of observation on food preferences behaviour parameters of *Z. cucurbitae* (i.e. number of food visit, duration of food visit, number of food consumption and duration of consumption completed) on four types of food hosts under choice experiment. Results show significant differences *($P<0.05$)* in the duration of food consumption by the flies after exposed to different types of food hosts. Flies consume Brewer's yeast longer than other food hosts with 19.29 ± 3.73 minutes, followed by banana (11.85 ± 1.96 minutes), MMT (7.47 ± 1.13 minutes), and cucumber (4.73 ± 1.02 minutes). Interestingly, when compared to other food hosts, yeast showed the lowest results in terms of the number of fruit visits (1.04 ± 0.13 times), the duration of food visits (3.00 ± 1.48 minutes), and the number of food consumptions (1.47 ± 0.24 times). On the other hand, there were no significant differences *($P>0.05$)* observed in the number of fruit visits, duration of fruit visits, and number of consumptions across all the food hosts.

Table 1: Food preferences behaviour parameters of *Z. cucurbitae* under choice experiment

Food Host	No. of Food Visit	Duration of visit (min)	No. of food consumption	Duration of food consumption (min)
Brewer's Yeast	1.04 ± 0.13^{a}	3.00 ± 1.48^{a}	1.47 ± 0.24^{a}	19.29 ± 3.73^{a}
Banana	1.43 ± 0.26^{a}	3.62 ± 1.45^{a}	2.06 ± 0.26^{a}	11.85 ± 1.96^{ab}
Cucumber	1.94 ± 0.37^{a}	3.27 ± 0.82^{a}	2.67 ± 0.46^{a}	4.73 ± 1.02^{b}
MMT	1.61 ± 0.30^{a}	3.98 ± 1.17^{a}	2.40 ± 0.31^{a}	7.47 ± 1.13^{b}

Means with same letters within columns were not significantly different ($P>0.05$) by Tukey's (HSD) test.

Based on the data presented in Table 1, it was observed that Brewer's yeast had the longest consumption period compared to other food sources. This finding suggests that *Z. cucurbitae* preferentially selects Brewer's yeast as a food source to support their lifecycle. This observation is in line with the research from the previous year [4], which emphasizes the importance of a protein-rich diet, along with carbohydrates and sufficient moisture, for female flies to achieve sexual maturity, particularly during the pre-oviposition period. The high protein content of Brewer's yeast, approximately 45–60%, as well as its recognized safety (GRAS) status [9], further supports its suitability as a preferred food choice for these flies. Meanwhile, the lower result of yeast concerning the three behaviour parameters could be due to the flies spending less time probing the food. This behaviour could be explained by the fact that they find yeast to be favourable and, consequently, consume it more rapidly than other food sources. Recent research also declared and identified that fruit flies, can eat for pleasure as well as necessity with greater feeding time indicating hedonic feeding drive [10].

CONCLUSIONS

To conclude, Brewer's yeast demonstrated the highest attractiveness and consumption rate for *Z. cucurbitae* compared to other food hosts. These results the importance of using yeast as a food bait to effectively control melon fruit flies. Employing yeast in food bait traps can significantly enhance their efficiency before implementing them in field research. Further investigations may be needed to confirm the factors that attract fruit flies to yeast, which could lead to improved pest management strategies.

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FORAGING ACTIVENESS AND HONEY PRODUCTION OF STINGLESS BEE, *Heterotrigona itama* IN MARANG, TERENGGANU

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ABSTRACT

Stingless bees are one of the most important pollinators in tropical and subtropical regions. However, studies on the interaction of stingless bee activeness with abiotic factors and honey production are very limited, particularly in the east coast of Peninsular Malaysia. A study to determine the relationship between *Heterotrigona itama* foraging activity with abiotic factors and honey production was conducted between February 2022 until April 2023 in Marang, Terengganu. Five healthy colonies of *H. itama* were selected for observation on foraging activeness pattern and were recorded 10 minutes for each one-hour interval from 0700-1700 hours every two months. Abiotic factors such as temperature, light intensity and humidity were also measured every hour. Honey production within two months interval from March 2022 until March 2023 was provided by the owner. There were significant differences in the interaction of bee activeness with time and months. The foraging activities were observed significantly increased from 0700 until the peak time at 1100 and then reduced from 1100 until 1500. The highest bee activeness was recorded in April 2022, followed by February 2023. While February, June and August in 2022 and April 2023 showed lower bee activeness. Bee activeness was not significantly affected by the abiotic factors and influenced honey production. Honey production showed a significant difference between months, where July 2022 yielded the highest honey production. Stingless bees are active in the morning due to flower blooming and honey production increased in July 2022 for food storage before the rain season. Findings from this study can help beekeepers in better management of their meliponiary.

Keywords: Heterotrigona itama, foraging, activeness, abiotic factors, honey

INTRODUCTION

Stingless beekeeping has gained significant popularity in Malaysia due to the remarkable medicinal benefits of stingless bee honey, which have greatly propelled the growth of the meliponiculture industry in the country. [1]. There are two types of stingless bee honey: Monofloral honey and Multifloral honey [2]. Stingless bees collect floral source nearby their nest and bring back to their nest to produce bee product such as honey, propolis and pollen bread [3]. The bee movement indicate the activeness and strength of the colony [4] which is influenced by abiotic factors [5]. Production of the stingless bee honey varies according to season and availability of floral resources [6]. Previous study revealed that stingless bee tends to produce more honey in dry season compared to wet season which is related to floral resource availability [6]. However, the information on foraging activeness of stingless bee (*Heterotrigona itama*) and the honey production in Terengganu, Malaysia is scarce. Thus, this study will help to determine the foraging activeness and honey production of *H. itama* in Marang, Terengganu.

MATERIALS AND METHODS

Observation of Stingless Bee Activeness and Data Collection on Abiotic Factors

Five healthy colonies of stingless bees, *H. itama* were selected for observation on foraging activeness pattern. Stingless bee's activeness was observed by video recording using phone camera. The recording duration for the number of stingless bee movement in and out from their hives followed Asma et al. (2019) [7] with slight modification (additional hours) where ten minutes were recorded at one-hour intervals from 0700-1700 hours. The observation was conducted for two months interval starting from February 2022 until August 2022 and from February 2023 until April 2023. The sampling date was postponed started from October 2022 until January 2023 due to monsoon season and to avoid flood that occurred on the road that leading to the sampling area for safety reason. In this study, the total number of bee movement per ten minutes was extrapolated to per minute to measure the bee activeness. The bee activeness was calculated and compared with *H. itama* colony activeness guide provided by Agricultural Department of Malaysia (2020) where an active colony of *H. itama* has 70-80 bees/min fly in and fly out (FIFO). Abiotic factors such as temperature, light intensity and humidity were measured every hour (0700-1700 hours). Temperature and relative humidity were measured using a portable wind speed meter (LM-8000A) while light intensity was measured using a portable lux meter (H197500).

Data Collection on Honey Production

The same five colonies selected for the stingless bee activeness were used to collect the honey production data. The data of honey production was provided by the owner of the meliponiary. The honey was harvested once every two months to make sure the colonies were sustained with enough food reserves. During the harvesting process, the top cover of the hives was removed gently. The stingless bee honey pots were pricked gently, and the honey was sucked using a portable battery-operated honey pump. A few honey pots were left in the hive as food source for the bees. The honey volume that collected in the pump container was recorded.

Statistical Analysis
All dependent variables were tested for normality of distribution (Kolmogorov–Smirnov test) before conducting One-way ANOVA and Two-Way ANOVA statistical tests. One-way ANOVA was used to calculate the differences between bee activeness with time and months while honey production with months. Two-Way ANOVA was used to calculate the interaction between bee activeness with time and months. Regression Analysis was used to determine the relationship between the bee activeness with abiotic factors (temperature, humidity and light intensity). All analyses were performed using the Statistical Package for the Social Science (SPSS) 23.0 statistical software.

RESULTS AND DISCUSSION

Stingless Bee Activeness with Time and Month
The activeness of stingless bees, *H. itama* from five different colonies throughout the study period were significantly different through time [$F_{(11,348)} = 2.052$, $p<0.05$]. The bee movement were increasing starting from 0700 (12.95 ± 3.43 bee/min) until the peak at 1100 (31.15 ± 6.89 bee/min) but then reduced from 1100 until 1500 (11.19 ± 2.50 bee/min). However, it was observed that there the bee movement were slightly increased from 1500 until 1800 (12.02 ± 2.71 bee/min). Result shows that the bee activeness increased in the morning could be related to the anthesis time of most flowering trees that make the stingless bee active to collect pollen in the morning [8]. Ramadani et al. [9] also discovered that stingless bee (*L. terminata*) was very active collecting pollen in the morning. The bee activeness peaked at 1100 were in line with Bharath et al., (2020) [4] where the study for stingless bees (*Tetragonula iridipennis*) foraging activity was also active in 1100 due to availability of nectar and pollen. Meanwhile, the result of bee activeness decreased at noon similar with [10] due to this time the weather getting hotter, temperature rises and low availability of pollen resource, which make most of the stingless bee preferred to stay in the hive and controlled the temperature in the hive by flapping their wings [11].

Stingless bee movement in and out was significantly different between months [$F_{(5,354)} = 21.419$, $p<0.05$]. April 2022 showed the highest mean number of stingless bee activeness (40.05 ± 4.29 bee/min) followed by February 2023 (28.44 ± 4.18 bee/min). In this study, the result show that bee activeness was higher in April 2022 and February 2023 which is the dry months in Terengganu. In comparison with Wan Nur Asiah et al. [12], the study revealed that highest foraging activity of stingless bee (*Geniotrigona thoracica and H. itama*) occurred in January 2015 which is in the wet month at Selangor. The result in this study contradictd the study by Wan Nur Asiah et al. [12]. However, the result was comparable with Vaidya et al., [13], which foraging activity was higher in dry season than wet season due to more floral resource available. Meanwhile, February, June and August in 2022 and April 2023 show lower bee activeness compared to April 2022 and February 2023. This is due to the foraging activity of stingless bee also which also varies depending on the floral resource availability nearby their hive [14].

Stingless Bee Activeness with Abiotic Factors
The result show that stingless bee activeness is not significantly influenced by the abiotic factors. From this study, the result was contradicted to Salatnaya et al. [15] and Souza-Junior et al. [5] where the stingless bee foraging activeness highly influenced by the abiotic factor. Most of previous study mentioned that temperature, humidity and light intensity is highly influenced the stingless bee foraging activity. Jaapar et al. [16] stated that the ideal temperature for *H. itama* to forage is 29°C to 32 °C while Salatnaya et al. [15] revealed that the ideal temperature is 26-28 °C, humidity is 55-71%, and light intensity is 46.875-91.347 lux. However, the result in line with Polatto et al. [17] where stingless bee in tropical region may not much influenced by the abiotic factors due to small changes of temperature, humidity and light intensity but may influenced the bee activeness when it comes to seasonal changes that affect the resource availability.

Stingless Bee Activeness with Honey Production
The honey production of *H. itama* were significantly different between months [$F_{(5,354)} = 51.843$, $p<0.05$]. July 2022 (1070.00 ± 23.51 ml) show the highest honey production of *H. itama* followed by May (890.00 ± 39.36 ml), September (770.00 ± 28.40 ml) and March (704.00 ± 19.77 ml) in 2022. Meanwhile, January (470.00 ± 39.83 ml) and March (476.00 ± 38.64 ml) in 2023 show lower honey production of *H. itama* in this study. In this study, dry weather started from March 2022 until July 2022 and the wet season begin late September 2022 until January 2023. Honeybees tend to collect more floral resource and produce more honey in dry season before the wet season begin to prevent food scarcity during wet season [18]. The study suggested that similar behaviour with *H. itama* in this study that more honey was produced in dry months (March, May and July in 2022). Faridatul et al., (2021) [19] mentioned that stingless bee produced less honey in wet season. The result is consistent with Faridatul et al., (2021) [19] where the honey production decreased in wet season in this study (September 2022 and January 2023) due to limited foraging movement by the bees and limited floral resources available during that period.

CONCLUSIONS

In conclusion, the bee activeness of *H. itama* varies across different time and months. This study shows that the peak of the bee activeness is at 1100 in the morning and the highest bee activeness occurred in April 2022 and February 2023 which is during the dry month. However, bee activeness was not significantly influenced by the abiotic factors and the honey production. The honey production of *H. itama* increase from March 2022 until the highest honey production in July 2022 which is during the dry months. This study can provide useful information thus increase the beekeeper knowledge. This study also can be used to improve the management of meliponiculture sustainably in the future.

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PREDATION ABILITY OF *Sycanus dichotomus* (HEMIPTERA: REDUVIIDAE) ON *Spodoptera frugiperda* (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Spodoptera frugiperda is an invasive pest that was introduced to Indonesia in 2019 attacking maize plants. *Sycanus dichotomus* is a predator that can be found on maize cultivation attacked by *S. frugiperda*. The purpose of this study was to determine the effect of sex and number of *S. dichotomus* predators on their predation ability on *S. frugiperda* larvae. The research was carried out at the Laboratory of Agriculture Faculty, Islamic University of North Sumatra between September 2022 and March 2023. This study was conducted using Completely Randomized Design (CRD) with 5 treatments which was labeled as P1(1 male), P2 (1 female), P3 (a pair of male and female), P4 (2 males) and P5 (2 females). Ten larvae of *S. frugiperda* instar 3 were placed in the treatment containers, before the *S. dichotomus* predator was introduced into the containers. There were five replications for each treatment. Results showed that all predators recorded > 50% of predation ability on the 3rd day. The two female predators demonstrated high predation efficiency by consuming all the larvae (100%) by the 2nd day. In contrast, the two male predators achieved complete predation by the 4th day. Meanwhile, a pair of predators and a single female predator successfully preyed on all *S. frugiperda* larvae by the 5th and 6th days, respectively. These findings highlight the superior predation ability of female predators, making them more effective as biological control agents for *S. frugiperda* larvae.

Keywords: predation ability, *Sycanus dichotomus*, *Spodoptera frugiperda*

INTRODUCTION

Spodoptera frugiperda, commonly known as the fall armyworm, is an invasive pest that was first detected in Indonesia in 2019.The first recorded infestation was in West Sumatra Province in 2019 and caused major damage with larval population reached 2-10 larvae/plant [1] then quickly spread to several provinces of South Sumatra, Lampung, West Java, East Kalimantan, Aceh and including North Sumatra. In June 2019, out of 33 districts in North Sumatra, 18 of the districts recorded *S. frugiperda* infestation on maize plants. The total area of infestation in farmers' maize crops was 3,278.9 ha, with the largest infestation was recorded in Karo District with 1650.5 ha, followed by Dairi District with 922.5 ha. Corn farmers in North Sumatra were alarmed regarding the infestation and anticipated the potential attack of *S. frugiperda*, which can infest more than 80 species of crops [2,3].

The insect pest spreads fast and has a high reproductive capacity and they feed on the crop leaves which resulted in serious damage to the farms. Generally, *S. frugiperda* the attack occurs both in vegetative and generative phases. The yield loss was up to 94%. At severe infestation, insecticides were applied with most of the active ingredients that were used were emmamectin benzoate, Siantraniliprol, Spinetoram and tiamectosam [3].

The use of insecticides to control pests in the long term can have negative impacts. Alternative control is needed to replace chemical control. Biological control is the method of managing pests so that their population is not at an amount that can harm cultivated plants. Biological control is one component of IPM that is expected to manage agro-ecosystems that aim to maintain pest populations and crop damage caused by them at a level that is not detrimental [4].

Natural enemies of *S. frugiperda* have been reported in several regions in Indonesia such as *Telenomus remus* (an egg parasitoid) [5]. Parasitoids from genera Charops and Microplitis, Apanteles, Tachinidae, Ichneumonidae and Euplectrus were found to parasitize only *S. frugiperda* larvae. In the field, predators Sycanus, Rhinochoris (Reduviidae), Carabidae, Coccinellidae, Araneae, Staphylinidae, Evaniidae and Euborellia sp. were also found [6]. A survey was conducted at 4 districts in North of Sumatra and grouped as 2 districts (Langkat and Deli Serdang) as low land (4 -18 m above sea level) and another 2 districts (Karo and Dairi) as high land (400 -1800 above sea level) in July to September 2022.

Survey results showed at four districts surveyed maize plantations attacked by *S. frugiperda* found predators *Euborellia annulata,* Coccinellidae species, *Sycanus dichotomus* and *Rhynochoris fuscipes.* Predators *S. dichotomus* and *R. fuscipes* are two types of generalist predators found attacking *S. frugiperda*. *Rhynochoris fuscipes* predators collected from Karo and Dairi district in maize plantations aged 2-4 weeks after plantation (WAP) and > 4 WAP (attack intensity of about 70%), and *S. dichotomus* collected from Langkat Distric maize plantations aged 4 WAP

In simple feeding tests, both predators were seen piercing and eating *S. frugiperda* larvae (instars 2, 3 and 4) [7]. *Sycanus dichotomus* is found in maize plantations infested with *S. frugiperda* in Langkat district, generally in corn plantations adjacent to oil palm plantations. It is possible that predators in oil palm plantations, which are predators of bagworm, *Setotosea asigna* and *Darna trima* [8] have migrated to maize plantations infested by *S. frugiperda*. Whilst, in the highlands (Karo and Dairi districts) there were no oil palm cultivation exist. Meanwhile, *R. fuscipes* can prey on several other pests in vegetable crops. For this reason, it is necessary to study the predation ability of *S. dichotomus* on *S. frugiperda* larvae in the laboratory. The results of this study can provide information on the ability of this predator to prey on *S. frugiperda*. The presence of natural enemies in the field is one of the most valuable pieces of information that can be used as a consideration for natural control in the future. One possibility to *control S. frugiperda* is by using natural enemies, *S. dichotomus*.

MATERIALS AND METHODS

Rearing of S. dichotomus

Male and female *S. dichotomus* adult predators were collected from *S. frugiperda*-infested maize plantations around oil palm plantations in Langkat district and then reared in the laboratory (Temp. 28 ± 2oC, 70 ± 5% RH, and 12L:12D). Predators were placed in plastic jars (18 cm high, 20 cm top and 16 cm bottom diameter) with a total of 3 pairs/jars. The feeding of *S. dichotomus* was Black soldier fly *Hermetia illucens* (Diptera: Stratiomyidae) larvae obtained from a bird food store. Predators copulated and laid eggs on the tile cloth covering the container. Eggs were separated by cutting the tile cloth (to avoid damage to the eggs) and placed in another plastic jar (8 cm high and 12 cm in diameter) and covered with tile cloth. Eggs hatch after 10-14 days. Newly hatched nymphs still gather around the eggs and are not yet active. Next instar nymphs are transferred to a larger container (25 cm high, 27 cm top and, 22 cm bottom diameter) and fed with *Hermetia illucens* larvae. Nymphs were reared until adults were formed as test insects. The time required to obtain adults is about 2 months.

Rearing of S. frugiperda

The 3rd instar *S. frugiperda* larvae were obtained through laboratory rearing. The *S. frugiperda* larvae were obtained from infested maize in the fields (3rd-5th instar larvae) and reared in the laboratory by placing them in plastic Petri dish with a diameter of 10 individually with baby corn as their diet. Petri dishes were cleaned daily, and food was changed. The pupae formed were placed in plastic jars (25 cm height, 27 cm top and 22 cm bottom diameter) with 6-7 pupae/container. After 5-7 days, adults were formed which were then fed with 10% honey dripped on cotton wool placed on the tile cloth lid of the jar. Adults copulated and laid eggs on the tile cloth, as well as the walls of the container. Newly hatched larvae temporarily gathered in egg clusters and then moved actively in search of food. Newly hatched 1st instar larvae (neonates) were collected with a small brush and placed on plastic jar (height 8 cm and 12 cm diameter) which had been lined with filter paper and placed with baby corn. The number of larvae was about 20 larvae/ jar. Larvae as test insects were 3rd instar.

Exposure of *S. dichotomus* to *S. frugiperda larvae*

The treatments were the number and sex of *S. dichotomus* predators, namely P1(1 male); P2 (1 female); P3 (1 male, 1 female); P4 (2 males); and P5 (2 females). Each treatment was fed with 10 *S. frugiperda* instar 3 larvae placed in a square plastic container (length x width x heigh 24 x 18 x 8 cm) and 10 pieces of baby corn feed. The food was spread out in the container so that each larva would be on a piece of corn as its food. Then the predators were introduced into the container after being fasted for 24 hours. The plastic container was covered with tile cloth and tied with rubber. The number of larvae preyed upon was observed after 24 hours.

Methods

There were five replications for each treatment. Statistical analysis was carried out by using ANOVA (P<0.05). Duncan's Multiple Range Test (DMRT) at 5% confidence interval was used to determine the difference of larva mortality from each treatment. Data was normalized using Arcsin Vx [9] before analysis. All statistical analysis was done by using SPSS Statistic 26 Program.

RESULTS AND DISCUSSION

Predation ability

The ability of *S. dichotomus* predators to prey on *S. frugiperda* larvae for 6 days is shown in Table 1.

Table 1. Larva of *S. frugiperda* preyed by *S. dichotomus*

Treatment (predator)	Larvae preyed (%)					
	1 DAE (SEM)	2 DAE (SEM)	3 DAE (SEM)	4 DAE (SEM)	5 DAE (SEM)	6 DAE (SEM)
P1 (♂)	22 ± 3.74c	42 ± 3.74 c	56 ± 3.99 c	76 ± 3.99 b	90 ± 7.73 a	96 ± 3.99 a
P2 (♀)	28 ± 5.82 bc	46 ± 3.99 c	58 ± 7.99 c	78 ± 3.74 b	96 ± 2.45 a	100 ± 0 a
P3(♂♀)	46 ± 7.47 b	64 ± 7.47 b	82 ± 3.74 b	98 ± 2.00 a	100 ± 0 a	100 ± 0 a
P4 (♂♂)	42 ± 8.59 bc	66 ± 6.77 b	94 ± 3.00 a	100 ± 0 a	100 ± 0 a	100 ± 0 a
P5(♀♀)	76 ± 6.77 a	100 ± 0 a	100 ± 0 a	100 ± 0 a	100 ± 0 a	100 ± 0 a

DAE = Day After Exposure.
SEM = Standart Error of Mean.
Means in a column followed by different letters are significantly different (*P = 0.05*) by DMRT's Test.

