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# DISTINCTIVENESS AND POTENTIALS OF TWO FLOWERING ROADSIDE HEDGEROWS, TURNERA ULMIFOLIA AND MELASTOMA MALABATHRICUM AS BENEFICIAL PLANTS FOR INSECTS



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**ABSTRACT**

Beneficial flowering plants play a vital role in attracting beneficial insects such as parasitoid that controls insect pests. In order to evaluate the effectiveness of two species of flowering plants as beneficial hedgerow plants, we identify insects communities of T. ulmifolia and M. malabathricum, which generally grown on roadside. We also compared the insects community of both plants based on time of the day. A total of 5,029 insect individuals were collected through three sampling occasions from five sampling stations of T. ulmifolia and five sampling stations of M. malabathricum. Chi-square test showed that there was a significant difference ($\chi 2=37.3848$, df=1, $P<0.05$) between the composition of insect communities on M. malabathricum and T. ulmifolia. The insect visiting M. malabathricum were similar at both night and day while T. ulmifolia attracted different insect community depending on the time of the day. The results suggested that different plant species would attract a different community of insects. T. ulmifolia success in attracting the visitation of beneficial insect but its effectiveness is limited to a short period of time. Meanwhile, the effectiveness of M. malabathricum as beneficial plant is yet illuminated.

**KEYWORDS**

beneficial plants, beneficial insects, insect-plant interaction, parasitoid

## 1. INTRODUCTION

The various interaction of insect community with flowering plant provides human with multiple benefits, hence ecosystem services. Positive interaction includes mutualism such as between flower and insect pollinator. Based on a study, a variety of insect such as bee (Hymenoptera: Apidae), butterfly and moth (Lepidoptera), fly (Diptera) and beetle (Coleoptera) depend on nectar and pollen to survive [1]. Study showed there is also negative interaction such as agonistic relationship between insect and crop [2]. The *Metisa plana* for example, is one of the important leaf-eating pests in oil palm crop causing loss in production of plantation [3]. Understanding the two types of interaction between flowering plant and insect is important in monoculture plantation that is exposed to high intensity of pest infestation [4].

According to a research, flowering plants had been proven to be useful to insect communities by providing breeding and nesting sites for a lot of beneficial insects and as such they are known as beneficial plants [5,6]. A researcher said that the insects depend on flowering plants for their nectar, seed and pollen which are vital for insect sustenance [7]. Beneficial plant needs to be low maintenance in order to save manpower and cost for its management. In this study, *T. ulmifolia* and *M. malabathricum* fit the condition where it is easily managed and easily adapt to local climate and soil types hence, requiring minimal care in trimming, watering and fertilizing.

In the current scenario, the *T. ulmifolia* is planted in oil palm plantation as one of the beneficial plants where it provides food resource for parasitoid [8]. Study showed the parasitoid then acts as biological control for insect pests of oil palm trees [9]. Meanwhile, *M. malabathricum* can be found wildly at agricultural areas, roadside and abandoned location [10]. The *M. malabathricum* also grows well in disturbed area and it is easy to manage as it does not need any special condition to grow. However, the potential of these two plant species as beneficial plant in oil palm plantations is yet to be explored.

*T. ulmifolia* and *M. malabathricum* are two of the many flowering plants often found as hedgerows in Malaysia. According to a study, the *T. ulmifolia* belongs to family Turneraceae which consists of 205 species from 10 genera [11]. It is non-native to Malaysia and the distributions of this plant are mainly on tropical and subtropical area of New World, Africa, Madagascar and Mascarene island [12]. According to a researcher, the *T. ulmifolia* is also a common plant on disturbed area in Jamaica archipelago [13]. The flower of *T. ulmifolia* is yellow with 2.5 cm to 5 cm width [14]. It blooms early in the morning until afternoon [15]. On the other hand, *M. malabathricum* which belongs to family Melastomataceae exhibit purple-magenta flower with 2.2 cm to 3.5 cm in size with yellow anter at the center of the flower [16]. Family Melastomataceae comprises of 200 genera and 4500 species. The distributions of *M. malabathricum* span from Madagascar to India and Australia and is native to Malaysia where it is commonly found at the roadsides.