In general, it can be seen that a single female *S. dichotomus* has the ability to prey on 28% of the prey provided, while the male is 22% at 1 day after the prey was exposed to predators. Likewise, on the following day, the percentage of insect predation by female predators was higher, although both of treatment were not significantly different. The greater predation ability of female predators may be due to the need for female insects to reproduce, which requires more food. Female predators of the Reduviidae group *S. annulicornis* consume more prey than female predators. This is thought to be for reproductive purposes to lay eggs so that it requires more prey as food. Research by Sahid *et al*. [10], reported that female *S. annulicornis* predators consumed an average of 3.29 Tenebrio molitor larvae and 2.91 *Crocidolomia. pavonana* larvae, while male predators consumed an average of 1.91 *T. molitor* larvae and 1.80 *C. pavonana* larvae at 24 hours after prey feeding. In this study, 24 hours after exposure time female predators consumed an averaged 2.8 larvae whilst male predators consumed an averaged 2.2 larvae.

Two male and two female predators showed significantly higher prey ability by the female predator, and by the second day, the two female predators had consumed all the *S. frufiperda* larvae provided to them. Competitiveness for food led the female predators to prey more on *S. frugiperda*. This shows that predation is also influenced by the presence of other individuals, presumably due to competition in accordance with the opinion of Malasari, [11] which states that the relationship between predators and their prey is influenced by many factors including the number of the predator. The behavior of *S. dichotomus* during the predation period before preying was that the predator initially rises to the surface of the container for a few moments and then the predator begins to descend to the bottom of the container to get prey. The stylet is lowered and the predator searches for prey. When *S. dichotomus* has found its prey, it first stays near the *S. frugiperda* larva for about 1 to 5 minutes and then pierces the body of *S. frugiperda* using its stylet.

After *S. frugiperda* larva was punctured by the stylet, it squirmed for a few seconds until it appeared limp due to the puncture. After that, *S. dichotomus* moved its stylet to several other segments of *S. frugiperda's* body. Furthermore, *S. frugiperda* began to appear limp and was marked black in the puncture area of the stylet of *S. dichotomus*. In this condition, the larvae no longer appear to be moving (dead). At certain times in preying, *S. dichotomus* sometimes grabs and lifts *S. frugiperda* to the edge of the container while sucking the body fluids of *S. frugiperda*. If the body fluids of *S. frugiperda* are sucked out by *S. dichotomus* using its stylet, the larvae appear to be dry. However, some predators do not suck the body fluids out of the larvae and move on to other prey, so the larvae remain wet. According to Sahid *et al.*, [10] if *S. dichotomus* does not finish sucking the liquid inside its body, the symptoms experienced by *S. frugiperda* are blackening and becoming soft throughout its body. When *S. dichotomus* finishes preying on *S. frugiperda*, it will release the puncture from the body *of S. frugiperda* then bend back its stylet and dwell for about 2 minutes and return to the surface of the application container.

One male of *S. dichotomus* appeared to take more time finding its prey. Generally, in the 10 preys given to each container, one predator sucked out 4 preys, while the remaining 6 were only poked and sucked on prey body fluids for a few moments, then abandoned. Predators searched for other prey. One female *S. dichotomus* predator always seemed to finish sucking the liquid inside the body of *S. frugiperda*. This is because females need more food for reproduction. This is similar as reported Saharayaj [12] there was the Reduviidae predator of female *Rhynocoris marginatus* consume more prey than males. It was suggested that female predatory insects consume more prey to produce their more offspring. A pair of male and female *S. dichotomus* clearly shows the difference between males and females in preying. There were the female predator has a stronger prey ability because the female preys on *S. frugiperda* larvae first and when the larvae look dead, the male predator comes and preys on the larvae that have been paralyzed by the female predator. Copulation occurred during the treatment.

The two male *S. dichotomus* predators were slow to find prey, and when preying *S. dichotomus* did not finish sucking the liquid inside the larvae's body, it was clear that there were 3 larvae that did not finish sucking the liquid in the treatment. Two female *S. dichotomus* appeared to be more active in preying. By 2 days after exposure, predation had reached 100%, and all larvae had been sucked out by the liquid inside the larvae as indicated by the shriveling, blackening and drying of the larval body. One female predator preyed on an average of 2.8 *S. frugiperda* larvae after 1 day of exposure time. One female predator preyed on an average of 2.8 *S. frugiperda* larvae after 24 hours of exposure time. Meanwhile, two female predators could prey on an average of 7.6 larvae, resulting in a1.4 times increase in preying ability when two females are put together. It is expected that in the field on *S. frugiperda* infested maize plants, adult females can be more aggressive in predating *S. frugiperda* larvae. Moreover, *S. frugiperda* larvae make burrows in the shoots of corn plants [1]. Good predator searching ability is a good potential for controlling pest populations.

CONCLUSIONS

The predator *S. dichotomus* has the ability to prey on the larvae *of S. frugiperda*, an invasive pest in corn plants. Both male and female predators have the ability to feed on *S. frugiperda* larvae. Female predators have a greater ability to prey than male predators. Two predators showed twice the prey power of a single predator, but two female predators showed 1.4 times the prey power of a single female. It is necessary to evaluate the predatory ability of predators in the nymphal stadia.

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EFFICIENCY OF REDUCING CRUCIFEROUS VEGETABLE WASTE USING BLACK SOLDIER FLY, *Hermetia illucens* (L.) (DIPTERA: STRATIOMYIDAE) LARVAE

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ABSTRACT

The larvae of black soldier flies (BSFL) are known to be natural degraders of organic matter. This prospective fly species offers a lucrative and sustainable alternative for managing biological waste. BSFL applications in waste management can also stimulate the production of useful derivatives such as animal feed and fertilizer to generate profit. This study was conducted to evaluate the efficiency of BSFL to reduce waste of cruciferous vegetables (*Brassica* sp.). A factorial design was used to investigate the effect of the larvae and feeding rate on BSFL growth and development and the reduction of cruciferous vegetable waste. Findings of the study revealed that a high feeding rate across the number of larvae resulted in a greater survival rate (83.33 – 95%), higher growth rate (63.33 – 68.07 mg/day) and faster development time (25.33 – 29.33 days) of BSFL. High feeding rates also generated the highest waste reduction index (1.20 – 3.12 %/day) but showed a decline in organic matter reduction (34.93 – 78.48%).

Keywords: black soldier fly larvae, decomposition agent, waste reduction, cruciferous vegetable waste.

INTRODUCTION

Agricultural waste is a collection of residues that are generated from agricultural operations [1]. This includes the leftovers of crops such as vegetables and fruits that have been removed from the chain of supply (i.e., producers, suppliers, sellers). Cruciferous vegetables (Family: Brassicaceae) such as cabbages and mustards are cultivated in large quantities and are commonly sold in markets for consumption [2][3]. Unsold produce or discarded parts are usually disposed of, which will eventually be transported into landfills, causing environmental pollution [4]. In Malaysia, about 35% of municipal solid waste is comprised of crop wastes such as vegetables [5]. This implication calls for the need to develop a sustainable method to manage cruciferous vegetable waste. A key alternative is by utilizing black soldier flies, as its larvae can convert waste into valuable and marketable by products such as animal protein, fertilizer, and biodiesel, which are attributed to the larvae's consumption habit, allowing it to survive in a variety of organic substrates [6][7]. This waste management method can be applied on a small scale, such as at the household level, or industrialized for commercial purposes [8][9].

MATERIALS AND METHODS

Study Site
Experiments were conducted at the insectarium at the Faculty of Tropical Forestry, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia.

Waste Collection and Food Preparation
Waste cultivars of *Brassica oleracea* (cabbages) were collected at Korporasi Pembangunan Desa Market at Likas, Kota Kinabalu, Sabah. Collected waste was stored inside a refrigerator compartment with a temperature of 20°C. During feeding time, the waste was taken out of the refrigerator and was crushed by using a grinding machine before being fed to BSFL.

Acquisition of Larvae
Eggs of black soldier flies were harvested from a lab-domesticated colony and hatched on a hatching media containing chicken feed. The larvae were starved a day before introduction into the substrate at 10-days old.

Experimental Design
A factorial design with two factors (number of larvae, and feeding rate) at three levels (low, medium, and high) was implemented in this study (Table 1). From this design, a total of nine treatment combinations were employed. Each treatment had three replicates. The treatments were tested against the BSFL growth and development and the reduction of cruciferous vegetable waste. The measured parameters for growth and development of BSFL include larval development time (LDT), larval growth rate (LGR), and survival rate (SR), while the measured parameters for waste reduction of cruciferous vegetables were organic matter reduction (OMR) and waste reduction index (WRI). BSFL feeding was carried out and measurements were recorded at an interval of 4 days, until 50% of the larval population turned into prepupae.

Table 1: Factorial experimental design

Factors	Levels		
	Low	Medium	High
Number of larvae (lv)	50	100	150
Feeding rate (mg/lv/day)	37.5	75	150

Statistical Analysis
Kruskal-Wallis test was performed to see if the feeding rate and number of larvae significantly affected the BSFL growth and development and the reduction of cruciferous vegetable waste. Spearman Rank Correlation was used to determine if there are significant correlations between the factors and the dependent variables. All analyses were conducted using SPSS (version 27).

RESULTS AND DISCUSSION

BSFL Growth and Development
Larval growth and development were generally better in treatments with high feeding rates across the number of larvae (Table 2). LDT was fastest in high feeding rate treatments (25.33 – 29.33 days) compared to those with a low feeding rate (85 – 101 days). LDT showed a highly significant difference among feeding rates ($p < 0.001$) but not among number of larvae ($p > 0.05$). LDT had a highly significant and strong negative correlation against feeding rate ($p < 0.001$, $r^2 = -0.966$) but no correlation with number of larvae ($p > 0.05$, $r^2 = -0.39$). This relates to food abundance, in which larvae can quickly acquire more energy for development. In low feeding rates, LDT was delayed past the average lifespan of a black soldier fly [10]. BSFL were documented to be able to extend its development time until a minimum amount of energy was attained for pupation, which allows larvae to survive for a longer time in circumstances where food is limited [11].

Food abundance also led to higher larval weight gain against time and higher survivability. LGR (63.33 – 68.07 mg/day) and SR (83.33 – 92.44%) values were highest in high feeding rates across the number of larvae. Both LGR and SR showed a highly significant difference among feeding rates ($p < 0.001$) but not among number of larvae ($p > 0.05$). LGR had a highly significant and strong positive correlation with feeding rate ($p < 0.001$, $r^2 = 0.943$). Similarly, SR showed a highly significant and strong positive correlation with feeding rate ($p < 0.001$, $r^2 = 0.935$). However, the number of larvae did not correlate with LGR ($p > 0.05$, $r^2 = 0.151$) and SR ($p > 0.05$, $r^2 = 0.242$). With a larger amount of food, larvae can consume more substrate and convert it into larval biomass, resulting in higher weight and a shorter development period. Weight gain is crucial for larval development, as it induces hormonal changes to trigger further development [12][13]. In high feeding rates, the larvae thrived vigorously, which resulted in higher survivability, owing to an abundance of food supply. However, in low feeding rates, larval survival declined due to scarcity of food. It was also observed that the larvae were still able to live longer even with limited food sources. Insects are known to exhibit adaptation mechanisms to survive in food-scarce environments until conditions become favorable [14][15].

The BSFL growth and development trends in this study align with the findings of other studies. Previous studies [11], [16], [17] reported a similar trend for LDT, though these studies reported a comparatively shorter BSFL development time. Similarly, the LGR trend obtained in this study corroborates the results of Paz *et al.* [16]. However, Paz *et al.* [16] reported higher LGR values compared to the values obtained in the current study. This indicates that the type of substrate can influence the growth and development of BSFL due to differences in nutritional quality [18].

Table 2: BSFL growth and development in different number of larvae and feeding rate treatments

Number of Larvae	Feeding Rate	Larval Development Time (LDT) (days)	Larval Growth Rate (LGR) (mg/day)	Survival Rate (SR) (%)
		Mean ± S.E	Mean ± S.E	Mean ± S.E
Low	Low	104.00 ± 0.00	9.42 ± 0.56	9.33 ± 2.91
	Medium	44.00 ± 0.00	28.95 ± 0.40	74.00 ± 2.00
	High	25.33 ± 1.33	64.99 ± 3.17	83.33 ± 2.40
Medium	Low	104.00 ± 0.00	13.69 ± 0.84	51.00 ± 5.20
	Medium	44.00 ± 0.00	29.52 ± 0.24	75.33 ± 2.33
	High	28.00 ± 0.00	68.07 ± 0.18	95.00 ± 2.89
High	Low	88.00 ± 0.00	14.57 ± 0.93	59.56 ± 6.14
	Medium	41.33 ± 1.33	31.63 ± 1.03	78.67 ± 1.39
	High	29.33 ± 1.33	63.33 ± 3.60	92.44 ± 0.97

NOTE: Feeding of BSFL was stopped after 104 days. The low number of larvae with low feeding rate treatment only reached 4 – 14% prepupae.

Waste Reduction of Cruciferous Vegetables
The reduction of cruciferous vegetable waste showed different trends across different treatments (Table 3). High feeding rates resulted in lower OMR (34.93 – 78.48%) compared to low feeding rates (86.73 – 94.01%) across number of larvae, which was consistent with the trends reported in previous studies [16], [19], [20]. Similarly, a high number of larvae also generated lesser OMR (34.93 – 86.73%) compared to a low number of larvae (78.48 – 94.01%), which supports the findings of Paz *et al.* [16].

It is likely that OMR values were influenced by the food quantity given to the larvae. Feeding rate determines the amount of food given to an individual larva, thus, in treatments with a higher number of larvae, a larger food amount was provided for the whole larval population. This suggests that there is a threshold for consumption in BSFL [14]. OMR showed a highly significant difference among feeding rates ($p < 0.001$). It was also found that OMR had a significant difference among the number of larvae ($p < 0.05$), which differs from the result obtained by Lopes *et al.* [21], who found that number of larvae did not have a significant effect on OMR. It is possible that the experiment scale and the type of organic waste used in both experiments contributed to the difference in result. The current study used small numbers of larvae as illustrated in Table 1 and used a fiber-rich substrate while the previous study reared larvae on a larger scale and used different types of substrates [21, Tab. 1]. OMR showed a highly significant and strong negative correlation against feeding rate ($p < 0.001$, $r^2 = -0.722$) and a significantly moderate negative correlation against the number of larvae ($p < 0.01$, $r^2 = -0.582$).

Conversely, high feeding rates produced better WRI (1.20 – 3.12 %/day) than low feeding rates (0.90 – 1.00 %/day) across the number of larvae. A study conducted by Horgan *et al.* [22] using apple residues revealed a similar pattern. Interestingly, these results contradict the findings of Paz *et al.* [16], who reported a decreasing trend in WRI as the feeding rate increased. The contrasting results are likely due to the differences in the substrate used to feed the larvae. This is due to BSFL having low digestibility for fibrous-rich food compared to food rich in protein and carbohydrate, which results in slower larval development [17], [23], [24]. The current study only used a single type of vegetable waste, which was high in fiber content, while Paz *et al.* [16] used a mixture of plant-based substrates which included a leafy vegetable, a tuber, and various fruits. WRI showed a highly significant difference among feeding rates ($p < 0.001$) but not among number of larvae ($p > 0.05$). There was a highly significant and strong positive correlation between WRI and feeding rate ($p < 0.001$, $r^2 = 0.687$). However, a significant moderate negative correlation was found between WRI and the number of larvae ($p < 0.05$, $r^2 = -0.419$).

Table 3: Reduction of cruciferous vegetable waste in different numbers of larvae and feeding rate treatments

Number of Larvae	**Feeding Rate**	**Organic Matter Reduction (OMR) (%)**	**Waste Reduction Index (WRI) (%/day)**
		Mean ± S.E	**Mean ± S.E**
Low	Low	94.01 ± 0.20	0.90 ± 0.002
	Medium	95.44 ± 0.29	2.17 ± 0.01
	High	78.48 ± 2.28	3.12 ± 0.24
Medium	Low	89.83 ± 0.90	0.86 ± 0.01
	Medium	81.31 ± 0.74	1.85 ± 0.02
	High	52.20 ± 0.59	1.86 ± 0.02
High	Low	86.73 ± 1.03	1.00 ± 0.09
	Medium	68.32 ± 1.38	1.65 ± 0.02
	High	34.93 ± 0.54	1.20 ± 0.07

CONCLUSIONS

In conclusion, high feeding rates generally resulted in better BSFL growth and development, in which larval development time was faster, larval growth rate was higher, and survival rate was better. Additionally, high feeding rates showed better waste reduction index. At higher levels of feeding rate and number of larvae, the organic matter reduction was diminished. The factor of feeding rate had a highly significant effect on the growth and development of BSFL, which included larval development time ($p < 0.001$), larval growth rate ($p < 0.001$) and survival rate ($p < 0.001$). Feeding rates also had a highly significant effect on the reduction of cruciferous vegetable waste, which included organic matter reduction ($p < 0.001$) and waste reduction index ($p < 0.001$). Number of larvae had a significant effect on the organic matter reduction ($p < 0.05$) but not on waste reduction index ($p > 0.05$). Furthermore, the number of larvae had no significant effect on larval development time ($p > 0.05$), larval growth rate ($p > 0.05$) and survival rate ($p > 0.05$). Feeding rate had a highly significant and strong positive correlation with larval growth rate ($p < 0.001$, $r^2 = 0.943$), survival rate ($p < 0.001$, $r^2 = 0.935$) and waste reduction index ($p < 0.001$, $r^2 = 0.687$) as well as a highly significant but strong negative correlation with larval development time ($p < 0.001$, $r^2 = -0.966$) and organic matter reduction ($p < 0.001$, $r^2 = -0.722$). The number of larvae resulted in a significantly moderate negative correlation with organic matter reduction ($p < 0.01$, $r^2 = -0.582$) and waste reduction index ($p < 0.05$, $r^2 = -0.419$).

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Elaeidobius Kamerunicus BEHAVIOR AND COUNT ON MALE INFLORESCENCE ANTHESIZING STAGES BY USING TRAIL CAMERA

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ABSTRACT

Oil palm, *Elaeis guineensis*, is a major oil-producing plant in the world. Its primary pollinator is *Elaeidobius kamerunicus*, also known as the oil palm pollinating weevil. Several oil palm regions in Malaysia experience seasonal poor pollination problems from time to time. The problem has been linked to the behavior and activity of *Elaeidobius kamerunicus*, largely influenced by climatic factors. The study of the behaviour of *Elaeidobius kamerunicus* in the laboratory had been conducted previously, while none had been carried out under field conditions. Thus, the objective of this study was to evaluate the *E. kamerunicus* behavior and their numbers on different male inflorescence anthesizing stages in the field using trail cameras. Weevil behavior was observed using a modified trail camera, focusing on a 2 cm x 3 cm area of a pre-anthesizing male inflorescence spikelet. The trail cameras were set to video mode, capturing a 10-second video at five-minute intervals. The assessment stopped when the male inflorescence reached the post-anthesis stage. All the video recordings were then analysed manually for object detection modelling of *E. kamerunicus* behavior and number assessments. The results showed that the highest *E. kamerunicus* mean count was during 100% anthesis of the male inflorescence, followed by 50% anthesis, 25% anthesis, 75% anthesis, post-anthesis and pre-anthesis with a total mean of 7.39, 4.57, 3.00, 2.75, 1.11 and 0.02 adults per 6 cm^2 unit of assessed area respectively. The anthesis process of the male inflorescences took around four days to complete. The *E. kamerunicus* behavior had been identified as resting, feeding, moving, mating, flying and laying eggs. Overall, our findings indicate that the usage of trail cameras to record *E. kamerunicus* behavior and count for future research is possible.

Keywords: Oil palm, *Elaeidobius kamerunicus,* pollination, behaviour, male inflorescence

INTRODUCTION

Oil palm pollination depended on the pollinating weevil, *Elaeidobius kamerunicus.* The pollinating weevil was the most efficient pollinator for oil palm. Pollination issue had been linked with the poor pollinating weevil behavior and aggressiveness. The pollinating weevil behavior and aggressiveness had been known to be affected by climatic conditions [1]. Current methodology to study pollinating weevil count is by using conventional methods of spikelet cutting or whole male inflorescence cutting. This method is a destructive method and can alter the nature states of the pollinating weevil in the environment. Apart from it, this method is time consuming and labor intensive. This method is also restricted by time as can only be conducted during the daytime, specifically between 7.00 am till 11.00 am only. This method is also not suitable to be used to study the pollinating weevil behavior in the field.

Because of all the disadvantages that the current method has, we would like to test on a new method of assessing the pollinating weevil by using the trail camera. The camera method is about placing a camera on male inflorescence and focusing on the pollinating weevil count, movement and behavior. This method is not destructive and is able to observe the pollinating weevil natural states in the environment. This method can reduce the labor work during the assessment phase and can cover both daytime and nighttime. The pollinating weevil behavior in the field is possible to assess by using this method. The downside of this method is that it is a new method, so a lot of optimization and correlation with the conventional method are required to be conducted.

A laboratory study of the pollinating weevil behavior had been conducted previously. As for the field study, no such data had been gathered. So, the objective of this study was to determine the pollinating weevil count and behavior on different male inflorescence anthesizing stages in the field by using trail camera.

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MATERIALS AND METHODS

Study Site
The study site was in Ijok, Selangor and was using oil palm's age of 5 years old planting (< 2.5m height)
Weather: normal days

Camera Optimization
This assessment was using male inflorescence between 50 – 75% anthesis. The assessment duration was around four to five days that covered from pre-anthesis until post-anthesis of the male inflorescence. The assessment was using both video recording and photo capturing. The assessment was set at every 2 minutes, and the video duration was set to 30 seconds. The camera was set up to focus on the not-yet anthesis area of 2 cm x 4 cm area (8 cm^2) of one male inflorescence's spikelet.

Elaeidobius kamerunicus Count and Behavior Assessment
This assessment was using the video and photo result obtained from the field. This assessment was about counting and identifying the behavior of the pollinating weevil individuals that presence in the video and photo captured. The counting assessment was using both manual & AI counting program while behavior assessment was using only manual counting. The pollinating weevil count and behavior will be sorted into hourly timeline and differentiated into different male inflorescence anthesizing stages. Pollinating weevil behavior was differentiated into moving, resting, eating, laying eggs, mating and flying.

RESULTS AND DISCUSSION

Elaeidobius kamerunicus Count
The highest count for pollinating weevil adult was during the 100% anthesis of male inflorescence, followed by post-anthesis, 75% anthesis, 50% anthesis, 25% and pre-anthesis (figure 1). The result was expected when compared with the previous literature. This result covered both daytime and nighttime on an hourly basis.

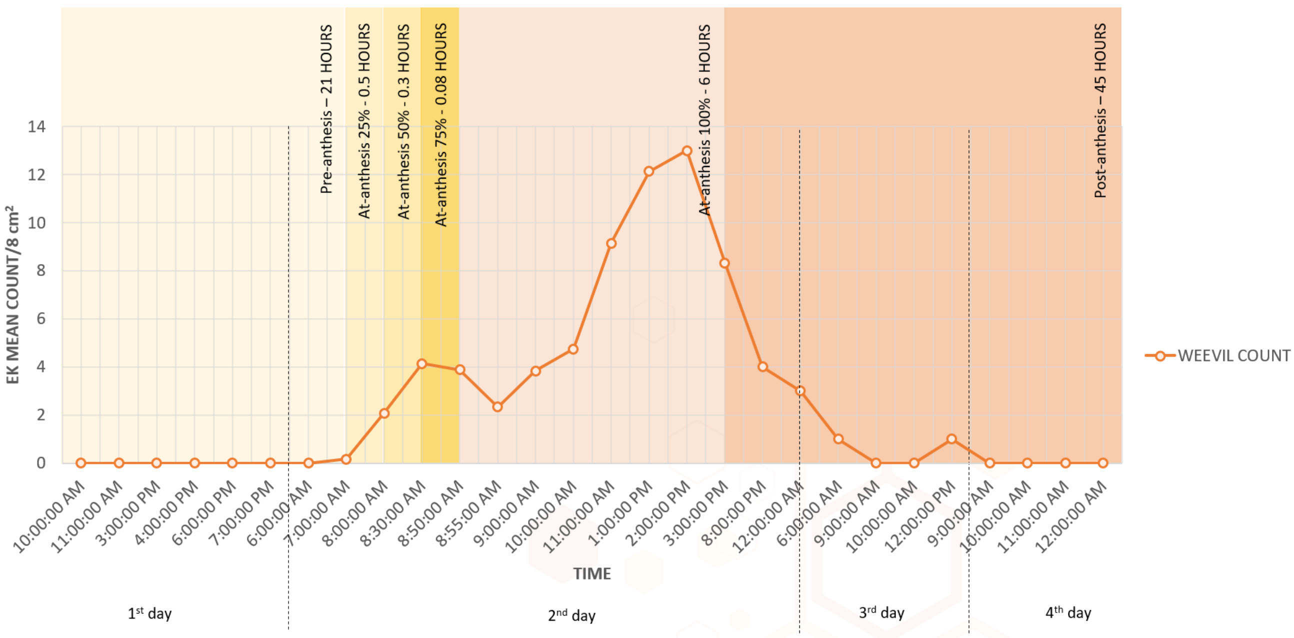

Figure 1: *Elaeidobius kamerunicus Count*

Elaeidobius kamerunicus Behavior
The highest behavior count was resting during 100% anthesis of male inflorescence, followed by moving, mating, feeding, flying and laying eggs (figure 2). This result will be double checked again with the previous literature and any changes to the behavior description will be conducted accordingly.

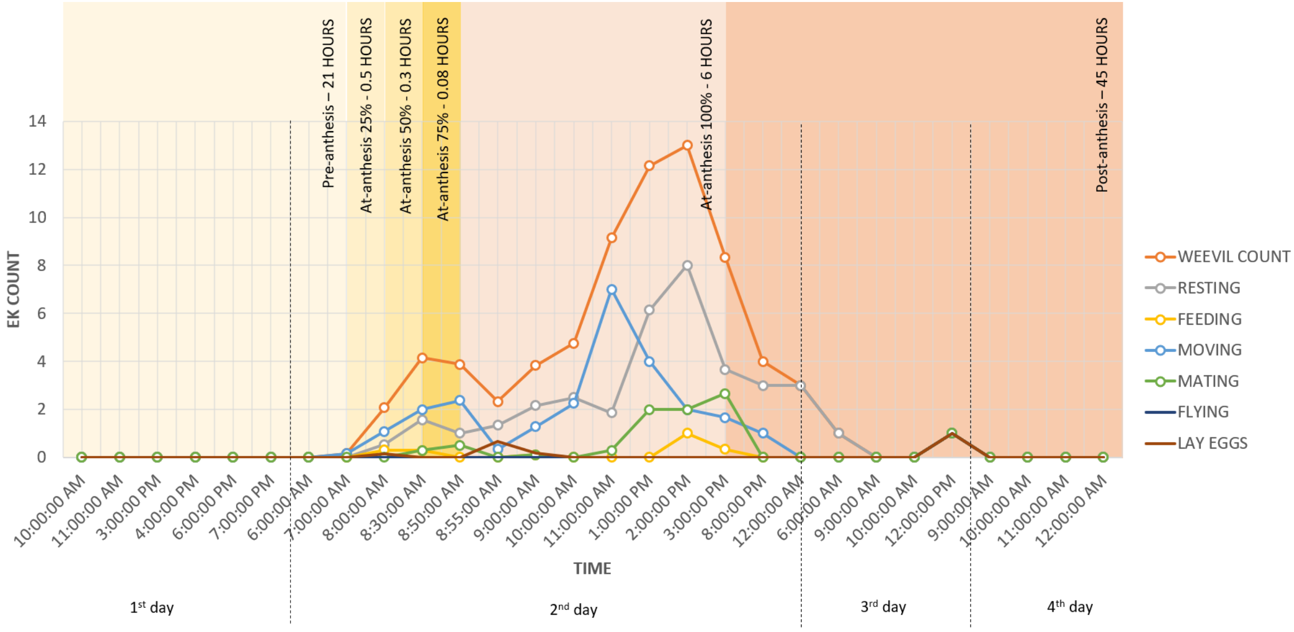

Figure 2: *Elaeidobius kamerunicus Behaviour*

CONCLUSIONS

Our findings indicate that the usage of trail cameras to record *Elaeidobius kamerunicus* behavior and count for future research is possible.

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PHENOTYPIC SCREENING OF BROWN PLANTHOPPER, *Nilaparvata lugens* RESISTANCE ON DIFFERENT RICE VARIETIES, *Oryza sativa*

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ABSTRACT

Brown planthopper (BPH) is a destructive monophagous insect pest and one of the main constraints of rice productivity causing huge yield losses every year in Asia is becoming more challenging, because ability of BPH possesses high adaptability and tolerance with chemicals. Host-plant resistance is an effective environment friendly approach to reduce BPH damage and increase yield potential of cultivars. This study was conducted to compare the effect of different rice varieties against the BPH. Screening was done according to standard evaluation system methods developed by International Rice Research Institute (IRRI) with some modifications. The assessment of resistance levels in three commonly cultivated rice varieties at Tanjong Karang—MR219, MR220, and MR220 CL1—revealed varying degrees of susceptibility to BPH. Among them, MR220 CL1 exhibited the highest resistance, with a minimum damage score of 1.90. In contrast, MR220 showed high susceptibility with a damage score of 9.0. MR219 was classified as moderately resistant based on the standard evaluation criteria for rice resistance to BPH. The differences between resistant and susceptible of rice varieties were expressed clearly despite different plant ages at infestation. MR 219 was released previously as resistant whereas at present the nature of these varieties has been changed to moderately resistant and susceptible respectively. Whereas the resistant characteristics exclusively disappeared in MR220, which was recorded as moderately resistant variety. Based on the results, the rice varieties MR220 CL1 and MR219 would be the ideal source of resistance for breeding rice crop for resistance against BPH.

Keywords: brown planthopper, rice varieties, resistance, susceptible, phenotypic screening.

INTRODUCTION

Brown planthopper (BPH), *Nilaparvata lugens* (Hemiptera: Delphacide) is an economically important and widespread insect pest of rice (*Oryza sativa*). Incidence of BPH infestation in Malaysia has been drastically rising in recent years and more '*hopperburn*' incidences have been reported [1]. In the initial stages of infestation, round yellow patches on the plant are seen which later turns brownish due to drying up of the plants, known as Hopperburn. The phenomenon of hopperburn was reported to cause 20 – 80% yield loss [2]. BPH attack was reported recently by MADA in 2020, an estimated 30,000 metric tonnes of paddy yield declined with farmers in the state suffering losses reaching RM36 million a year [3]. Conventional measures to reduce BPH damage to rice have included the application of chemical insecticides but this is expensive, ineffective under some weather conditions and the chemicals can kill BPH predators, which may lead to increased pest incidence as well as change in BPH biotypes [4]. Host plant resistance has been recognised as one of the most economical and effective measures in controlling the brown planthopper population in the fields [5]. Therefore, utilisation of resistant rice varieties is a viable alternative to chemical control methods in managing BPH. Therefore, in order to contribute with helpful information for the management of this pest species, the aim of this study was conducted to compare the effect of different rice varieties against the BPH.

MATERIALS AND METHODS

Phenotypic screening for assessing the levels of resistance to BPH across the 3 major rice varieties (MR219, MR220, and MR220 CL1) was carried out involving two screening methods viz., Modified Seed-box Screening Test (MSST) and Days to wilt (DW) with some modification [6,7].

BPH Collection and Rearing

BPH was collected from the paddy fields at Tanjong Karang, Selangor, Malaysia and reared at the rain shelter in Faculty of Plantation and Agrotechnology, UiTM Puncak Alam Campus, Selangor following the method of Heinrichs with some modification [8].

Rice Varieties

The rice varieties of MR 219, MR 220, and MR 220 CL1 received from MARDI's Rice Germplasm Centre were screened for assessing their levels of resistance to BPH at seedling stage.

Seedling Stage Screening by Modified Seed-box Screening Test (MSST)

The MSST was used to assess the levels of resistance to BPH across the rice accessions at the seedling stage. Screening was done according to the standard evaluation system (IRRI, 2010) with some modifications. The experiment was conducted at a temperature of 28 to 30°C and relative humidity of 70% to 80%. The seed box was filled with sterilized soil for about one inch thickness. After the leveling of soil, holes were prepared in equal distance to sow the seeds. The seeds were pre-soaked and sown in rows in 60 cm x 45 cm x 10 cm seed boxes. 25 to 30 seedlings per row were maintained per varieties. All agronomic practices were carried out properly to maintain the seedlings of rice varieties. Before imposing treatments, it was also confirmed that plants were free from eggs of any insects. The experiment was arranged in a completely randomised design (CRD) with five replications.

Tillering Stage Screening Based on Days to Wilt Method (DW)

Days to wilt was used as a measure of tolerance where the damage by BPH population on each accession was decided by counting the number of days required to kill the plants after insect infestation. Pre-germinated seeds were sown on 15 cm diameter clay pots and emerging seedlings were caged with cylindrical mylar sheet cage (14 cm x 110 cm). 50 numbers of first to second instar nymphs were released on the plants and allowed to feed 45 days after sowing. The day on which the plant wilted completely was recorded. The experiment was conducted in a Complete Randomized Block Design (RCBD) with five replications for each variety.

Data Analysis

The seedlings were observed daily, and the damage were graded by using Standard Evaluation System (SES) released by International Rice Research Institute (IRRI, 2008) (Table 1). The data were analyzed by variance (ANOVA) while to distinguish the mean between treatments DMRT test was conducted at the level of 5%.

Table 1: Scale Based on Standard Evaluation System for Rice (SES)

Scale	Description	Reaction
0	No damage	Highly resistant
1	Very slight damage	Resistant
3	One or two leaves were yellowing or slight stunning	Moderately resistant
5	More than half the leaves shrunk	Moderately susceptible
7	More than half of the plant dead and remaining alive	Susceptible
9	Whole plant dead	Highly susceptible

RESULTS AND DISCUSSION

In this study, MR220 CL1 was found to be with minimum damage score of 1.90 indicating the highest level of resistance to BPH, whereas MR220 was found to be with damage score of 9.0 indicating their high susceptibility. MR219 was moderately resistant to BPH according to the evaluation standard of rice resistance to planthoppers (Table 2). Though MSST differentiates resistant and susceptible genotypes it cannot clearly expose the causes behind resistance or susceptibility. The accessions screened based on MSST were subjected to another screening method developed by Soundararajan wherein known number of insects were allowed to infest individual rice plants 45 days after sowing and the number days taken for the complete wilting was observed [6]. The data generated from this method based on days to wilt is clearly quantitative and differentiates the accessions without much overlapping.

Table 2: Mean Scores for the BPH Resistance across Rice Varieties Screened by MSST Method and Days to Wilt

Varieties	Damage score	Days to wilt
MR219	5.77	19.13
MR220	9.00	10.00
MR220 CL1	1.90	14.50

Out of 3 rice varieties screened, MR220 wilted 10 days after infestation with BPH whereas MR219, took 19.13 days after infestation indicating high level of tolerance to BPH attack. MR220 CL1, which was found to be with high level of resistance based MSST score over the other varieties wilted 14.50 days after infestation indicating clear difference between the two methods adopted. The comparison made between damage score by MSST and days to wilt across the 3 rice varieties indicated more variations for days to wilt when compared to damage score (Table 3 and 4).

Table 3: ANOVA for Damage Score by MSST Method

Source	df	SS	MS	F	PROB
Replication	5	1.853	0.926		
Genotype	3	169.815	7.075	8.64	0.000**
Error	15	39.266	0.818		
Total	23	210.0935			

TABLE 4: ANOVA for Days to Wilt

Source	df	SS	MS	F	PROB

Replication	5	70.940	10.134		
Genotype	3	4049.920	168.746	18.943	0.000**
Error	21	1496.560	8.908		
Total	31	5617.420	28.228		

Among the rice varieties mainly cultivating in the Tanjong Karang, MR 219 was released previously as resistant whereas at present the nature of these varieties has been changed to moderately resistant and susceptible respectively. Whereas the resistant characteristics exclusively disappeared in MR220, which was recorded as moderately resistant variety in early, though susceptible presently. Simultaneously MR220 CL1 stands still as moderately resistant [5].

Rice varieties that are often cultivated by farmers in Selangor are MR219, MR220 and MR220 CL1. At the beginning, the released and popular Malaysian rice varieties were evaluated for resistance assessment against BPH. This was later followed by screening of varieties obtained from the International Rice Research Institute (IRRI) of Philippines [5]. Several identified resistant varieties were then utilised as donor parents in a local breeding programme. However, as the plants grow, it gradually becomes within more favourable environmental conditions for pests' population. The types of crops varieties may consist of different nutrients and different plant traits such as, its physical and physiological appearance that may incline towards attracting the brown planthopper population [2].

CONCLUSIONS

This study is important to study the interaction of the BPH in different types of rice varieties that commonly used in the study area. The findings are an attempt to provide adequate knowledge in recommending potential farmers to select the best variety, which is more resistant to BPH attacks. Based on results aforementioned, the rice varieties MR220 CL1 and MR219 would be the ideal source of resistance for breeding rice crop for resistance against BPH. However, in order to recommend the rice varieties from the tested varieties, the similar screening study should be repeated. Different findings stated that there might be a chance to drift off the performance of rice varieties, like nutrient contents, vigorous of plants and growing under different climatic conditions.

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MASS REARING OF BLACK SOLDIER FLY AS A PROTEIN SOURCE FOR LIVESTOCK AND COMPOST PRODUCTION

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ABSTRACT

The black soldier fly (BSF), *Hermetia illucens*, is a non-pest insect that is native to tropical and subtropical regions around the world. BSF larvae are voracious feeders and can consume a wide variety of organic waste materials, including manure, food scraps, and agricultural byproducts. In recent years, there has been growing interest in using BSF larvae as a sustainable source of animal feed due to the traditional plant-based protein becoming increasingly expensive and unsustainable. *Hermetia illucens*, is one of the most promising insect species for use as a livestock protein source. BSF larvae have a high protein content, ranging from 40-60% of their dry weight, and are a rich source of essential amino acids and minerals. The nutritional composition of BSF larvae can be further improved by supplementing their diet with specific nutrients. Additionally, BSF are easy to cultivate and have a fast life cycle, which makes them attractive for mass rearing. BSF eggs were obtained from a colony that is maintained at Unique Biotech Sdn. Bhd. facility at Sepang, Selangor. Larvae were reared on a variety of substrates, including grains, food scraps, and agricultural by-products. The substrate was mixed with water to a moisture content of 60-90%, and then the larvae were added to the substrate. The larvae fed on the substrate and grew for approximately 2-3 weeks, at which point turned to prepupae. For every 1000 grams diet supplied it can feed between 400 - 500 BSF with a weight ranging from 0.01 – 0.2 gram each. While the compost and frass produced is about 500 grams. BSF rearing through this method can preserve the environment by fully utilizing the food and agriculture waste. The BSF larvae produced can be used as a protein source for livestock while the frass can be used as a compost fertilizer.

Keywords: Hermetia illucens, insect rearing, BSF, decomposer, protein source

INTRODUCTION

The black soldier fly (BSF), *Hermetia illucens*, is a non-pest insect that is native to tropical and subtropical regions around the world. BSF larvae are voracious feeders and can consume a wide variety of organic waste materials, including manure, food scraps, and agricultural byproducts [1]. In recent years, there has been growing interest in using BSF larvae as a sustainable source of animal feed due to the traditional plant-based protein becoming increasingly expensive and unsustainable. There are several advantages to using BSF larvae as animal feed. First, BSF larvae are a high-quality source of protein and fat. Second, they are a sustainable source of feed, as they can be reared on a variety of organic waste materials.

Black soldier fly is one of the most promising insect species for use as a livestock protein source. BSF larvae are rich in protein, comprising 40–60% of their dry weight, and serve as an excellent source of essential amino acids and minerals. The nutritional composition of BSF larvae can be further improved by supplementing their diet with specific nutrients. Additionally, BSF are easy to cultivate and have a fast life cycle, which makes them attractive for mass rearing.

MATERIALS AND METHODS

Rearing location
Rearing facility located in Insect Rearing Room, Biological Control Laboratory, MARDI Serdang. For the start BSF eggs were obtained from a colony reared by Unique Biotech Sdn. Bhd. at Sepang, Selangor.

Prepare the substrate
The first step is to prepare the substrate on which the larvae will be reared. The substrate that has been used in this study were a mixture of corn and wheat (CW), plant waste (PW), wheat (W), soybean (SB) and corn (C) as the control. The 500 grams for each type of substrate then was mixed with water to a moisture content of 60-90% to ensure that the newly hatched larvae had enough moisture to survive and grow. A total of 5 grams of BSF egg was then placed on each substrate with tissue dressing.

Larvae rearing
After 3-4 days the eggs were hatched and the newly hatched BSF larvae or called neonate were consumed by the substrate. The larvae fed on the substrate and grew for approximately 2-3 weeks, at which point turned into prepupae. Each treatment is given 500 grams of substrate and changed and added once a week (figure 1).

Maintain the temperature and humidity
The ideal temperature and humidity of the rearing environment is important for the optimum growth and development of the larvae. The temperature and relative humidity (RH) were set at 25-30ºC and 60-90%.
Monitor the larvae and data collection
The larvae were monitored regularly to ensure that they were healthy and growing properly. The larvae regularly checked for pests and diseases, and the substrate was replaced when needed. The larvae weight and body size were recorded every week and total number of larvae were counted after the larvae turned into prepupae.

Pre-pupae harvesting
The larvae were harvested when they turned into pre-pupae. These mature larvae were about 2 cm long and brown or black in color. The larvae were harvested by sieving the substrate and then the larvae were picked up by the hand. The harvested larvae then were dried into the microwave oven in 10 minutes. After that the larvae were ground using the laboratory miller IKA® WERKE MF 10 basic on 4000rpm with 1mm sieve for further analysis.

Figure 1: Rearing methodology for BSF

RESULTS AND DISCUSSION

Growth of H. illucens larvae
Weight, body size and total number of *H. illucens* were recorded over the study period to see if there was a difference between the treatments given. Results from the study showed that the BSF larvae given the substrate C had the highest weight, body size and number of larvae per 100 grams of substrate followed by SB, W, PW and the lowest was CW (figure 2, figure 3 and figure 4).