In order to evaluate the effectiveness of *T. ulmifolia* and *M. malabathricum* as beneficial hedgerow plants, this study was conducted with two objectives: 1) to identify the insect communities present on the two plant species and 2) to compare the abundance of insect community on both plant at different time of the day. Hopefully this study will lead to better pest management in oil palm plantation.

## 2. MATERIALS AND METHOD

### 2.1 Study site

This study was conducted at Ladang Endau-Rompin, Pahang and Tanjung

Gemuk, Rompin, Pahang. Based on a study, it is located approximately 15 km from the town of Tanjung Gemuk, Kuala Rompin, Pahang and Padang Endau, Mersing, Johor. The plantation area extended up to 3, 654 hectares and situated at the border of Endau-Rompin National Park [17]. In this plantation area, *T. ulmifolia* were planted at every roadside in the plantation as a strategy to control the population of insect pests. This flowering plant could attract the beneficial insect, parasitoid. The other location for this study was at the roadside around Tanjung Gemuk. This location was chosen for the sampling of *M. malabathricum* as the shrubs are found in patchy clumps along the roadside. The sampling was conducted alongside 5 km of the road. Five sampling stations were identified in the oil palm plantation and another five sampling stations were at the roadside of Tanjung Gemuk area. The distance between each sampling stations were approximately 1 km.

### 2.2 Sampling method

The sampling was conducted in three sampling occasions within 12 weeks (January 2011- April 2011) at day and night using sweep net. The sampling was performed from 9 to 11 in the morning and evening. The net was swept 10 times with 10 sweeps for each time. A gap of 5 minutes between each time was allocated for the insect to settle at rest before net was swept again. The sampling was replicated three times for every sampling occasions. All the samples were placed into a plastic bag that contained etil acetate and then taken to the laboratory for further processes. Identification was done according to previous researcher [18].

### 2.3 Data analysis

A Chi squared test was conducted to identify the differences of insect composition between the *T. ulmifolia* and *M. malabathricum.* The analysis was performed using MINITAB 15. A two-way cluster analysis was used to determine the similarity of insect compositions between *T. ulmifolia* and *M. malabathricum*. Overlapping families of insect is showed by a dendogram from the analysis. Species diversity was calculated using Shannon Index, and carried out using PCORD software.

## 3. RESULTS AND DISCUSSION

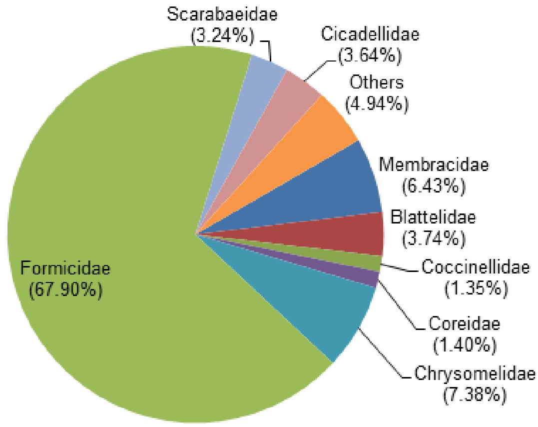
A collection consisted of nine orders of insect including Hymenoptera, Coleoptera, Hemiptera, Diptera, Mantodea, Blattodea, Orthoptera, Lepidoptera dan Dermaptera were sampled in this study (Table 1).