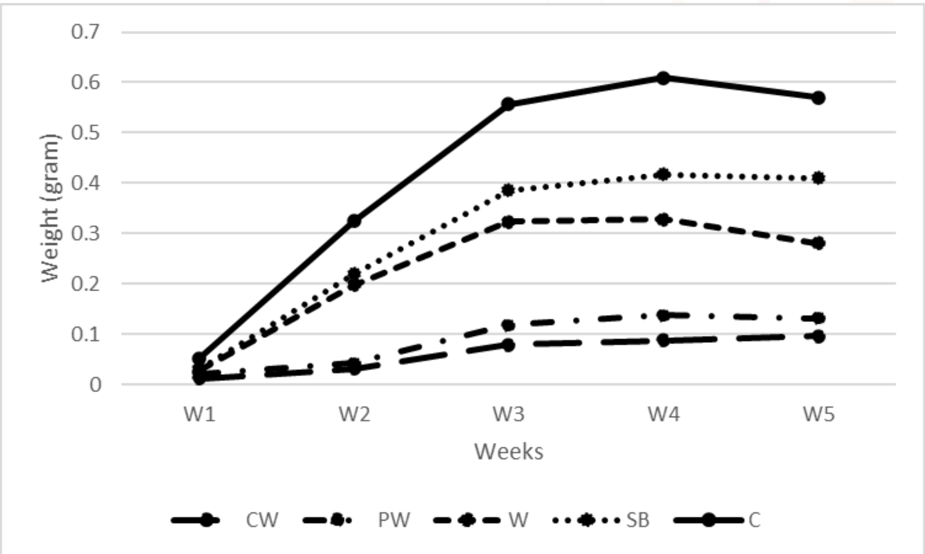

Figure 2: The weight of the BSF larvae given the different substrate over a period of 5 weeks

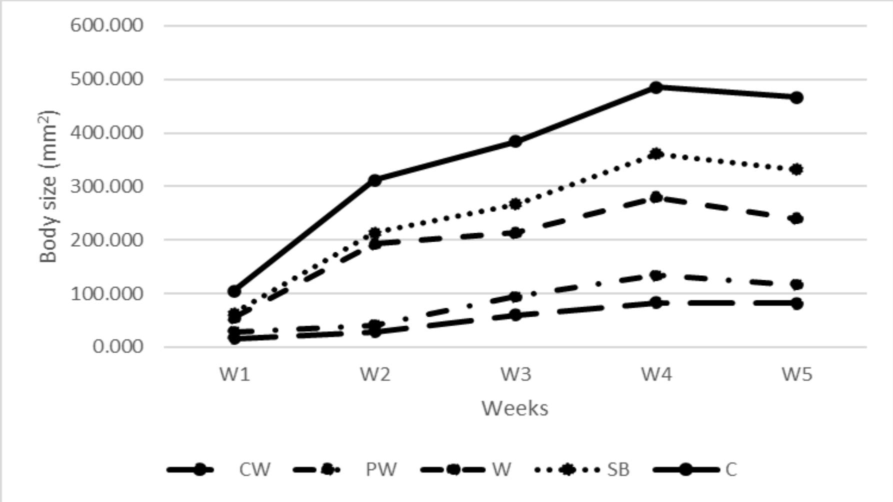

Figure 3: The body size of BSF larvae given the different substrate over a period of 5 weeks

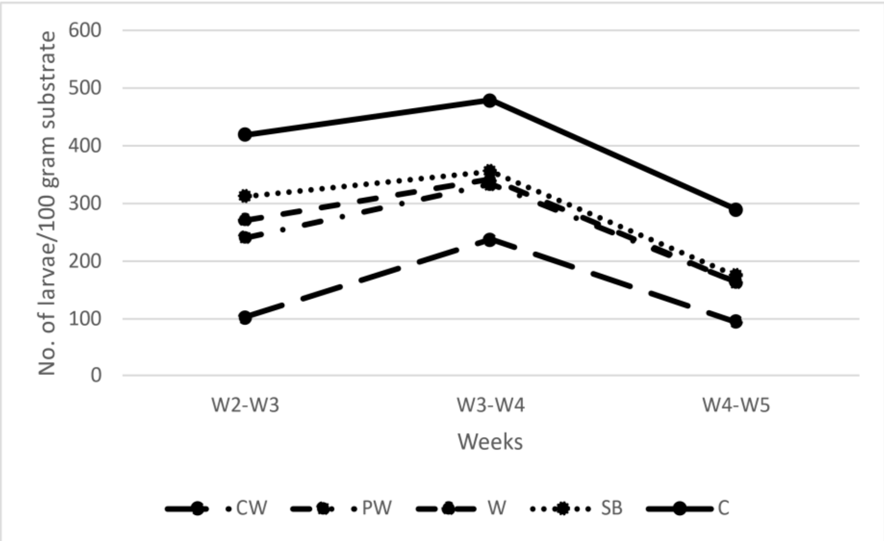

Figure 4: The number of the BSF larvae per 100-gram substrate given the different substrate over a period of 5 weeks

The yield of frass and larvae of BSF

The harvested yield of frass and BSF larvae recorded after the study showed no significant differences between the types of substrates given (figure 5). For every 2000 grams of substrate, the yield of BSF larvae obtained was around 200 – 800 grams while frass was between 200 – 400 grams. The reduction in the substrate recorded ranged from 80 – 90%.

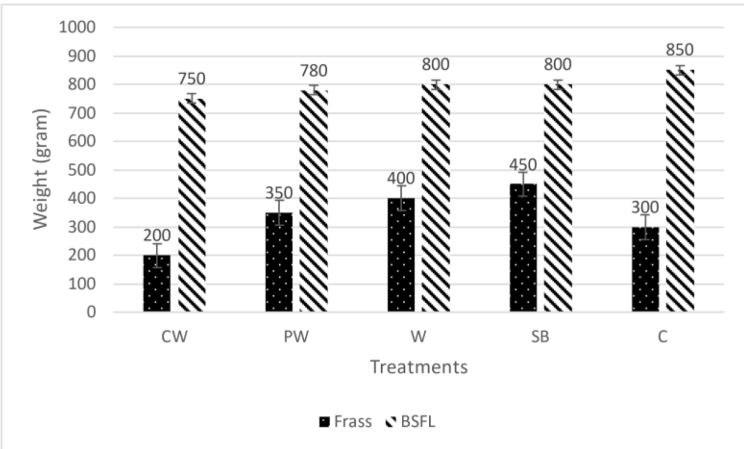

Figure 5: The yield of frass and BSF larvae according to the type of substrate given to the BSF

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CONCLUSIONS

From this study it can be concluded that the BSF larvae can convert all the substrates given to frass that can be used as components of compost fertilizer and BSF larvae that can be used as a source of protein. However, high fibre-containing substrates such as plant residues can cause stunted growth of BSF larvae.

ACKNOWLEDGEMENTS

Much grateful to the Director of the Agrobiodiversity & Environment (BE) Research Center and the Deputy Director of the Biological Control Program for their support in conducting this research. I would also like to thank the Biological Control Program staff for their direct and indirect contributions to the fieldwork or laboratory work.

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APPLICATION OF PARASITOID TO MANAGE CRUCIFERS PEST, *Plutella xylostella*, IN CAMERON HIGHLANDS THROUGH FARMERS' FIELD SCHOOL (FFS) APPROACH

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ABSTRACT

Diadegma semiclausum is a major pest's natural enemy of the cruciferous plant, *Plutella xylostella*. The tiny hymenoptera insects were brought over from Australia in the late 1970's and have been used as the biological control agents to control *P. xylostella* pests in vegetable farms around Cameron Highlands. Biological control agents are a vital part of Integrated Pest Management (IPM), where synthetic pesticides are minimally used according to recommended procedures. In 2019, MARDI re-launched *D. semiclausum* in Cameron Highlands and they were mass-reared in the insect rearing laboratory. These agents were then released to selected vegetable farms around Cameron Highlands to assess its effectiveness and the stability of the population in the field. More than 20 vegetable growers around Cameron Highlands attended a session of Farmers' Field School (FFS) in December 2019; where farmers were introduced to the IPM concept and the use of biocontrol agents to control *P. xylostella* pests. Six farmers from Habu, Batu 33 (southern zone), Sg. Palas, Sg. Mensun (central zone), and Ulu Telom, Kg. Raja (northern zone) were selected for scheduled release of *D. semiclausum* into the vegetable garden. Each farm was visited three times within a month throughout the study. For each visit, the number of *D. semiclausum* and *P. xylostella* populations on the farm was documented, and a pupa sample was brought to the laboratory to record *D. semiclausum* parasitism rate on the farm. In addition, 100-200 adult of *D. semiclausums* were released at the farmers' farm with each visit. The farmers were trained to identify biological control agents and beneficial insects on their farms. Farmers were also given guidance on the procedure for the proper use of pesticides and the selection of more eco-friendly pesticides. Data observation showed that *D. semiclausum* population recorded an upward trend while *P. xylostella* showed a downward trend throughout 3 visits. This trend indicates the effectiveness of *D. semiclausum* in the field. As for the parasitism rate, the laboratory rate for *D. semiclausum* was at 83.33% (normal rate) while the parasitism rate in the farm ranges from 43% to 73.33%. The low rate of parasitism in the fields is because the population of *D. semiclausum* is still unstable in the fields.

Keywords: biological control agent, IPM, farmers field school, *Diadegma semiclausum*, *Plutella xylostella*

INTRODUCTION

Plutella xylostella is the major pest of the crucifers crop which is widely grown in the Cameron Highlands. Attacks by these pests cause losses of up to 90% on farmers' yield [1]. To overcome this problem, most farmers use synthetic chemical pesticides intensively and exceed the prescribed dosage [2]. This situation causes pollution to the environment and harms the health of consumers due to the effect of the remaining remnants of pesticides on the harvested vegetables. The use of biological control methods using natural enemies of these pests is one of the good strategies to reduce the use of chemical pesticides on farms.

Biological control is one of the components of Integrated Pest Management (IPM) which uses the natural enemies of a pest to control the pest population. Among the natural enemies that are regularly used are predators and parasitoids. There are some predators or parasitoids that are natural enemies of *P. xylostella*, such as *Diadegma semiclausum*, *Diadromus collaris*, *Cotesia vestalis* and so on [3].

Diadegma semiclausum is an endoparasitoid of the Ichneumonidae family that makes the larvae of *P. xylostella* a host to hatch their eggs [4]. Usually, this parasitoid attacks the second and third instars of the *P. xylostella* larvae by injecting its eggs into the body of the larvae and completing its life cycle inside the larvae before coming out as an adult [5]. The life cycle of *D. semiclausum* is for 12 – 19 days compared to *P. xylostella* for 18 – 26 days. Their shorter life cycle gives them the advantage of reproducing faster than *P. xylostella* [6]. This species is also more dominant in highland areas and has been found to be more effective at controlling *P. xylostella* in that area [7].

The objectives of this project are to promote the use of biological control agents among farmers in Cameron Highlands in managing crop pests, to guide farmers to practice safer farming methods of using natural enemies of pests and to use pesticides in proper way and to evaluate the population of pests, *P. xylostella* and biological control agent, *D. semiclausum* in farmers' farms.

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MATERIALS AND METHODS

Materials

Diadegma. semiclausum was reared in the biological control agent rearing laboratory at MARDI Cameron Highlands at temperatures between 20 – 27^{o}C and relative humidity (RH) between 80 – 90%. Adults of *D. semiclausum* were given a diet of diluted honey solution at a ratio of 30 (honey): 70 (water), while the larvae of *P. xylostella* were used as a host for the breeding of *D. semiclausum.*

Study location

Figure 1 shows the location of the farm for the study is divided into three zones, namely south, central and north according to the direction of the wind and the altitude of the zone from sea level. The southern zone includes Ringlet, Bertam Valley and Habu (ca. 1000 – 1100m), the central zone covers Tanah Rata, Brinchang, Kea Farm, Sg. Mensun and Sg. Palas (ca. 1200 – 1650m) and the northern zone covers Kuala Terla, Kg. Raja and Blue Valley (ca. 1200 – 1450m) [8]. There are six (6) farms that were conducted at the study site which were two (2) farms for each zone, namely Habu and Batu 33 (southern zone), Sg. Mensun and Sg. Palas (central zone) and Ulu Telom and Kg. Raja (northern zone).

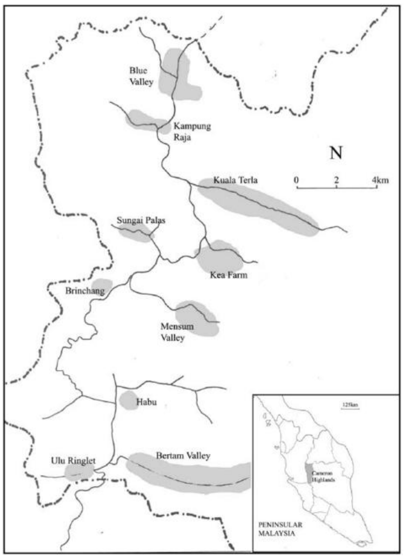

Figure 1: Map of the Cameron Highlands

Methods

Each farm was visited 3 times during the study period with the duration for each visit within 1 month. For each visit, the number of populations of *D. semiclausum* and *P. xylostella* on the farm was recorded and a sample of pupa *P. xylostella* was taken back to the laboratory to record the rate of parasitism of *D. semiclausum* on the farm. All the recorded data then were compared using plotted and bar graph. In addition to taking the study data, 100 – 200 adult of *D. semiclausum* were also released at the farmers' farm for each visit session and the farmers were also given training to identify biological control agents and beneficial insects on their farms (figure 2). Farmers were also given guidance on the procedure for the proper use of pesticides and the selection of more environmentally friendly pesticides (figure 2 and 3).

Figure 2: Guide farmers to carry out pest monitoring and biological control agents in the farm

Figure 3: Data collection and insect sampling

Figure 4: *D. semiclausum* released in the farm

RESULTS AND DISCUSSION

Plutella xylostella and D.semiclausum population

Population data for *P. xylostella* and *D.semiclausum* recorded in the study farms showed that there was a change from the first to the third visit. The population of *P. xylostella* was found to be decreasing while the population of *D. semiclausum* was found to be increasing in most farms (figure 5, 6 and 7).

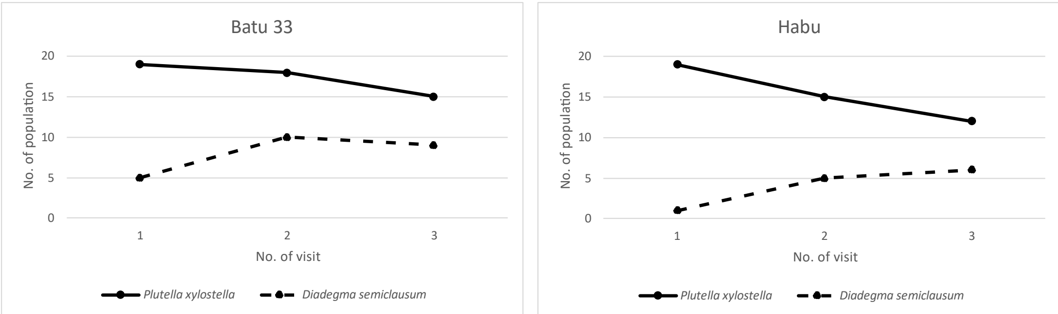

Figure 5: Number of populations of *P. xylostela* and *D. semiclausum* for three (3) times visit in southern zone

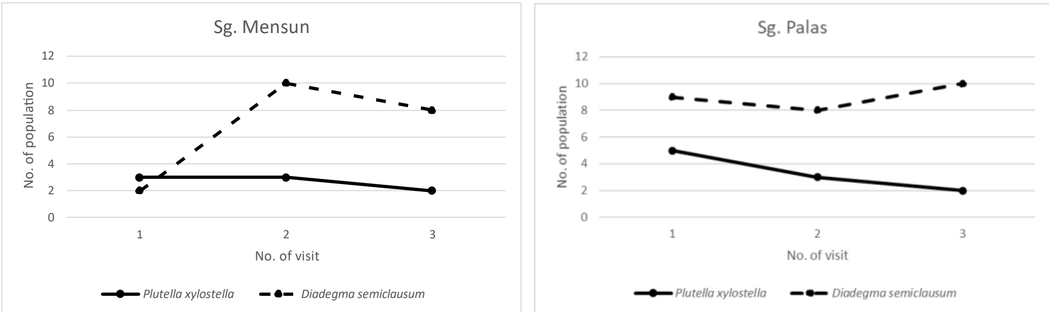

Figure 6: Number of populations of *P. xylostela* and *D. semiclausum* for three (3) times visit in central zone

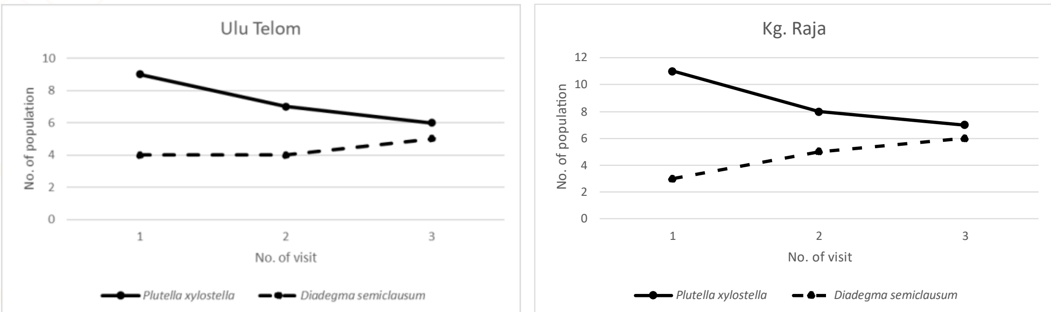

Figure 7: Number of populations of *P. xylostela* and *D. semiclausum* for three (3) times visit in northern zone

Based on a study conducted by Upanisakorn et al. *D. semiclausum* has parasitized the larvae of *P. xylostella* as early as the fifth week after the first released was carried out [9]. Consistent released over a short period of time can help stabilize the population of *D. semiclausum* in the field and provide a more effective effect. This periodic released of large amounts is known as augmentative biological control method in which a report by Perez-Alvarez et al. [10] shows that there was a positive interaction between the larvae of *Pieris rapae* and the abundance of parasitoids ($F_{1,44} = 6.273$, $P = 0.016$), by using this method.

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He also suggests that predation on insect pests' eggs were higher in complex landscape area than in simple landscape area but there were significant differences in predation at the larval level.

Parasitism rate of D.semiclausum

As for the parasitism rate, the laboratory rate for *D. semiclausum* is at 83.33%, which is the normal rate while the parasitism rate in the farm ranges from 43.00% to 73.33% (figure 8). The low rate of parasitism in the fields is due to the fact that the population of *D. semiclausum* is still unstable in the fields. This finding is in line with observations conducted by Upanisakorn et al. which found that the rate of parasitism of *D. semiclausum* was at 80% with an increase of 1.3% initially in early December 2005 to 27.3% in mid-March 2006, over quite a short period of only three-and-half months [9].

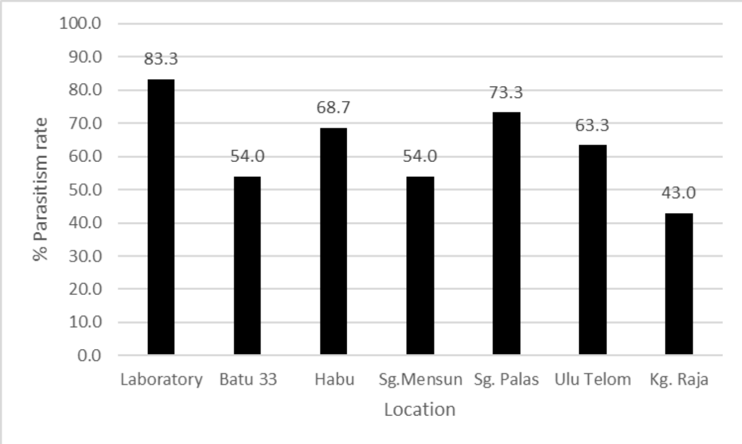

Figure 8: Parasitism rate of *D. semiclausum* reared in the laboratory and in the farms

CONCLUSIONS

From this study it can be concluded that the use of biological control agents can help control the reduction of the population of pests, *P. xylostella*, in farmers' farms. However, in order to ensure its effectiveness in the early stages, the scheduled release of *D. semiclausum* once a month should be carried out as the population is not yet stable. In addition, guidance to farmers for them to use pesticides correctly should be given prior attention.

ACKNOWLEDGEMENTS

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INFESTATION OF PARASITIC NEMATODE *Elaeolenchus parthenonema* ON OIL PALM POLLINATING WEEVIL, *Elaeidobius kamerunicus* IN PENINSULAR MALAYSIA

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ABSTRACT

The pollination efficiency of the oil palm pollinating weevil, *Elaeidobius kamerunicus* garnered much attention in the Malaysian palm oil industry due to reports on low fruit sets, especially in peat soil areas. Nematode infestation was among the factors that influenced the weevil's fitness and pollination efficiency. However, the parasitisation rate by *Elaeolenchus parthenonema* among the weevil population has not been thoroughly investigated. Hence, this study aims to quantify the rate of nematode parasitisation among the oil palm pollinating weevil in three oil palm plantations in Peninsular Malaysia. Adult *E. kamerunicus* were sampled from full anthesising male inflorescences spikelets on a quarterly basis throughout the monitoring period. Within the 10 hectares of the study plot, 150 palms were systematically selected and marked as recording palms. In vitro inspection on 30 of each adult and larval stage shows that the maximum adult female *E. parthenonema* infestations was only up to 10%, and the presence of nematode inside adult weevils is mostly at the juvenile stage. Furthermore, there was no significant reduction in adult weevils per spikelet (AWS) during the sampling period. Based on these findings, we conclude that the risk of nematode-induced mortality at the adult stage weevil was very low (<10%). Nevertheless, the continuous monitoring of nematode parasitisation is recommended to ensure the formation of good fruit sets in oil palms, especially in peat areas.