**Table 1:** Composition of insect families on (a) *T. ulmifolia* and (b*) M. malabathricum.*

| **Order** | **Family** | **Code** | ***T.ulmifolia*** | | ***M.malabathricum*** | |
|---|---|---|---|---|---|---|
| | | | ***Day*** | ***Night*** | ***Day*** | ***Night*** |
| Hymenoptera | Apidae | HYMapid | 24 | 0 | 0 | 0 |
| | Halictidae | HYMhali | 8 | 0 | 1 | 0 |
| | Scoliidae | HYMscol | 1 | 0 | 0 | 0 |
| | Pompiliidae | HYMpomp | 46 | 0 | 0 | 0 |
| | Sphecidae | HYMsphe | 7 | 0 | 1 | 0 |
| | Crabronidae | HYMcrab | 7 | 0 | 2 | 0 |
| | Mutilidae | HYMmuti | 3 | 0 | 0 | 0 |
| | Ichneumonidae | HYMichn | 11 | 2 | 1 | 0 |
| | Formicidae | HYMform | 1326 | 1002 | 663 | 699 |
| | Chalcididae | HYMchalc | 112 | 0 | 1 | 0 |
| | Colletidae | HYMcoll | 56 | 3 | 0 | 0 |
| | Evaniidae | HYMevan | 1 | 0 | 0 | 0 |
| | Tiphiidae | HYMtiph | 2 | 0 | 0 | 0 |
| Orthoptera | Gryllidae | ORTgryl | 1 | 0 | 0 | 3 |
| | Tettigonidae | ORTtett | 0 | 6 | 3 | 0 |
| | Acrididae | ORTacri | 10 | 11 | 0 | 1 |
| Coleoptera | Cetoniidae | COLceto | 1 | 0 | 0 | 0 |
| | Coccinellidae | COLcocc | 5 | 4 | 21 | 6 |
| | Curculionidae | COLcurc | 0 | 0 | 2 | 3 |
| | Scarabaeidae | COLscar | 0 | 21 | 0 | 65 |
| | Tenebrionidae | COLtene | 0 | 0 | 0 | 17 |
| | Chrysomelidae | COLchry | 17 | 5 | 61 | 87 |
| | Attelabidae | COLatte | 0 | 0 | 1 | 0 |
| | Cerambycidae | COLcera | 1 | 0 | 0 | 0 |
| Diptera | Syrphidae | DIPsyrp | 1 | 0 | 0 | 0 |
| | Dolichopodidae | DIPdoli | 22 | 5 | 12 | 2 |
| | Neriidae | DIPneri | 30 | 7 | 0 | 0 |
| | Asilidae | DIPasil | 0 | 0 | 1 | 2 |
| | Muscidae | DIPmusc | 47 | 8 | 2 | 4 |
| | Drosophilidae | DIPdros | 70 | 9 | 0 | 0 |
| | Sarcophagidae | DIPsarc | 2 | 0 | 0 | 0 |
| | Calliphoridae | DIPcall | 8 | 0 | 0 | 0 |
| Hemiptera | Reduviidae | HEMredu | 9 | 3 | 2 | 1 |
| | Cicadellidae | HEMcica | 0 | 22 | 73 | 0 |
| | Membracidae | HEMmemb | 0 | 0 | 112 | 12 |
| | Coreidae | HEMcore | 0 | 0 | 8 | 20 |
| | Cercopidae | HEMcerc | 0 | 1 | 8 | 2 |
| | Dictyopharidae | HEMdict | 5 | 3 | 0 | 0 |
| | Plataspidae | HEMplat | 0 | 0 | 0 | 2 |
| | Acanaloniidae | HEMacan | 2 | 2 | 7 | 10 |
| Blattodea | Blattelidae | HEMblat | 2 | 15 | 5 | 70 |
| | Mantidae | HEMmant | 6 | 4 | 3 | 0 |
| Lepidoptera | Hesperiidae | HEMhesp | 18 | 0 | 0 | 0 |
| | Lepidoptera1 | LEP1 | 0 | 30 | 0 | 0 |
| Dermaptera | Forficulidae | DERforf | 0 | 1 | 3 | 0 |
| | Total | | 1861 | 1164 | 993 | 1011 |

A total of 5,029 insect individuals was collected through three time samplings from five sampling stations of *T. ulmifolia* and five sampling stations of *M. malabathricum*. There were 3,025 individuals on *T. ulmifolia* and 2,004 individuals of insect on *M. malabathricum*. The most abundant family on *T. ulmifolia* and *M. Malabathricum* were Formicidae with 2,328 individuals (76.96%) and 1, 362 individuals (67.90%) respectively. (Figure 1).