Keywords: Elaeis guineensis, pollinator population, parasitisation, coleoptera

INTRODUCTION

Fruit set in oil palms has been improved since the introduction of the palm pollinating weevil in early 1981 [1]. Over three decades, the oil palm pollinating weevil had a major contribution to the Malaysian oil palm industry, such as increments in fruit set [2], yield [3][4], and savings of an estimated USD60 million were able to be made, mainly resulting from discontinuation of manual hand pollination [1][5]. However, poor fruit set, declining in oil and kernel extraction rates (OER and KER) were reported from several parts of Sabah in the middle to late nineties [6]. It was reported that the low weevil population was associated with the indirect effects of weather changes [7] or mites and nematode infestation in the insect pollinator [4][8][9]. Prior to that, it was suggested that the insufficient number of weevils was caused by inbreeding depression [6]. This idea has been refuted after a report that the genetic diversity of *E. kamerunicus* in Malaysia was comparable to that of Papua New Guinea (PNG) and Ghana, ruling out the likelihood of inbreeding as a reason for the fall in pollinating weevil population [4]. Nonetheless, both of these causes have led to calls for Malaysia to introduce new breeds of weevils into oil palm plantations in order to boost the weevil population and fruit set. It was discovered that the production of oil palm was connected to the population of weevils, inflorescences, and the environment. The weevil is important in determining a healthy fruit set, although a bigger population of weevils may result in a worse fruit set and fruit to bunch ratio, most likely due to pollinator competition. The environment had a greater influence on the oil extraction rate (OER) and kernel extraction rate (KER) than the weevil.

MATERIALS AND METHODS

Site of study
Population monitoring of *E. kamerunicus* was conducted in several sites across Peninsular Malaysia. The study was conducted between the year 2014 to 2016 (Table 1). Ten hectares of young mature oil palm planting were selected. The recording palms were systematically selected, representing 10% of the total sampling area. Every tenth palm in the plot was marked using weather-resistant tape, giving 150 recording palms per site.

Table 1: Sites selected for Population Dynamic Study in Peninsular Malaysia

Sites	Soil Type	Palm Age	Period
FELDA Chuping 2, Kangar	Mineral (dry)	5	2014-2016
FELCRA Tembeling Tengah, Jerantut	Mineral (high rainfall)	4	2014-2016
Ladang Sg Bebar Selatan, Rompin	Peat	4	2015-2016

Samples of E. kamerunicus
Adult *E. kamerunicus* were sampled from full anthesising male inflorescences spikelets quarterly with ten fully anthesising male inflorescences from marked palms in the designated 10 hectares study plots. A total of nine spikelets with adult *E. kamerunicus*, three each from the top, middle and bottom part of the inflorescence, were cut using sharp secateurs and stored in individual plastic bags before being brought to the lab for further processing.

Counting of male and female inflorescences and sampling of anthesising male inflorescences
Anthesising male inflorescence numbers were determined, and the stage of anthesis was categorised as 25%, 50%, 75% or full bloom. The total number of anthesising female inflorescences was also determined and categorised as pre-anthesis, at-anthesis and post-anthesis. From the total number of anthesising male inflorescences, ten inflorescences, preferably those between 25% to 75% anthesis were randomly selected for adult weevil counting. From the ten inflorescences, nine spikelets with adult *E. kamerunicus*, three each from the top, middle and bottom part of the inflorescence, were cut using sharp secateurs and stored in individual plastic bags before being brought to the laboratory for further adult weevil counting.

Fruit Set Counting
A total of ten ripe fruit bunches from recording palms were harvested monthly using a harvesting chisel for the fruit set counting procedure. Each of the bunch was weighed using a mechanical scale (max weight 50 kg) before being chopped using a steel axe to separate the fruit-bearing spikelets from the stalk. The number of fruits with and without kernel was counted and the percentage of fruit set was calculated using a formula.

$$\text{Fruit set \%} = \frac{\text{Total number of fertile fruitlets}}{\text{Total number of fruits within the bunch}} \text{ x } 100$$

Nematode infestation
A newly dead weevil was placed on the glass slide and dripped with a drop of distilled water. The weevil's abdomen was carefully incised using a needle, and the number of nematodes present in each weevil was classified and counted into a juvenile and adult females. The percentage of adult female nematodes was calculated representing the parasitic stage of nematode.

RESULTS AND DISCUSSION

The laboratory finding revealed that the presence of nematode did not cause any significant effects on the adult weevils per spikelet (AWS) as shown in Figure 1, Figure 2, and Figure 3. This result suggests that the danger of mortality induced by *E. parthenonema*, which drastically reduces fruit set development, is extremely low. Nematode parasitisation achieved 10% while sampling on pupa during July 2014 at Ladang Sg Bebar shown in Figure 1. The nematode was present more than three times in adult stage but parasitisation percentages were very low.

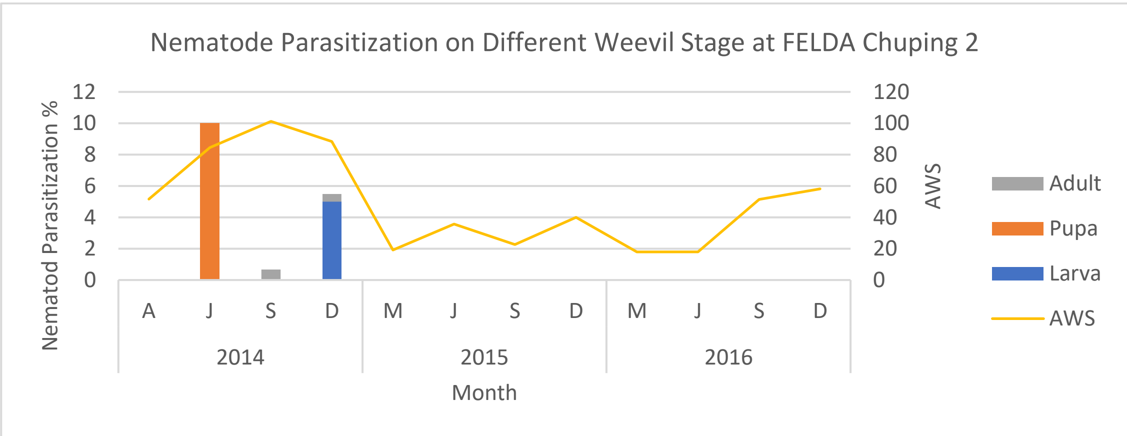

Figure 1: Percentage of nematode parasitisation on the different stages of weevil at FELDA Chuping 2

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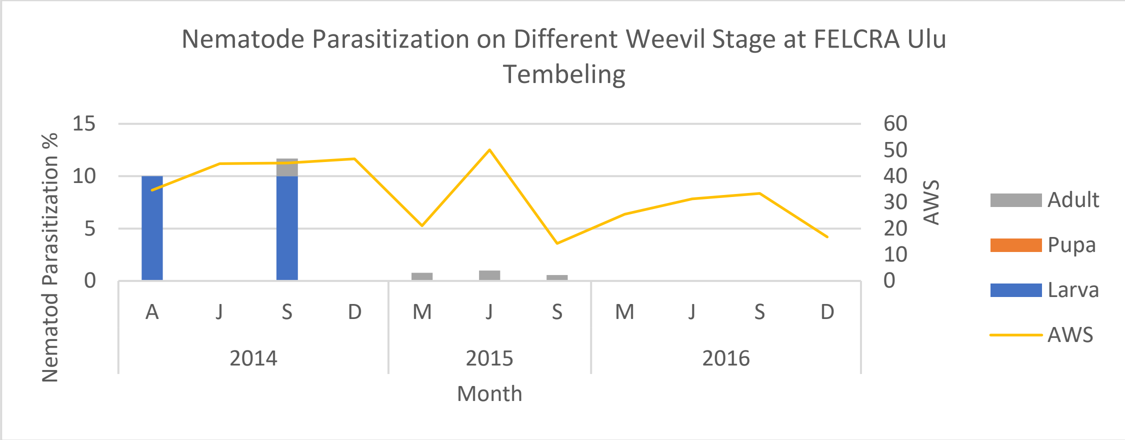

Figure 2: Percentage of nematode parasitisation on the different stages of weevil at FELCRA Ulu Tembeling

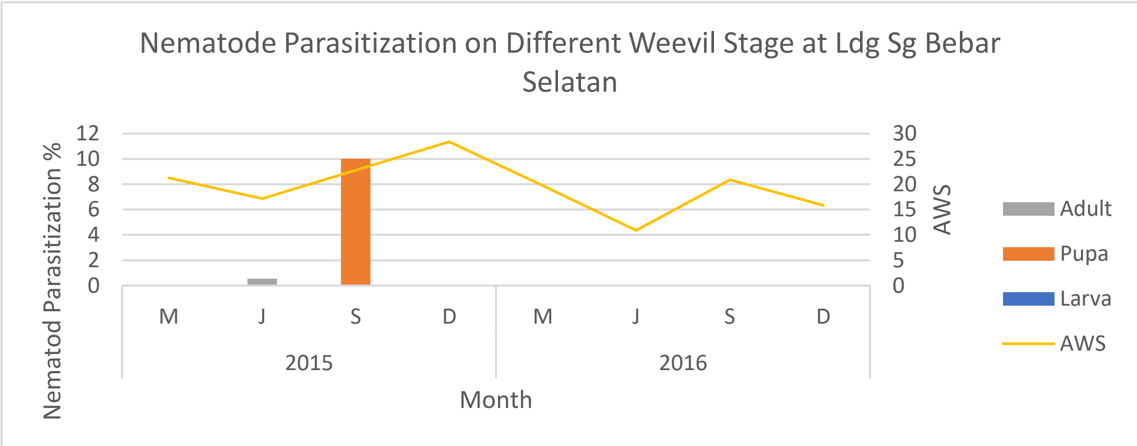

Figure 3: Percentage of nematode parasitisation on the different stages of weevil at Ladang Sungai Bebar Selatan

FELCRA Ulu Tembeling, as shown in Figure 2 also showed that the adult stage was frequently found to be parasitised by adult female nematodes but in a very low percentage. Figure 3 shows the same verdict on pupa for the peat soil area of Ladang Sg Bebar Selatan where the nematode parasitisation achieved 10%. Based on this study, adult female nematode occurs in every weevil stage. Even in the second phase of sampling, the nematode parasitism was still below 10%. Worryingly, nematode parasitisation reduced the life span of adult weevils by 37%, especially in severe parasitisation. It was observed that the presence of nematode was not consistent and fluctuated heavily. Perhaps, some other factors (i.e. humidity and palm age) might influence the level of parasitisation. *Elaeolenchus parthenonema* species was previously related to rain, as it was stated that the nematode population increased significantly after rain. This nematode is able to swim through its infective parthenogens by rapidly undulating their bodies and rising to the surface of water droplets. [8]. Based on the previous study, J3 nematodes (third juvenile stage) emerge from adult weevils via their reproductive system, mature to the infective stage adult in the floret, and enter the weevil larvae's haemocoel [8]. Because they feed inside the florets, the weevil is most likely to be parasitised during the late larva to pupa stages. Some adult nematodes may survive the weevil pupa stage. Although the number of juvenile nematodes is large, their sex is only known in the adult stage. The amount of female adult nematodes is a factor that may affect the weevil's longevity or pollination ability. Laboratory trials conducted have caused a high rate of infestation, which might possibly reduce the life span and fecundity of the weevil.

CONCLUSIONS

Nematode infestation at the three study sites was found to be lower than 10%. It was found that at this rate, the nematode parasitisation does not affect the weevil population and the formation of fruit sets. Pollinator force at anthesising female inflorescences is important as it reflects the number of possible pollinating visits by the pollen-carrying weevils from the anthesising male inflorescences to receptive female inflorescences.

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A SURVEY OF THE EFFECTIVENESS OF *TURNERA* PLANTS IN ATTRACTING PARASITOIDS IN PADDY FIELD

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ABSTRACT

Beneficial plant like *Turnera* offers a rich source of nectar to a variety of insects, particularly parasitoids, thus sustaining them in the field. However, studies on the effectiveness of *Turnera* plants in paddy fields in influencing the number of parasitoid populations are still lacking, particularly in Malaysia. Therefore, this survey aims to identify parasitoids and determine their abundance in paddy fields cultivated with *Turnera* plants. The survey was conducted in the paddy fields located in Besut, Terengganu. To assess the parasitoids abundance, two paddy plots were surveyed; one plot included *Turnera* plants grown alongside the paddy, while the other served as a control plot without any *Turnera* plants. Three Malaise traps were randomly placed in each plot, and insects were collected on a weekly basis during the paddy off-season from March to May 2021. All collected insect samples were subsequently transported to the laboratory for sorting and identification. The survey identified a total of 101 parasitoids belonging to four families within the Hymenoptera order: Ichneumonidae, Braconidae, Chalcididae, and Bethylidae. The paddy plots with *Turnera* plants exhibited a significantly higher abundance of parasitoids, accounting for 73.3% of the total, compared to the control plots, which only accounted for 26.7%. The findings of this study highlight the significance of incorporating *Turnera* plants into paddy field ecosystems to sustain populations of parasitoids. This integration enhances pest management strategies in paddy fields, contributing to a more effective and sustainable approach.

Keywords: beneficial plant, parasitoids, paddy, *Turnera*.

INTRODUCTION

Insects rely on the paddy plant as their primary food source throughout the entire growth cycle, consequently, paddy fields serve as crucial habitats for these insects as they go through various developmental stages within a short span of time [1]. In order to combat pest infestations, pesticides have been widely employed. However, the regular use of insecticides diminishes the effectiveness of natural enemies, such as parasitoids, leading to outbreaks of insect pests. To address this issue, the implementation of biological control methods, such as planting beneficial plants like *Turnera*, has been proposed to enhance the population of beneficial insects like parasitoids in the field [2]. Due to this reasons, paddy farmers in Besut, Terengganu initiated a program in 2019 to introduce *Turnera* plants in selected paddy fields. However, no specific study has been conducted to evaluate the impact of planting *Turnera* in paddy fields, particularly in terms of attracting parasitoids. Therefore, the purpose of this survey is to assess the effectiveness of *Turnera* plants in attracting parasitoids in the paddy fields of Besut, Terengganu.

MATERIALS AND METHODS

Sampling Area and Method
The study was carried out in a rice granary at Besut, Terengganu, Malaysia (5°42'00.2"N 102°33'01.5"E). The study area comprises of two hactare of paddy fields, which the first plot is a paddy field cultivated with *Turnera* plants (Plot A), and control plot is a paddy field without *Turnera* plants (Plot B). Three Malaise traps were randomly installed at three different points in each sampling plot. The traps were left for three months, and the insect samples were collected weekly starting from 35 days after sowing (DAS). Collected insects were brought to the laboratory for isolation, counting and identification.

Parasitoids Identification and Calculation
Parasitoids were calculated and identified by sorting and enumeration from order up to the family level. All specimens were examined and identified under a stereomicroscope (Olympus SZ51, Japan) based on their morphological characteristics and family's keys according to [3] and other related references. The number of individuals per family from different plots were counted and recorded.

RESULTS AND DISCUSSION

Overall, a total of 101 individuals of parasitoids consisting of four hymenopteran families were collected from both plots namely Ichneumonidae, Braconidae, Chalcididae, and Bethylidae (Figure 1). The total number of parasitoids collected in Plot A was 74 individuals, which was significantly 73.3% higher than the parasitoids collected in Plot B (27 individuals, 26.7%). Among the families, Ichneumonidae had the highest number of individuals for both plots, with 44 individuals in Plot A and 19 individuals in Plot B, followed by Braconidae with 28 individuals in Plot A and 7 individuals in Plot B. Only one individual of Chalcididae was collected for each plot, while Bethylidae was only found in Plot A with one individual collected (Figure 1).

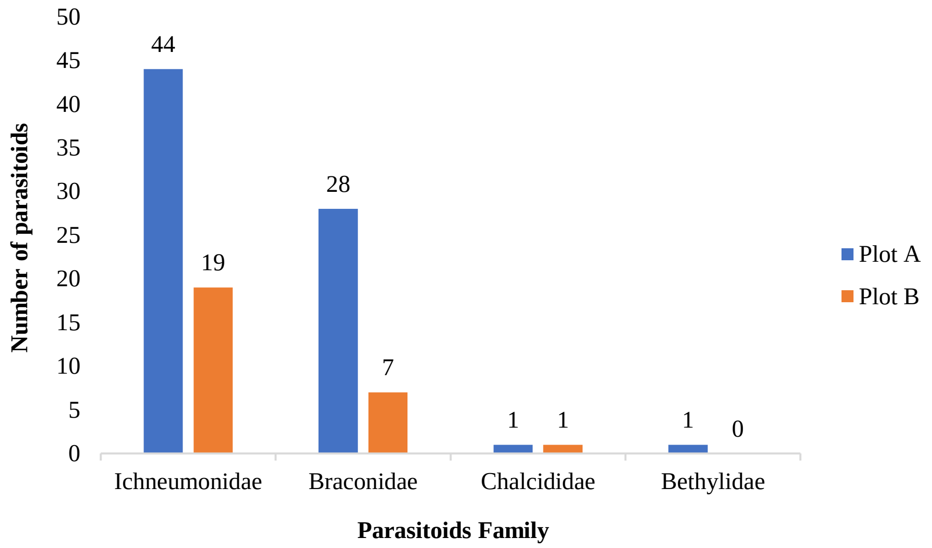

Figure 1: Total abundance of parasitoids collected in different paddy plots.

Based on Figure 1, the study revealed that the abundance of parasitoids collected was significantly higher in paddy plots where *Turnera* plants were planted (Plot A) compared to paddy plots without *Turnera* plants (Plot B). This indicates that the presence of *Turnera* in Plot A likely contributed to a more diverse community of hymenopteran parasitoids compared to the control plot. The higher abundance of hymenopteran parasitoids observed in Plot A, as opposed to Plot B, can be attributed to the availability of life support resources, such as insect hosts and nectar sources, provided by the *Turnera* plants. According to [4], *Turnera* plants are known to attract many insects due to their bright colours and rich nectar and pollen contents. Additionally, the presence of the plant might have influenced the abundance of parasitoids by providing shelter to the insects, as suggested by [5]. It was also shown that among the recorded parasitoid families, Ichneumonidae was found to dominate in terms of the number of individuals collected for both seasons. This could be attributed to the availability of various insect hosts in the paddy fields. [6] pointed out that larvae of Lepidoptera and Coleoptera are the most common insect hosts for Ichneumonidae.

CONCLUSIONS

In conclusion, the paddy plot cultivated with *Turnera* plants showed a higher abundance of parasitoids than the paddy plot without *Turnera* plants. This suggests that the presence of *Turnera* in paddy fields can have a positive impact on the abundance of parasitoids, which can help to control pests in paddy fields. Further studies may be needed to confirm the factors that attract beneficial insects to *Turnera* plants for better pest management strategies.

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ACTIVITY OF COCONUT-SHELL LIQUID SMOKE AS A BIOPESTICIDE ON THE RICE BROWN PLANTHOPPER (*Nilaparvata lugens* Stal.)

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ABSTRACT

Brown planthopper (BPH) is one of the main pests that attack rice plants. By the IPM concept, brown planthopper control can use environmentally friendly biopesticides, namely coconut-shell liquid smoke (CSLS). This biopesticide contents of chemical compounds that are suitable for controlling insects. This research aimed to determine the concentration of coconut-shell liquid smoke to control brown planthopper populations in the Ciherang variety. The experiment was conducted at Balai Besar Peramalan Organisne Pengganggu Tanaman (BBPOPT), Jatisari, Karawang Regency, from March 2021 to June 2021. The experimental design was used Randomized Block Design (RBD) with seven treatments and four replications. The treatments were: A (Control/no treatment), B (1% CSLS), C (2% CSLS), D (3% CSLS), E (4% CSLS), F (5% CSLS), and G (BPMC Insecticide). The results showed that all concentrations of coconut shell-liquid smoke could reduce the population of brown planthopper, and at a concentration of 5% CSLS gave 76.78% mortality with 73.17 population and an intensity attack of brown planthopper, respectively 23.15%.

Keywords: biopesticide, coconut-shell liquid smoke, *Nilaparvata lugens*, rice

INTRODUCTION

Brown planthopper (BPH), *Nilaparvata lugens* Stal. is a major insect pest on rice crops. It is a significant insect pest causing damage by sucking plant fluids so that the plants wither, dry out, and eventually look like they are burnt (hopperburn). These insect pests can also damage rice plants by transmitting grass dwarf virus and hollow dwarf virus, viruses that cause rice plants to become stunted and empty grains [1]. BPH attacks reduce rice yields, both qualitatively and quantitatively. BPH attack spots still occur in various regions, so it is necessary to watch out for the five-year cycle of this pest explosion.

The damage caused by BPH can lead to crop failure [2]. Rice production in 2020 amounted to 9.017 million tons of dry-milled rice, decreasing by 68.18 thousand tons or 0.75 percent compared to 2019, which amounted to 9.085 million tons of dry-milled rice [3]. Several significant pests, including the brown planthopper, cause a decrease in production. The area of attacks in West Java in 2019, which was 7,474 ha, increased in 2020 with an attack area of 13,232 ha with a puso area of 13 ha [4].

One alternative control to overcome BPH attacks is liquid smoke, which is thought to have potential as a biopesticide. Liquid or liquid smoke results from distillation or vapor condensation from indirect or direct combustion of materials containing many carbon and other compounds [5]. *Liquid smoke* is a smoke vapor condensate liquid resulting from wood pyrolysis containing the main constituent compounds of acids, phenols, and carbonyls due to the thermal degradation of cellulose, hemicellulose, and lignin components. The acid, phenol, and carbonyl compounds in liquid smoke have contributed to providing characteristic properties of aroma, color, and flavor as well as antioxidants and antimicrobials [6]. In addition, liquid smoke containing a number of chemical compounds is estimated to have potential as raw materials for preservatives, antioxidants, disinfectants or as biopesticides [7].

The raw materials widely used to make liquid smoke are coconut shells, wood, palm humps, sawmill dregs, and other biomass. Among the many essential ingredients that can be used as liquid smoke, coconut shells are abundant in the field. The chemical composition of liquid smoke derived from coconut shells has a phenol content of 5.13%, carbonyl 13.28%, and acidity of 11.39%. [8].

The role of liquid smoke as an insecticide is inseparable from the role of phenol contained in it. Phenols are insecticidal and toxic because phenols are highly caustic to tissues. If insects swallow phenols, they cause throat irritation and inflammation of digestive system [9]. Liquid smoke from wood has been applied as a pesticide for wood preservatives, fungicides,

insecticides, herbicides, and animal feed [10]. Palm kernel shell liquid smoke contains phenol compounds and propionic acid, which can inhibit fungal growth [11].
The laboratory research results [12] proved that grade 2 coconut shell liquid smoke is an effective insecticide against BPH. Pure coconut shell liquid smoke has a pH of 1.2 can be neutralized to a pH of 6.46 by adding calcium oxide as much as 7 grams per 100 ml. LC50 neutral coconut shell liquid smoke at a concentration level of 12.5% is suitable for development into application concentration because it is non-toxic to plants. Pure coconut shell liquid smoke (pH 1.2) is phytotoxic to rice seedlings at a concentration of 6.25%, while neutral coconut shell liquid smoke (pH 6.46) is phytotoxic to rice seedlings at a concentration of 25%. The aim of this research is to determine the activity and concentration of CLS as a biopesticide which can suppress the development of BPH populations on Ciherang rice varieties.

MATERIALS AND METHODS

Materials

CSLS grade-2 (Madinah LS), an insecticide BPMC (*Buthyl Phenyl Methyl Carbamate*), 3rd-instar BPH nymph, Ciherang rice varieties, and polybag were used in this study.

Methods

The experimental design was used Randomized Block Design (RBD) with seven treatments and four replications. The treatments were: A (control), B (1% CSLS), C (2% CSLS), D (3% CSLS), E (4% CSLS), F (5% CSLS), and G (BPMC Insecticide). When the rice plants contained in the polybags are 10 DAP (Day After Plant), a bamboo or iron lid frame with a zipper lid installed, each treatment consists of 5 polybags with 7 treatments and 4 replications. Investment in 3rd instar BPH nymph of 5 pairs per polybag at the age of 12 DAP. When the plants are 14 DAP, the number of BPH is recalculated, if it is reduced, add more so that it remains 5 pairs per polybag. After the number of BPH in each polybag is appropriate at 14 DAP, the application of CSLS will be tested in each treatment. The amount of CSLS that is sprayed in a calibrated manner is 3.125 ml (first application), 3.75 ml (second application), and 4.375 ml (third application) per polybag with concentrations according to treatment at 14 DAP, 42 DAP, and 70 DAP. Observational data was analyzed using ANOVA.

RESULTS AND DISCUSSION

Mortality of BPH

Based on the results of the analysis of the activity of CSLS on the development of BPH population in Ciherang variety rice plants, regarding the average mortality of BPH observed in 3 phases of in each phase, it was observed 1-7 days after application (DAA). The first mortality was observed began at ages 15 DAA. Second mortality was observed at ages 43 DAA. The third mortality observed at the age of 71 DAA (Tables 1 to 3).

Table 1: First Mortality of BPH

Treatment	Mortality (%)													
	1 DAA		2 DAA		3 DAA		4 DAA		5 DAA		6 DAA		7 DAA	
A = without	1,67	a	2,50	a	2,50	a	2,50	a	2,50	a	2,50	a	2,50	a
B = 1% CSLS	9,17	b	15,00	b	28,33	b	38,33	b	44,17	b	47,50	b	49,17	b
C = 2% CSLS	14,17	bc	20,83	b	35,00	bc	47,50	bc	55,83	bc	60,00	bc	63,33	c
D = 3% CSLS	17,50	c	24,17	b	39,17	cd	52,50	cd	65,00	c	72,50	c	74,17	cd
E = 4% CSLS	15,00	bc	24,17	b	40,00	cd	54,17	cd	64,17	c	72,50	c	75,00	cd
F = 5% CSLS	20,83	c	35,00	c	48,33	d	59,17	d	69,17	c	76,67	c	79,17	d
G = BPMC	87,50	d	87,50	d	87,50	e	87,50	e	87,50	d	87,50	c	87,50	d

Note : The average number followed by the same letter on column does not significant according to Duncan's Multiple Distance Test at 5% level

Table 2: Second Mortality of BPH

Treatment	Mortality (%)													
	1 DAA		2 DAA		3 DAA		4 DAA		5 DAA		6 DAA		7 DAA	
A = without	2,32	a	2,32	a	2,32	a	2,32	a	2,32	a	2,32	a	2,32	a
B = 1% CSLS	8,26	b	13,52	b	26,52	b	36,33	b	43,68	b	46,57	b	49,36	b
C = 2% CSLS	13,31	c	19,37	c	33,64	c	45,93	c	54,25	c	59,64	c	61,99	c
D = 3% CSLS	18,03	d	24,62	d	36,39	d	50,19	d	63,02	d	70,57	d	73,84	d
E = 4% CSLS	14,68	c	23,47	d	38,15	d	53,39	d	63,85	d	71,36	d	74,41	d
F = 5% CSLS	20,80	e	32,61	e	45,03	e	59,62	e	69,75	e	76,54	e	78,60	e
G = BPMC	84,12	f	84,12	f	84,12	f	84,12	f	84,12	f	84,12	f	84,12	f

Note : The average number followed by the same letter on column does not significant according to Duncan's Multiple Distance Test at 5% level

Table 3: Third Mortality of BPH

Treatment	Mortality (%)													
	1 DAA		2 DAA		3 DAA		4 DAA		5 DAA		6 DAA		7 DAA	
A = without	2,30	a	2,30	a	2,30	a	2,30	a	2,30	a	2,30	a	2,30	a
B = 1% CSLS	7,54	b	12,84	b	23,80	b	34,58	b	40,63	b	43,67	b	46,46	b
C = 2% CSLS	12,92	c	18,51	c	30,90	c	42,61	c	51,62	c	57,72	c	59,66	c
D = 3% CSLS	16,89	e	22,44	e	35,56	d	49,70	d	62,18	d	69,65	d	71,85	d
E = 4% CSLS	14,43	d	20,80	d	35,65	d	49,95	d	62,56	d	69,73	d	73,85	e
F = 5% CSLS	20,45	f	30,63	f	43,78	e	56,38	e	68,78	e	75,59	e	76,78	f
G = BPMC	76,22	g	81,16	g	81,16	f	81,16	f	81,16	f	81,16	f	81,16	g

Note : The average number followed by the same letter on column does not significant according to Duncan's Multiple Distance Test at 5% level

Based on the average observation results of the BPH mortality, the CSLS can control BPH compared to treatment A (control/no treatment). From the first to the third mortality, there was a slight decrease in its ability, and looked slower than the BPMC insecticide. The ability of CSLS to control is still under G treatment (BPMC insecticide). The percentage of death of BPH, 3% CSLS concentration in 3 DAA was obtained 39.17% (first mortality), 36.39% (second mortality), 35.56% (third mortality). These results are almost by research [12] in the laboratory which showed that the concentration of CSLS of 3.125% with a pH of 1.2 in 3 DAA caused the death of BPH by 42%. In this experiment, it was continued to 7 DAA so that the average mortality percentage for CSLS concentration was 3% from the average of the three mortalities obtained a mortality percentage of 73.2%. The liquid smoke from pyrolysis of empty palm bunches contains 3.56% phenol and 20.80% 4-methyl phenol. Phenols act as contact poisons, damage protoplasm, penetrate walls and precipitate cells. Phenols also cause damage to cells, denaturation of proteins, inactivate enzymes, and cause cell leakage. This can disrupt insect development and cause death in in these insects [13].

The liquid smoke component acts as a contact poison, an acetic acid compound that can damage the permeability of the insect cuticle, causing death. Contact (direct) liquid smoke application is better when compared to giving as bait or indirect application [14].

BPH Population

Based on the results of the analysis of the activity of CSLS on BPH population in Ciherang variety rice plants was observed begin 21 days after plant (DAP) every 2 weeks until 84 DAP (Table 4).

Table 4: BPH Population

Treatments	BPH Population (pcs)							
	21 DAP		42 DAP		63 DAP		84 DAP	
A = without	9,75	A	236,00	c	387,67	c	511,00	c
B = 1% CSLS	5,08	B	165,92	b	266,17	b	313,58	b
C = 2% CSLS	3,67	C	154,50	ab	256,00	b	235,50	b
D = 3% CSLS	2,58	Cd	140,08	ab	189,92	b	119,00	a
E = 4% CSLS	2,50	D	126,92	ab	196,42	b	114,08	a
F = 5% CSLS	2,08	De	146,67	ab	189,58	b	98,58	a
G = BPMC	1,25	E	93,17	a	90,25	a	38,42	a

Note : The average number followed by the same letter on column does not significant according to Duncan's Multiple Distance Test at 5% level

The population of BPH fluctuates due to the treatment of CSLS that suppresses the population; it is also influenced by environmental conditions such as temperature and humidity in the greenhouse. Although the population of BPH at treatment F (5% CSLS) at all age of observation is not significantly from treatment G (insecticide BPMC) but the population was higher than all treatments. When the plant has begun to dry, the BPH population is more dominant macroptera-shaped imago because there is no food source. The trigger for the increase in BPH population was caused by the presence of high nitrogen content in [15]. The N element absorbed by plants serves as a source of nutrition for BPH. Many plants absorb N elements with the amount occurring due to feed availability in the planting area report states that insects and egg laying influence the increase in BPH [16].

Intensity of BPH Attacks

Based on the results of the analysis of the activity of CSLS on intensity of BPH attacks in Ciherang variety rice plants was observed begin 21 days after plant (DAP) every 2 weeks until 84 DAP (Table 5).

Table 5: Intensity of BPH Attacks

Treatments	Intensity of BPH Attacks (%)			
	63 DAP		84 DAP	
A = without CSLS	20,37	d	96,30	e
B = 1% CSLS	7,41	c	70,37	d
C = 2% CSLS	7,41	bc	48,15	c
D = 3% CSLS	1,85	ab	27,78	b
E = 4% CSLS	1,85	ab	28,70	b
F = 5% CSLS	0,93	a	18,52	ab
G = BPMC	0,00	a	5,56	a

Note : The average number followed by the same letter on column does not significant according to Duncan's Multiple Distance Test at 5% level

At the age of 21 DAP to 56 DAP, there was no intensity of BPH attacks, and no analysis of variance or differentiation tests was performed. At the age of 63 DAP to the age of 84 DAP, the highest observation of the intensity of BPH attacks was shown by treatment A (control/ no treatment). In contrast, the most minor insensity of BPHs attacks was shown by plants treated with F (5% CSLS). At the age of 84 DAP, treatment F (5% CSLS) was significantly different from treatment B (1% CSLS) and treatment C (2% CSLS) but not significant to another treatments. Treatment G (BPMC insecticide) resulted in a lower intensity of BPH attacks that differed markedly from all treatments except with treatment F (5% CSLS).
The intensity of BPH attacks occur when the plant cannot withstand a very high population of BPH, so it becomes dry. The BPH are poignant and sucking insects, mainly sucking phloem sap, reducing chlorophyll and leaf protein content, and reducing the rate of photosynthesis [17]. Collections of imago and nymphs of BPH suck plant fluids, which causes plants to languish, grow stunted, yellow leaves, wither and eventually cause symptoms of brown leafhopper attacks called hopper burn or dry death [18].

Harvested Dry Grain Weight and Milled Dry Weight
Based on the results of the analysis of the activity of CSLS on harvested dry grain weight and milled dry weight in Ciherang variety rice plants are presented in Table 6.

Table 6: Harvested Dry Grain Weight and Milled Dry Weight

Treatments	Harvested Dry Grain Weight (g)		Milled Dry Weight (g)	
A = without	3,06	a	2,76	a
B = 1% CSLS	8,72	b	7,94	b
C = 2% CSLS	15,82	c	14,64	c
D = 3% CSLS	18,13	c	16,56	c
E = 4% CSLS	20,99	cd	19,12	cd
F = 5% CSLS	23,99	d	21,91	d
G = BPMC	33,37	e	30,45	e

Note : The average number followed by the same letter on column does not significant according to Duncan's Multiple Distance Test at 5% level

The table above shows that the CSLS gives a heavier weight of harvested dry grain weight and milled dry weight. Treatment F (5% CSLS) produced a heavier harvest dry grain weight significantly from treatment A (control/no treatment), treatment B (1% CSLS), treatment C (2% CSLS), and treatment D (3% CSLS) but not significantly with treatment E (4% CSLS). In contrast, treatment G (BPMC insecticide) produces heavier harvested dry grain weight significantly from all treatments. The weight of dry grain harvest shows that the yield of rice plants is indeed influenced by the level of health of the plant during its vegetative phase; if in the vegetative phase, the population of BPH is high, it produces dry grain harvest that is lighter than plants with fewer BPH populations because rice plants do not grow healthy or normal and grain filling becomes not optimal or empty. The weight of milled dry grain is a follow-up calculation of the weight of harvested dry grain, which is dried in the sun for approximately three days so that the moisture content is less than 14%. The value of milled dry grain is lighter than harvested dry grain. The highest harvested dry grain weight yeild is in treatment F (5% CSLS). However, the difference is not confirmed from treatment E (4% CSLS). In contrast, the treatment of G (BPMC insectide) differs markedly from all treatments.

CONCLUSION

The results showed that all concentrations of coconut shell-liquid smoke could reduce the population of brown planthopper, and at a concentration of 5% CSLS gave 76.78% mortality with 73.17 population and an intensity attack of brown planthopper, respectively 23.15%.

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EFFECTIVENESS OF *Cordyceps fumosorosea* WETTABLE POWDER FORMULATION AGAINST *Metisa plana* (WALKER) IN OIL PALM PLANTATION

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ABSTRACT

Metisa plana Walker is one of the bagworm species that cause significant yield losses in oil palm plantations in Malaysia. Since there is no effective way in managing this problem, the development of mycoinsecticides with *Cordyceps fumosorosea* as an active ingredient is established as an alternative way to control the bagworm population besides reducing chemical insecticide dependence. Three mycoinsecticide formulations (SS6, SS7, and SS8) with dispersing and wetting agents were developed as wettable powder formulations in this trial. SS8 demonstrated the best wettability, suspensibility, and dispersibility with viability at 10^7 Colony Forming Unit (CFU)/mL even after three months of storage. However, mycoinsecticide formulation SS7 developed with *Cordyceps fumosorosea* as an active ingredient was found to effectively reduce the bagworm population by more than 95%. Application of all mycoinsecticide formulations in the oil palm-infested area was able to reduce the *M. Plana* population by more than 95% after 30 days of treatments, comparable to flubendiamide. This finding indicates that *Cordyceps fumosorosea* has the potential to manage the bagworm in oil palm plantations.

Keywords: Bagworm, biological control, *Cordyceps fumosorosea*, entomopathogenic fungi.

INTRODUCTION

In Malaysia, three major bagworm species are documented as the most significant pests affecting oil palm plantations, namely *Metisa plana* Walker, *Pteroma pendula* Joannis, and *Mahasena corbetti* Tams [1]. Both *M. plana* and *P. pendula* can cause severe yield losses, up to 33-47%, with *M. plana* being the most economically significant and important defoliator [2]. During the outbreaks, the bagworm larvae devoured an enormous amount of the photosynthetic leaf areas of oil palm trees [3], thus affecting productivity in both the number and size of fruit bunches [4]. Without proper control, severely attacked palms can suffer high crop loss, which further affects the livelihoods of oil palm planters, especially the smallholders. Currently, chemical control using conventional synthetic insecticides is the main solution against bagworm infestation. Recent interest in eco-friendly entomopathogenic fungi has provided an alternative to conventional insecticides [5-7]. There are many ways of formulating entomopathogenic fungi, and the most common is as a wettable powder (WP). The recent development of inert WP ingredients such as dispersants and wetting agents has provided more options in the formulation of entomopathogenic fungi, particularly in the aspect of good wettability and infectivity of the fungi. A WP could provide long-term storage stability, good miscibility with water, and convenient application due to its compatibility with conventional spraying equipment [8]. Thus, the aims of this study are to prepare a physically and biologically stable WP formulation of *C. fumosorosea* mycoinsecticide and evaluate its field efficacy against *M. plana*.

MATERIALS AND METHODS

Preparation of wettable powder formulation of Cordyceps fumosorosea
Cordyceps fumosorosea (voucher number TSJ772C) coded as BSB01 was obtained from Bukit Senorang, Kemayan, Pahang, Malaysia (3.14°N, 102.38°E). It was then mass produced, and three WP mycoinsecticide formulations were prepared at the Toxicology Laboratory, University Putra Malaysia (UPM, Malaysia). *Cordyceps fumosorosea* WP formulations comprised of compatible wetting and surfactant agents were prepared by constructing a dispersant-wetting agent mixture called a surfactant system through a pseudoternary diagram. Formulations prepared were evaluated for its wettability, suspensibility, foam formation and sedimentation, and dispersibility.

Study site
The study was conducted on 5-year-old oil palm trees (*Elaeis guineensis*) at Felda Lepar Hilir 1, Pahang, Malaysia (3.65°N, 103.08°E). In the study, 522 trees set up in a randomized complete block design (RCBD) received five treatments with three replications. The treatments included the three formulated WPs, a standard practice flubendiamide (granule), and the control.

Samplling
The *M. plana* population was monitored pre- and post-census at 3, 7, 15, and 30 days after treatment (DAT). Frond number 17 was pruned from each sample palm, and the bagworms collected from each pruned frond were sorted, counted, and recorded

according to their larval stages; 1.3-2.5 mm, 2.2-3.2 mm, 3.5-4.4 mm, 4.4-6.5 mm, 7.3-8.8 mm, 7.6-10.1 mm, and 9.3-11 mm for the first seventh instar, respectively [9].

RESULTS AND DISCUSSION

Wettable powder formulation

The selected point X, D1:D2:W = 52:33:15 in figure 1 was subjected to physical evaluation with the addition of fungal propagules to the formulation mixture, which gives good suspensibility, dispersibility, and wettability. SS8 showed the best wettability performance, suspensibility test, and dispersibility with viability at 10^7 CFU/ml even after three months of storage.

Efficacy of formulations against the population of M. plana

Table 1 shows that all wettable powder formulations were effective and as good as the positive control. At 30 DAT, the highest mean population of bagworms was with flubendiamide treatment, and the lowest was with formulation SS7. Both pre-census and at 30 DAT, there was a significant difference in the reduction of bagworm populations. All in all, the population of bagworms was reduced below the economic threshold level (ETL), 10 larvae per frond, within 30 days of treatment application.

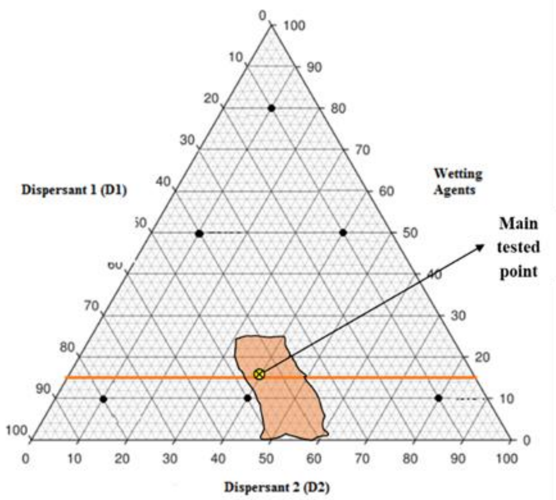

Figure 1: Point selected from the mutual stable region for all surfactant systems tested

Table 1: Mean population of *M. plana* at each DAT application

Treatment	Pre-census	3 DAT	7 DAT	15 DAT	30 DAT
SS6	41.0 ± 3.6 b	13.2 ± 3.8 bc	19.0 ± 7.1 a	7.9 ± 2.0 b	3.0 ± 0.8 b
SS7	39.0 ± 3.1 b	12.2 ± 2.3 c	14.2 ± 4.7 a	5.1 ± 2.0 b	2.3 ± 0.8 b
SS8	50.8 ± 2.8 a	29.0 ± 4.9 a	31.7 ± 6.2 a	11.0 ± 2.4 ab	3.1 ± 0.9 b
Flubendiamide	29.2 ± 1.8 c	25.0 ± 5.4 ab	18.7 ± 7.5 a	10.7 ± 3.1 ab	6.1 ± 0.8 ab
Control	34.3 ± 3.7 c	21.4 ± 4.5 abc	18.00 ± 4.4 a	15.6 ± 2.2 a	2.4 ± 0.6 b
P value	0.0016**	0.0719	0.6707	0.2789	0.0013**

*Note: Means followed by the same letter in the same column are not significantly different at 95% using Least Significant Difference (LSD)

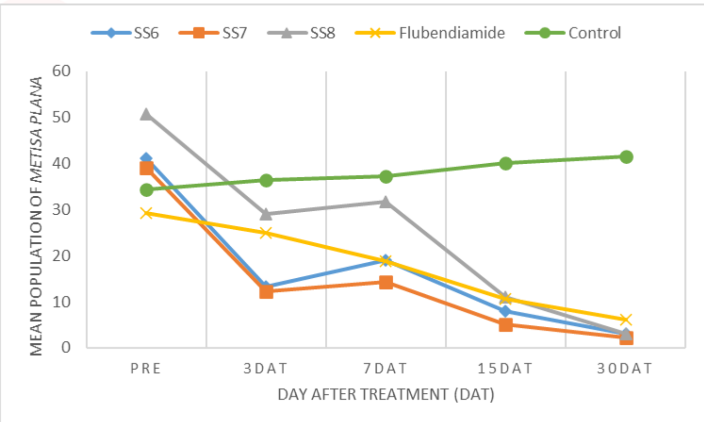

Figure 2: Mean population of *M. plana* at each DAT application

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CONCLUSIONS

The result of the study suggests that the application of all mycoinsecticide formulations in the oil palm-infested area was able to control the *M. plana* population. With the ability of this wettable powder to adhere on top of the bagworm's bag, this could be the key to success in preventing the outbreak of *M. plana*. However, the best way to control the defoliating pest is via oral uptake. Contact between the propagules and the insect body may only result in death if the propagules are able to enter the pest body through the pores or any other opening.

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EFFICACY EVALUATION OF LOCAL PLANT ESSENTIAL OILS TOWARD RED PALM WEEVIL, *Rhynchophorus ferrugineus* IN DIFFERENT LIFE STAGES

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ABSTRACT

The onslaught from red palm weevil (RPW) is getting serious as its arrival in Malaysia about 15 years ago, and its population spread to the whole peninsular throughout the times. This invasive pest insect is causing a worrisome problem, especially to all the oil palms and coconut trees in Malaysia. Current integrated pest management is heavily dependent on chemical control as such applying synthetic pesticides in spraying and trunk injection methods, yet these pesticides are detrimental to humans and ecosystems. This study aims to evaluate the effects of local plant essential oils (EO) against RPWs, while looking for an alternative that is able to replace these pesticides. Adult RPWs were collected by pheromone traps around coconut plantation areas in Terengganu state, then acclimatized and reared in laboratory to obtain larvae. Several contact bioassays were conducted among EOs and RPWs, including olfaction and gustatorial. Two plant EOs, *Cymbopogon citratus* and *Melaleuca cajuputi* are exhibiting antifeedant effect toward RPWs in different stages, which significantly reduce the prick-mark numbers and damage that caused on the food substrate that treated with 5% EO solution. While these two EOs show no repelling effect in olfactory bioassay. It is suggested that to carry out further analysis with these two EOs, thus developing an effective and eco-friendly bioinsecticide for suppressing RPW populations.

Keywords: Rhynchophorus ferrugineus, Cymbopogon citratus, Melaleuca cajuputi, essential oil, antifeedant activity

INTRODUCTION

Red palm weevil, *Rhynchophorus ferrugineus* (RPW) is a serious pest insect that causes massive destruction of palm plants around the world. RPW was invaded into Malaysia about 15 years ago, it then spread through the entire peninsular. This phenomenon is putting the six million hectares of coconut and oil palm plantations into a troublesome condition, also directly affecting the economy in Malaysia [1]. The difficulty to encounter RPW is no obvious early symptom that can be detected on the infested host plant, due to the concealing behavior of pests within the host. When late infestation symptoms such as umbrella-shape wilted crown are noticed, the host plant is commonly incurable and generations of RPW that within it are possibly matured and ready for the next destructive wave. Currently, chemical applications like trunk injection and crown spraying are heavily relied on to control the RPW populations. However, these pesticides, cypermethrin and methamidophos are also detrimental to the plant, ecosystems, as well as human health [2]. To overcome this situation, it is hoped to replace the synthetic pesticide with a natural and ecological friendly substance as an alternative. Hence, this study is aimed to evaluate the effects of two local plant essential oils against RPW through different bioassays, including olfactory and antifeedant activity (Figure 1).

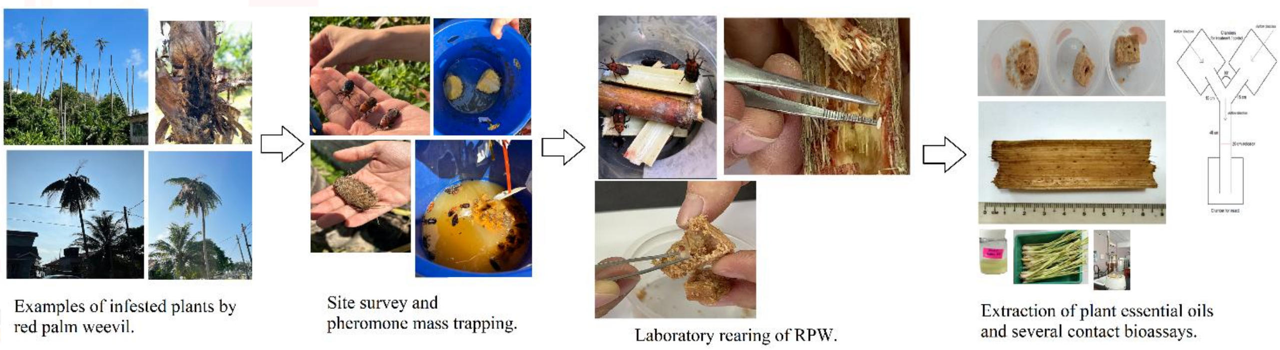

Figure 1: Supportive photos for introduction of red palm weevil and procedures.

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MATERIALS AND METHODS

Materials

Two local plants, which are lemongrass, *Cymbopogon citratus* and Gelam, *Melaleuca cajuputi* were purchased from local people and collected from Gelam forest in Bari Besar, Permaisuri, Terengganu respectively. These plants were obtained and used freshly for essential oil extraction through hydrodistillation method. Sugarcane, *Saccharum officinarum* and sago palm, *Metroxylon sagu* which were the food substrates for red palm weevil adults and larvae were purchased from locals.

Methods

Pheromone mass trapping was conducted around Kuala Nerus, Terengganu to collect wild weevils for further rearing in the laboratory [3]. Three contact bioassays were conducted, olfactory and antifeedant toward adults, also antifeedant toward third instar larvae. The Y-olfactometer was used for an olfactory experiment, in which adult red palm weevil was assigned to locomote through the tube and enter a chamber that contained control treatment or food that was treated with essential oil [4]. Prick-mark counting method was used for antifeedant activity toward adult RPW, in which the cumulative frequency of prick marks on sugarcane were consecutively observed and recorded [5]. In addition, no choice feeding bioassay was conducted for RPW larvae to compare the destruction level in control and food substrate that was treated with essential oils [1]. Datasets were then analyzed using SPSS.

RESULTS AND DISCUSSION

Olfactory bioassay

Both lemongrass and gelam essential oils showed no significant attractant or repellent effect toward the adult red palm weevil, regardless of its gender.

Prick-mark counting antifeedant activity

The prick marks on essential oil treated food substrates are significantly reduced compared to control treatment. The strength and durability of 5% and 10% essential oil solutions were determined.

No choice feeding bioassay

The consumption of treated food substrates (with 5% and 10% for each essential oil) by the larvae were significantly lower than control treatment, the feeding deterrent indices are at least 24%. Moreover, the weight change of instars in 10% lemongrass oil treatment was significantly lower than the instars in control treatment.

CONCLUSIONS

Both lemongrass and gelam essential oils showed promising results in antifeedant activity against red palm weevil adults and larvae, while there is no strong evidence to prove the attracting or repelling effect of these essential oils through olfaction mechanism. Further investigations such as RPW detoxification mode and chemical constituents of essential oils are required to be conducted for more information to ensure its effectiveness.

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IN VITRO EVALUATION OF SEVERAL CROP EXTRACTS AGAINST WHITEFLIES, *Bemisia tabaci* ON CHILI PLANT

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ABSTRACT

Whitefly, *Bemisia tabaci* is one of the pests that have a significantly negative impact on chili plants. This pest is a major destructive pest on various vegetable plant crops in Malaysia. Using chemical pesticides is the most effective and easy way to control whiteflies. However, using the same pesticides over time will provide high resistance to whiteflies. Thus, this study aims to compare the mortality rate of whiteflies after being sprayed with biopesticides made from natural extracts and to determine the efficient concentration of these extracts towards whiteflies. This study was conducted in the plant nursery and laboratory of Universiti Teknologi MARA, Arau, Perlis. The Maceration extraction method was used to extract onion, turmeric, garlic, lemon, and chili in primary treatments. The whiteflies were collected from the farm and brought back to the laboratory, where they were divided into 5 replicates for each treatment and sprayed with five different natural extracts according to the average level of concentration (50%). After the most effective extracts have been identified, the efficient extract was then sprayed on the whiteflies at different concentrations of 100%, 50%, 25%, 12.5%, 6.25%, and 0% with 5 replicates at each level. The whitefly mortality rate was recorded hourly for three hours after treatment. This study found that garlic extracts are efficient, and based on the LD50, 10.3% of the garlic extract was needed to eliminate 50% of the whiteflies. Meanwhile, at the LD90, 21.7% of garlic extracts were required to achieve 90% mortality of whiteflies for 3 hours after treatment. The findings can assist farmers to control pests by using this organic approach. However, further studies should be done on other plant crops to determine whether this treatment may produce the same impact as whiteflies on the chili plant.

Keywords: organic, whiteflies, *Bemisia tabaci*, chili

INTRODUCTION

Chili, *Capsicum annum* is a fruiting vegetable that is popular among the people of Malaysia. Commonly known as red chili, green chili, and pepper, these plants are typically cultivated in lowland regions. Perak, Johor, and Kelantan are the most important producers of chilies in Peninsular Malaysia. Growing chilies is a challenging endeavour. The whitefly (WF) pest, scientifically known as *Bemisia tabaci*, is a major destructive pest that can have a significant negative impact on the output of chili. It causes direct damage to chilies because it feeds on the phloem of the leaves and disrupts the photosynthetic process, which is necessary for growth and producing yield [1]. Alternative approaches are the use of resistant varieties or biological control. This research has been conducted to replace the pesticide applications that can cause pesticide resistance and harmful usage that could destroy natural enemies with the environmentally conserved technique. A few organic extracts of turmeric, onion, chili, garlic, limonene, and imidacloprid as a positive control were evaluated in controlling the whiteflies' mortality and the whiteflies' duration of mortality was tested under the different concentrations of the best extracts. This research includes both field and laboratory work.

MATERIALS AND METHODS

Materials
Turmeric, onion, chili, garlic, and limonene were used in this study while imidacloprid was used as a positive control.

Methods
Rearing of Whiteflies (Bemisia tabaci)
Colonies of *Bemisia tabaci* were reared in custom-made cages made of PVC pipe and plastic net and irrigated with a hand-held manual irrigation system. LED lights at night help them develop and multiply, and adults were collected from 3-5 days after maturity. From the rearing cage, a few leaves and plant parts of chili plants with the whiteflies were collected and placed in a ventilated plastic container and covered with a plastic mesh net to act as a lid. Each type of extract and different concentrations were replicated five times, and 1,200 adults were tested by a random sampling of 20 adults for each treatment.

Preparation of natural ingredients extracts
The maceration technique was used to extract 300g of natural samples. The plant material was finely cut using a knife and ground into moderately coarse powdered material. The extraction solvent, 500 ml of distilled water, was then poured on the plant material until it completely covered it. The solvent-to-sample ratio was 5:3. At the end of the extraction process, the

solvent was strained and separated from the solid residue material by filtration using a soft cloth or fine plastic mesh. The extracts were then transferred into 200ml glass bottles, weighed exactly, and kept refrigerated at -18°C for further analysis.

Different levels of extract concentration procedures

The most efficient garlic extract for whiteflies was identified by using an equation to calculate the different concentrations where C1V1 = concentration/amount (start) and volume (start), and C2V2 = concentration/amount (final) and volume (final). The garlic extracts with 100% purity were diluted into different concentrations of 50%, 25%, 12.5%, 6.25% except 0%. Six levels of concentration were tested.

Applications of organic extract to chili plants

The mortality rate of whiteflies was observed in a laboratory using five replicates of chili plants. The leaves were placed into a plastic container and 50% concentrations of onion, garlic, turmeric, lemon, and chili extracts were sprayed directly on the fine plastic mesh. The positive control was imidacloprid at 18.3% w/w [2]. The insecticide was diluted according to the recommendation rate followed by using the dilution equation. The data for the mortality rate was taken for 1 hour, 2 hours, and 3 hours after spraying with the treatments. The procedure was repeated with other organic extracts, including the different concentrations of garlic extract in the second experiment.

Whiteflies mortality evaluation

During the process of counting the whiteflies and determining the mortality, the ones that did not show any sign of movement while being stimulated were considered to be dead. This includes not breathing or flying away. The data was collected by number and was calculated in percentage as total of dead wf/total of observed wf x 100%.

Statistical Analysis

Two-way ANOVA was used to compare the effectiveness of different types of organic extracts (independent variables) towards the mortality rate of whiteflies (dependent variable). Next, the Tukey test was used to analyze the significant difference for each type of organic extract when the F-value was significant at $P < 0.05$. For the second experiment, the mortality rate of whiteflies after spraying with a concentration of the best organic extracts was analyzed by using Probit Analysis to obtain LD50 and LD90. All the analysis was conducted by using IBM SPSS software version 25.0.

RESULTS AND DISCUSSION

Mortality of Whiteflies (Bemisia tabaci) on different types of organic extracts

A statistically significant difference in the number of whiteflies mortality was found based on Figure 1. There was a difference in the mortality of whiteflies. The overall mortality numbers for these whitefly larvae were found the highest total mortality for adult whiteflies was obtained by garlic extract and the positive control imidacloprid which resulted in a mortality of 100% whiteflies after 3 hours. The lowest reading for total mortality number was recorded by the onion extract at 16%, which means the onion extract is the least effective in controlling whiteflies.

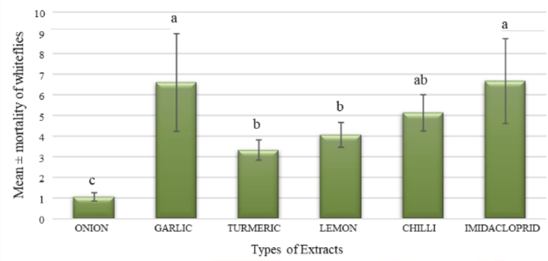

Figure 1: Mortality of whiteflies for each type of extraction

The data gathered were taken from the three trials of experiments for 3 hours to ensure consistency of results. The results found there was a statistically significant difference in the mean interest between the various types of extracts and the time, which means the mortality of whiteflies was influenced by the different types of extract applied. There is a difference in the amount of time required for whitefly mortality for every hour indicates 1 hour, 2 hours, and 3 hours. It takes a longer time for mortalities to occur in the onion, lemon, and turmeric extracts, compared to the garlic and chili pepper extracts. Moreover, there is an interaction that has a statistically significant influence on the mortality of whiteflies caused by the different types of extracts and the time period, and the significant value is less than 0.05 ($F_{10} = 29.170$, $p < 0.05$).

For each treatment level and type of extract, the following mortality rates were calculated as a total: for the first hour, the garlic extracts and imidacloprid had the highest mortality rates of 95% and 85%. However, the chili and lemon extracts performed the same results of the mortality rate of 34 % and 35 % respectively with a 1% difference. Followed by the turmeric extracts had a mortality rate of 24 %, and onion extracts had the lowest mortality rate of 16 %. For the second hour, the garlic extract and imidacloprid both have resulted in 100% of whiteflies mortality which indicates that garlic extracts need less than 2 hours to kill all the populations. The chili and lemon extracts were performed with mortality rates of 49 % and 52 % respectively with a 3% difference. After 3 hours all the extracts resulted differently, and all the extracts showed an upward trend in the mortality rate (Figure 2). This indicates that garlic extract is the most effective in controlling whiteflies, while onion extract is the least effective in controlling whiteflies.

For the second experiment, the results showed that the dose of the concentrations appeared to influence the mortality rates of the insects that were studied. The garlic extracts were tested on different levels indicating 100%, 50%, 25%, 12.5%, and 6.25% including 0% which is water (control). For a lethal dose of 50%, it was found that 10.3% of the garlic extract was needed to eliminate 50% of the whiteflies. Meanwhile, at the lethal dose of 90, 21.7% of garlic extracts were required to achieve 90% mortality of whiteflies for 3 hours after treatment. The analysis significantly gives the lowest LD90 values at a 95% confidence interval which is 10.271 % and 21.661 % respectively which indicate the highest potency among the treatment groups, 31% is the most garlic extract needed because it can induce 99% mortality on whiteflies (table 1). As observed from the results, this leads to the conclusion that the higher increment in level concentrations of garlic extract will result in a greater number of whiteflies being killed. Since this value was considerable, it can be concluded that the degree of concentration had a significant impact on the total number of whiteflies that perished. Additionally, based on the observations, higher concentrations tend to have a shorter duration for mortality, as opposed to the range for the mortality of whitefly was found to be more than three hours for lower concentrations. Similarly, to prior research, the higher the concentration of extracts used, the more positive reactions it will have [1] in order to give a fast effect on mortality for the whiteflies.

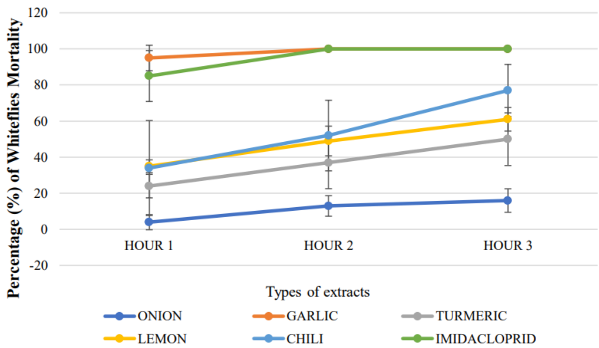

Figure 2: An interaction on the mortality of whiteflies caused by the different types of extracts and the time period.

Mortality of Whiteflies (Bemisia tabaci) on different levels of concentrations of the efficient organic extracts

Table 1: Lethal Dose (Ld) for 50% and 90% Mortality of Whiteflies Treated with Garlic Extracts.

Lethal Dose	**Lethal Dose for Garlic Extracts % (m/m)**	**Lower 95%**	**Upper 95%**
LD50%	10.271	7.244	13.522
LD90%	21.661	17.427	30.098

*Lethal dose % was calculated by using regression analysis

CONCLUSIONS

To summarize the findings of the study, it was discovered that every type of natural extract made a significant difference in the mortality of whiteflies for three hours. Garlic extract is an efficient extract to control whitefly infestations with the highest mortality rate at a concentration level of 50%. It was found that 10.3% of the garlic extract was needed to eliminate 50% of the whiteflies and LD90, 21.7% of garlic extracts were required to achieve 90% mortality. The effectiveness of garlic extract in preventing whitefly infestation is proportional since larger doses of the extract resulted in an increase in the total mortality rate for whiteflies. Insects that have developed a high level of resistance to various pesticides, such as whiteflies, have finally been successfully targeted by biopesticides made from a variety of natural extracts. Further studies should be done to determine whether this treatment may produce the same impact as for whiteflies on the chili plant if sprayed on places that have numerous factors such as weather, management techniques, and others.

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POTENTIAL OF SELECTED ESSENTIAL OILS AS BIOPESTICIDES FOR CONTROLLING *Metisa Plana*, MAJOR INSECT PEST OF OIL PALM

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ABSTRACT

Oil palm (*Elaeis guineensis*) is a highly productive tropical crop cultivated for its oil-rich fruit. It is grown in countries like Indonesia and Malaysia, which are major palm oil producers. However, the industry faces challenges including pests, environmental concerns, and social issues. *Metisa plana*, known as bagworms, is a significant pest in oil palm plantations. These larvae construct protective cocoons and feed on oil palm leaves, causing yield losses. The pests' resistance to certain insecticides makes effective management difficult. Essential oils have been employed for eco-friendly pest control practices. Therefore, this study will be focusing on evaluating the effectiveness of essential oils from wood vinegar, *Alpinia galanga* (galangal), *Zingiber officinale* (ginger), and *Cymbopogon citratus* (lemongrass), in controlling *Metisa plana* infestation. The essential oils were tested on *Metisa plana* for three concentrations (200 ppm, 400 ppm and 600 ppm) and observation of mortality is recorded for 24, 48, 72, 96, and 120 hours after treatment. Results show the highest mortality rate for *Metisa plana* from the essential oils of wood vinegar (90%), galangal (100%), and ginger (73.3%) at 400 ppm concentration. Lemongrass essential oil demonstrates the highest mortality rate of 99.7% at 600 ppm concentration. These findings suggest that essential oils have potential as effective biopesticides for managing *Metisa plana* infestation in oil palm plantations. By utilizing natural compounds, the oil palm industry can address the challenges associated with pest control in a more sustainable and environmentally friendly manner.

Keywords: biopesticides, essential oils, *Metisa plana*, oil palm, pest control.

INTRODUCTION

Palm oil production in Malaysia is on the rise due to innovation and the growing global population. Malaysia is the second-largest producer of palm oil after Indonesia [1]. However, the industry faces threats like pest and disease attacks like bagworm, which can significantly reduce yields [2]. Bagworm, also known as *Metisa plana,* is the most dangerous pest, causing a loss of up to 33-40% of the yield caused by scraping [3]. The 12th Malaysia Plan emphasizes the use of biopesticides to manage pest control and meet sustainable green agendas [4]. Essential oils extracted from plant extracts, such as wood vinegar, *Alpinia galanga* (galangal), *Zingiber officinale* (ginger), and *Cymbopogon citratus* (lemongrass), can be used as biopesticides against bagworms. Terpenoids found in plants can repel insects and reduce growth and reproduction. This study evaluates the effectiveness of essential oils extracted from wood vinegar, *Alpinia galanga* (galangal), *Zingiber officinale* (ginger), and *Cymbopogon citratus* (lemongrass), in controlling *Metisa plana* infestation. Biopesticides are environmentally friendly and safe, with lower intrinsic toxicity and effectiveness on target pests [5]. Essential oils extracted from plants are a type of biopesticide due to their low field persistence and lack of toxicity to fish, birds, and other animals. Blends of essential oils or complex chemical compositions can last longer in use, making them a viable option for Integrated Pest Management (IPM) programs.

MATERIALS AND METHODS

Metisa plana sampling

Metisa plana sampling was done at Felda Bukit Damar, Lanchang, Pahang. 10 rearing cages (17.5 cm ✕ 17.5 cm ✕ 17.5 cm) were used during the sampling. *M. plana* were collected following desired instar stage (instar stage 4) and were acclimatized in the laboratory before treatment applications (instar stage 5).

Stock solution

Stock solutions of essential oil from galangal, ginger, lemongrass, and wood vinegar were prepared in percent solution (%) and 100% concentrated, which consists of essential oils and surfactant (ethanol). The diluted stock solutions were prepared with different concentrations (200, 400, and 600 ppm). Essential oils of galangal (GL), ginger (G), lemongrass (LG), and wood vinegar (WV) were replicated three times for each concentration level. Cypermethrin was used as control treatment.

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Mortality test

The mortality test procedure was carried out with some modifications [6]. Fresh palm oil leaves were treated with different concentrations (200, 400, and 600 ppm) of essential oils from galangal, ginger, lemongrass, and wood vinegar. Palm oil leaves treated with cypermethrin were considered as control. The 10 bagworms were then placed on the treated leaf and placed in a rearing cage (60 cm × 60 cm × 120 cm). The mortality of *Metisa plana* was assessed for 24, 48, 72, 96, and 120 hours after treatment application. Percentage of the bagworm's mortality was calculated and corrected using Abbott's formula [7] :

$$Abbott's\ percent\ corrected\ mortality = \frac{\%\,MT - \%\,MC}{100\% - \ \%\,MC} \times 100$$

Where,
% MT = % Mortality in treatment
% MC = % Mortality in control

RESULTS AND DISCUSSION

Mortality test with different treatments of essential oils against Metisa plana

The symptoms of death observed as bagworms show no movement or response, falling, and not coming out from the casing. Figure 2 shows the percentage mortality of *Metisa plana* using different treatment of essential oils including control treatment. The highest mortality percentage of bagworms are GL400 (400 ppm with 100% mortality at 96 HAT), G400 (400 ppm with 73.3% mortality at 120 HAT), LG600 (600 ppm with 99.7% mortality at 120 HAT), and WV400 (400 ppm with 90% mortality at 120 HAT). As for control treatment, it achieved 100% mortality rate at 72 HAT. From the results, concentration becomes the factor that leads to bagworm mortality after the treatments. Based on the descriptive data (Table 1), the highest mean value (21.8667) of bagworm mortality resulted from galangal (GL), while the lowest mean value (10.6000) recorded was from lemongrass (LG).

The present study found that 1.6% concentration of lemongrass essential oil showed highest mortality (100%) 120 HAT [8]. The mode of action through lemongrass essential oil causes the demise of pests and involves the disruption of the pest's cell wall. It infiltrates the pest's body, spreading throughout and impairing the normal metabolic processes of its cells. Ginger essential oils give effectiveness in controlling red flour beetles, *Tribolium castaneum* with the effective concentration is 4% at 7.5 g mL 72 HAT [9]. A study on rice weevil said that the solution treatment had an impact on rice weevil mortality rates based on concentration and exposure time [10]. The mortality of pests increased as the concentration and exposure time increased.

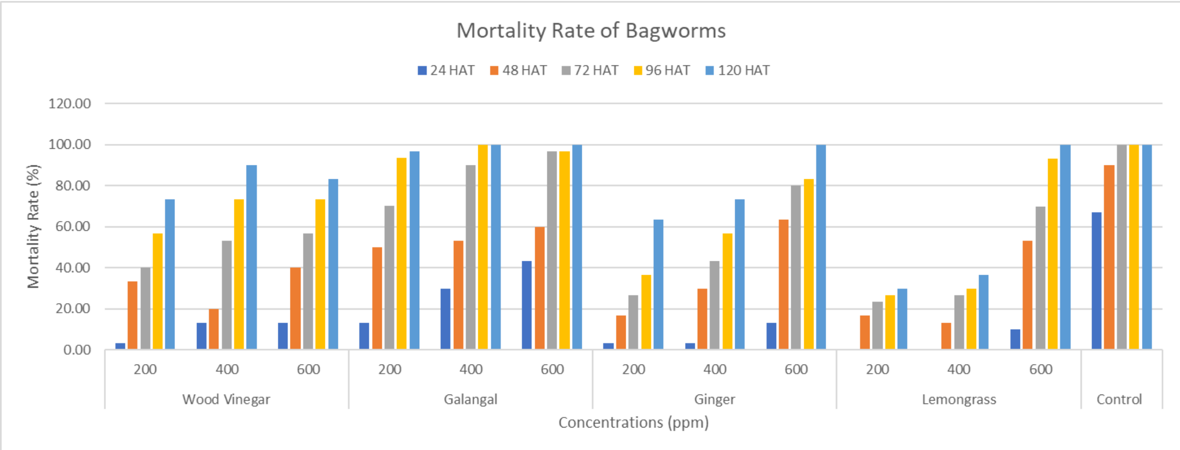

Figure 2: Mortality rate of bagworms

Table 1: Descriptive statistics of the bagworms' mortality rate.

Mortality of Bagworm

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Galangal	15	21.8667	8.76573	2.26330	17.0124	26.7210	4.00	30.00
Wood Vinegar	15	14.4667	8.27101	2.13556	9.8863	19.0470	1.00	27.00
Ginger	15	13.8667	9.21851	2.38021	8.7616	18.9717	1.00	30.00
Lemon Grass	15	10.6000	9.27978	2.39603	5.4610	15.7390	.00	30.00
Total	60	15.2000	9.60896	1.24051	12.7177	17.6823	.00	30.00

CONCLUSIONS

In brief, galangal essential oil achieved a 100% bagworm mortality rate at 400 ppm within 96 hours, while wood vinegar essential oil resulted in a 90% mortality rate at the same concentration within 120 hours. Lemongrass biopesticide's effective treatment concentration was 600ppm, with a 99.7% mortality rate within 120 hours, and ginger biopesticide achieved 73.3% mortality at 400 ppm within 120 hours. All the biopesticides function through a mortality mode of action, demonstrated after 96 hours of observation. Essential oils from *Alpinia galanga* (galangal) have the highest potential as biopesticides for controlling *Metisa plana.*

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DNA BARCODING OF ARMYWORMS (LEPIDOPTERA: NOCTUIDAE) INFESTING CORN, *Zea mays* L. IN BINTULU, SARAWAK, MALAYSIA

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ABSTRACT

Corn is the third-largest crop in the world after wheat and rice. However, corn production in Malaysia is still lacking due to the low number of farmers involved in the plantation despite the high demand for this crop. Sarawak has the potential for this undertaking, considering its vast areas. Still, the corn cultivations in Sarawak are currently threatened by infestations from the armyworms that devour the vegetative parts of the corn plants, including new cobs. Therefore, this study uses DNA barcoding analysis to identify armyworm species associated with corn crops in Sarawak. Active sampling of armyworm samples was conducted at two locations of corn cultivations in Bintulu, Sarawak [Kuala Tatau and Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB)]. Two armyworm species were successfully identified using a DNA barcoding approach: the invasive fall armyworm (FAW), *Spodoptera frugiperda* (Smith, 1797) and the lawn armyworm, *Spodoptera mauritia* (Boisduval, 1833). This study serves as the DNA barcode data for FAW and the lawn armyworm from Sarawak. Outcomes from this study can help in accurate species identification, update the list of armyworm species associated with corn cultivations, and aid the eradication strategies for armyworms from spreading and further damaging the corn industry, particularly in Sarawak and Malaysia.

Keywords: DNA barcodes, *Zea mays*, *Spodoptera frugiperda*, *Spodoptera mauritia*, Borneo.

INTRODUCTION

Although corn is the third-largest crop in the world after wheat and rice, corn production in Malaysia is still lacking due to the low number of farmers involved in the plantation, despite the high demand for this crop. Sarawak has the potential for this undertaking as it still has plenty of lands, from smallholder plots to state and native customary rights land, that can be developed for high-scale corn cultivations. However, data on the lepidopteran corn borers, such as armyworms threatening corn cultivations in Sarawak, is still limited and needs further updates. Armyworms (Lepidoptera: Noctuidae) are well-known for their distinctive habit of marching in large groups and causing significant damage to Poaceae crops such as grasses and cereals, which can result in widespread damage, hence the name "armyworms." A sudden spike of interest and concern started in 2016 due to the global invasion of the highly polyphagous fall armyworm, *Spodoptera frugiperda*, that caused significant losses of corn crops [1]. Among other notable armyworm species includes true armyworm (*Mythimna unipuncta*) and beet armyworm (*Spodoptera exigua*). Hence, this study aims to identify armyworm species infesting corn cultivations in Bintulu, Sarawak, using DNA barcoding approach.

MATERIALS AND METHODS

The insect sampling was done by handpicking armyworms at corn cultivation areas in Kuala Tatau and Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB) in Bintulu, Sarawak. Collected samples were then stored in 90% ethanol prior to molecular works. In Entomology Laboratory, the samples were sorted and photographed using Dinolite digital microscope. Samples were then proceeded with DNA barcoding approach starting with DNA extraction by using DNeasy Blood & Tissue Kit (QIAGEN, USA) and Polymerase chain reaction (PCR) of armyworms utilizing Cytochrome oxidase 1 subunit (COI) genetic marker following a set of primer [2] (650 base pair). Obtained DNA sequences were compared in BLAST and BOLD databases for identification. As for phylogenetic analysis, relationships of different armyworm species were visualized using distance criterion in the Neighbor-Joining (NJ) tree using PAUP 4.0 software.

RESULTS AND DISCUSSION

Two armyworm species were successfully identified: the invasive fall armyworm, *Spodoptera frugiperda* (Smith, 1797) and the lawn armyworm, *Spodoptera mauritia* (Boisduval, 1833), which supported with high levels of confidence (98-100%) (Table 1). All armyworm samples were monophyletic and cladded with their reference sequences (MW876212.1 and AB733407.1) (Fig. 1). *S. frugiperda* has been reported to invade corn cultivations in Bintulu, Sarawak, since mid-2019 [3] and steadily building its population in Borneo. Currently, there are two strains of *S. frugiperda* in the world: the commonly found corn strain (C) that prefers to feed on corn and sorghum; and rice strain (R) that feeds on rice and pasture grasses [4]. *S. mauritia* was first reported in Sarawak during an outbreak in 1967, causing significant losses of 25,000 acres of lowland and upland rice [5]. *S. mauritia* is polyphagous and devours various gramineous crops and weeds, with upland rice as its preferred host [6]. It is widely distributed throughout rice-producing regions such as East and Southern Asia, the Australian region, and the Indian subcontinent [6].

Table 1: Results of BLAST and BOLD analyses on the armyworms collected from selected corn cultivations from Bintulu, Sarawak, Malaysia

No.	Sample name	Locality	Species identification by using DNA barcoding	Percentage of similarities (%)	
				BLAST	BOLD
1.	AU1	UPMKB	*Spodoptera frugiperda*	100	100
2.	AU2	UPMKB	*Spodoptera mauritia*	100	100
3.	AT1	Kuala Tatau	*Spodoptera frugiperda*	100	100
4.	AS1	Ulu Sebauh	*Spodoptera frugiperda*	100	100

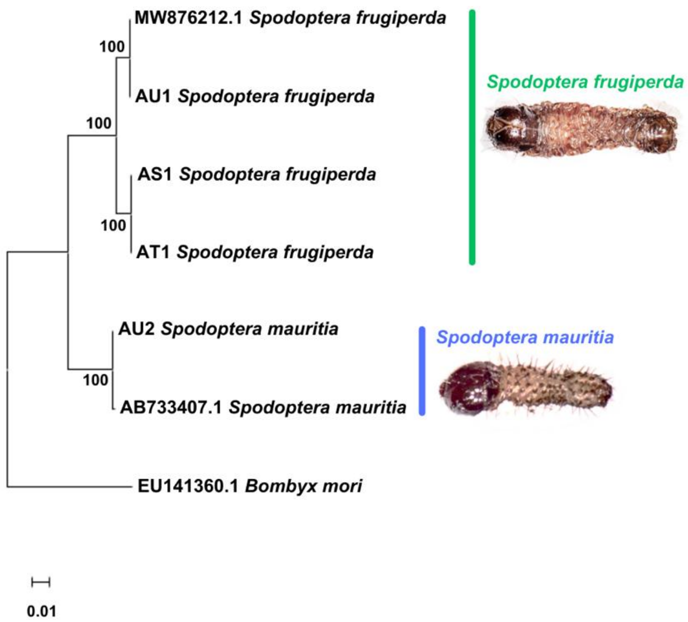

Figure 1: Neighbor-Joining (NJ) tree of armyworms collected from selected corn cultivations from Bintulu, Sarawak, Malaysia, with reference sequences from the Genbank. Trees are generated using distance criteria, and bootstrap support values are expressed on tree branches.

CONCLUSIONS

Both *S. frugiperda* and *S. mauritia* might become critical pests for the corn and rice industries in Sarawak as they can devour these crops based on their availability. DNA sequences of armyworms provided in this study are crucial for further monitoring and geneticizing populations of these highly spreading species.

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DENGUE NON-STRUCTURAL PROTEIN 1 (NS1) ANTIGEN RAPID TEST: TO PREVENT AND TO DETECT, A WAY FORWARD

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ABSTRACT

Dengue non-structural protein 1 (NS1) antigen rapid test is a convenient tool for early qualitative detection of dengue virus NS1 antigen in human serum, whole blood and plasma. Surveillance and vector controls are the typical preventive measure applied in areas infested with dengue vectors namely *Aedes aegypti* and *Ae. albopictus.* Recent findings shows that NS1 antigen rapid test can be used for the early detection of dengue among *Aedes* mosquitoes. This study evaluates the viability of NS1 antigen rapid test in detecting dengue virus in wild-caught *Ae. aegypti* near dengue outbreak locality of the Federal Territory of Labuan, Malaysia. A cross-sectional study was conducted for a month during the first and second dengue outbreak in March 2023 and May 2023 at Kiamsam Refugee Community Settlement Scheme. A total of 46 dried wild-caught *Ae. aegypti* trapped in sticky traps were tested using the AccuBioTech® NS1 antigen rapid test resulting in a positive circulation of dengue virus during the first and second outbreak period. Six (6) of the eight (8) pool of *Ae. aegypti* tested using the NS1 antigen rapid test were found to be dengue positive. This allows for prompt vector control in infested areas. A delay in proper vector control measures and low community participation in dengue prevention may result in a recurrent outbreak in the same area. From the current study, it was highly probable that the lack of community awareness as well as intervention shortfall from the vector control unit resulted in a recurring epidemic. In conclusion, the result reinforces the viability of NS1 antigen rapid test as a vital tool for dengue surveillance. A possible viral transmission can still occur even after an outbreak period has ended if the dengue positive mosquitoes persist.

Keywords: Aedes aegypti, dengue, mosquitoes, NS1 antigen rapid test, sticky ovitrap

INTRODUCTION

Dengue non-structural protein 1 (NS1) antigen rapid test is a convenient tool for early qualitative detection of dengue virus NS1 antigen in human serum, whole blood and plasma. The utilization of NS1 antigen rapid test due to their rapid result help in proper dengue case detection for symptomatic patient. However, the dengue virus can be a silent transmission from human to mosquitoes as the vector of dengue, *Aedes aegypti* or *Aedes albopictus* can pick up the dengue virus (DENV) when biting asymptomatic or symptomatic human infected with DENV. The detection of DENV in *Aedes* mosquitoes includes using a real-time polymerase chain reaction (RT-PCR) or enzyme-linked immunosorbent assay or immunofluorescene assay is laborious method, require highly trained staff and expensive specialized laboratories. These has made the techniques impractical to be used as a regular surveillance of DENV-infected mosquitoes. Recent findings shows that NS1 antigen rapid test can be used for the early detection of dengue among *Aedes* mosquitoes. The advantages of the detection of DENV in mosquitoes by using rapid test NS1 kit require minimal laboratory facilities and can be tested directly in the field. Therefore**,** this study evaluates the viability of NS1 antigen rapid test in detecting dengue virus in wild-caught *Ae. aegypti* near dengue outbreak locality of the Federal Territory of Labuan, Malaysia.

MATERIALS AND METHODS

Trapping of mosquitoes using the sticky trap

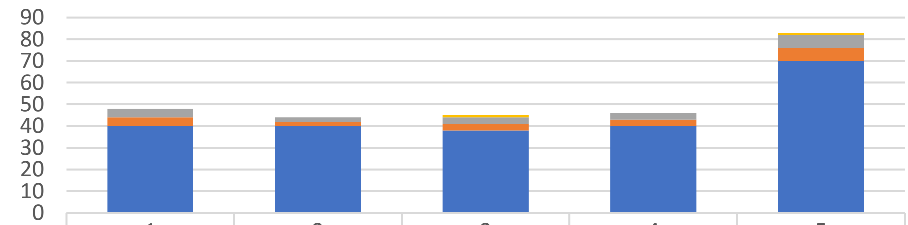
A total of 738 sticky ovitrap (SO) were deployed at random houses in Kiamsam Refugee Community Settlement Scheme (5.257526°, 115.167033°) with a total of 228 sticky ovitrap during March 2023 and a total of 510 sticky ovitrap during May 2023. The traps were checked weekly, and the water changed during inspection. One team consisting of two men checked the traps weekly. Traps were inspected and trapped mosquitoes were put inside an Eppendorf tube and brought back to laboratory for further processing. In the laboratory, the mosquitoes were identified morphologically to species. A pair of heat sterilized forceps was used to remove the mosquitoes from the sticky surface to prevent cross contamination. All the abdomens of the *Ae. aegypti* were pooled (minimum five per pool) for viral antigen detection tests.

Detection of dengue viral antigen in pooled mosquitoes

The AccuBioTech ® NS1 antigen rapid test was used to detect dengue antigen in the pooled abdomen mosquitoes. A 50 ul of PBS was added to the pooled abdomens and homogenized. The lysate was centrifuged briefly, and the supernatant was added to the well of the test kit. After 20 minutes, the reading was recorded. The positive result was interpreted as positive when two bands appeared, meanwhile, if the control band appeared, it considered negative.**RESULTS AND DISCUSSION**

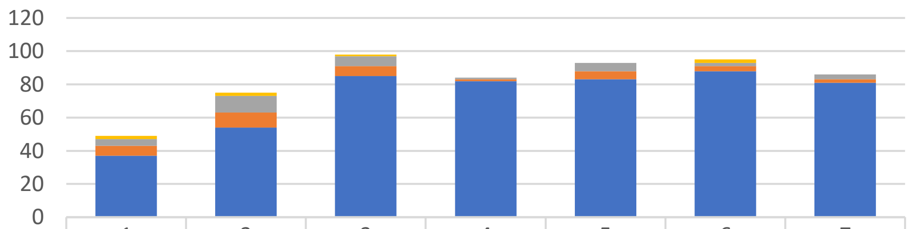
A total of 57 *Aedes* sp. consisting of 48 *Aedes aegypti* and 9 *Aedes albopictus* were captured in the sticky traps (Figure 1 and 2). The study site was dominated by *Aedes aegypti* whereby the number caught of *Aedes* aegypti was higher (84%) than *Aedes albopictus* (16%). In the first dengue outbreak which occurred in March 2023, three (3) pool of *Aedes aegypti* were tested (Table 1). Each pool contained six (6) mosquitoes as a pool samples. A positive result was detected in all three (3) tested pool mosquitoes. This result can be indicated which there were still infective and virus dengue circulation among mosquitoes in dengue outbreak areas even the fogging as a vector control has been conducted during dengue outbreak period. As a first dengue outbreak period has been ended, no more fogging activity has been conducted in the study area. After a lag period of two months, a second dengue outbreak occurred again in May 2023. A more proper vector control planning was implemented during second dengue outbreak by using positive detection of mosquitoes as an indicator. A more pool of mosquitoes was tested in which seven (7) pools of mosquitoes were tested for dengue virus antigen. A total of three (3) out of seven (7) pool were showed positive with mosquitoes-dengue virus antigen. A prompt vector control has been taken once the positive mosquitoes were detected whereby the fogging was took place within 24 to 48 hours once the mosquitoes were detected as a positive. The environmental clean-up by communities were also activated with a cooperation with heath staff department and COMBI (Communication of Behavioral Impact).

The NS1 test and the mosquitoes sampling were also extended until the result showed a promising result even the dengue period has been added. A last two (2) pool of mosquitoes were detected negative dengue-mosquitoes twice. No more dengue cases were recorded from the last detection of virus mosquitoes. Since the silent transmission of dengue virus from humans to mosquitoes or vice versa can be occurred, the rapid detection of positive virus mosquitoes urgently needed to stop the dengue circulation in outbreak areas. The results showed that NS1 antigen kit able to detect dengue antigen in mosquitoes in study area similar with a previous study conducted in Selangor [1]. The sensitivity of the NS1 antigen kit on mosquitoes was higher compared to the RT-PCR and virus isolation on dried mosquitoes [2][3]. A possibility of recurrent dengue outbreak with positive dengue-mosquitoes can be occurred if delay action of proper vector control measure and low community participation was taken.



	1	2	3	4	5
Number of Ae albopictus	0	0	1	0	1
Number of Ae aegypti	4	2	3	3	6
Number SO positive	4	2	3	3	6
Number of SO installed	40	40	38	40	70

Figure 1: Number of SO installed, SO positive and *Aedes* species caught during first outbreak of March 2023.



	1	2	3	4	5	6	7
Number of Ae albopictus	2	2	1	0	0	2	0
Number of Ae aegypti	4	10	6	1	5	2	3
Number SO positive	6	9	6	1	5	3	2
Number of SO installed	37	54	85	82	83	88	81

Figure 2: Number of SO installed, SO positive and *Aedes* species caught during second outbreak of May 2023.

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Table 1: NS1 antigen test result of *Aedes aegypti*

Test	Dengue Outbreak 1			Dengue Outbreak 2				
	1	2	3	1	2	3	4	5
Species pool	*Ae aegypti*	*Ae aegypti*	*Ae aegypti*	*Ae aegypti*	*Ae aegypti*	*Ae aegypti*	*Ae aegypti*	*Ae aegypti*
Number of adult mosquitoes	6	6	6	4	10	6	6	2
Results	Positive	Positive	Positive	Positive	Positive	Positive	Negative	Negative

CONCLUSIONS

The result indicated that the NS1 antigen rapid test able to detect virus dengue in mosquitoes. Therefore, the test significantly importance for dengue preventive measure.

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