(a)




(b)

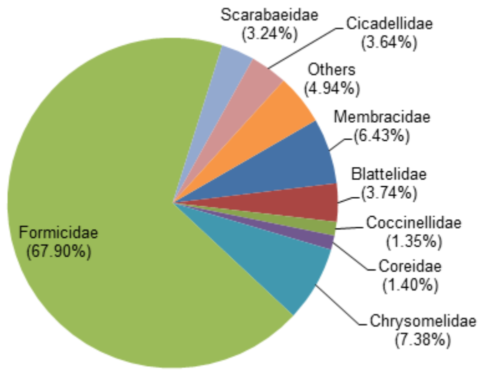



**Figure 1:** Composition of insect on (a) *T. ulmifolia* and (b*) M. malabathricum.*

Shannon diversity index value (H') represents the diversity of insect at different location. The diversity index value of insect on *M. malabathricum* and *T. ulmifolia* are (H'= 1.380) and (H'=1.228). Therefore, the values of the diversity index of insect on *M. malabathricum* and *T. ulmifolia* were considered low. There was no significant difference (P>0.05) for the diversity of insect on both flowering plants.

Nevertheless, both flowering plants relatively are capable of attracting variations of insect which can possibly be beneficial in terms of protection of crops against pest. Several family of insect collected on both flowering plant such as Ichneumonidae, Chalcididae, Braconidae and Reduviidae were similarly found on *Cassia cobanensis* as reported by [19]. The *C. cobanensis* are a well-known beneficial plant that had been propagated in the oil palm plantation in a measure to control the bagworm (Lepidoptera: Psychidae). *M. plana* is a common pest in oil palm ecosystem which causing 33% to 40% of crop loss by defoliating on the palm fronds. The insect family such as Braconidae, Ichneumonidae and Chalcididae is very dominantly associated with the bagworm species, *Metisa plana* which successfully use in controlling the number of *M. plana* in the plantation [20]. *T. ulmifolia* apparently are able in attracting beneficial insect as well as *C. cobanensis*.

In contrast to *T. ulmifolia and C. cobanensis*, *M. malabathricum* attracts more herbivorous insect such as Membracidae, Cicadellidae and Acanaloniidae. *T. ulmifolia* was known to contain chemical compound that is known as cyanogenic glycosides [13]. This chemical compound protects

*T. ulmifolia* from herbivourous insect [21]. The result shows that the herbivorous insects were very fond of *M. malabathricum* inflicting the susceptibility of *M. malabathricum* towards herbivorous insect which can also mean that *M. malabathricum* can be a reservoir for pest in crop plantation. To date, there are no previous reports of chemical compound in *M. malabathricum* that could repel herbivorous insect.

The composition of insect on both plants were proved to be significantly different ($\chi^2$ = 37.3848, df= 1, P<0.05). Insect community visiting *M. malabathricum* and *T. ulmifolia* is contrasting to each other owing to variations in flower morphology and physiology. The insect visitation particularly the pollinators are associated to unique floral trait such as floral colour and odour [22]. *T. ulmifolia* attracts a lot of insects due to the bright-coloured yellow flower which contrast to the background [23]. As such, this study found multiple pollinators family such as Apidae, Halictidae and Scoliidae visiting *T. ulmifolia*. It is undeniable that bright colour on parts of plant played an important role in attracting the attention of pollinators including insects and birds [24]. While the purple colour of *M. malabathricum* is an attraction to the insect, it is also important to note that the yellow stamen at the center of the flower also increases insect visual attraction to the plant [25]. It was very unfortunate that through visual observation during sampling, the yellow stamens were mostly absent on the flower which may cause a lower number of insect families visiting *M. malabathricum* in comparison to *T. ulmifolia*.

The differences in abundance of insect visiting plants are also affected by the condition of the plant itself where a denser plant attracts more insect compared to less-dense plant [26]. The *T.ulmifolia* was purposely planted in organized manner as hedgerows in the oil palm plantation which resulted in a denser growth and attracting visitations of more insect. This holds true to the study done by a researcher which illustrate the need of flower density for greater insect diversity [27]. As *M. malabathricum* grows in patches in the midst of other plant species, it becomes less dense which also contributed to the lower number of insect visitation when compared to the *T. ulmifolia*. Nevertheless, Formicidae as spatio-temporally dominant family occur at all sampling location of *T. ulmifolia* and *M. malabathricum* irrespective of night or day. Extrafloral nectar on *T. ulmifolia* apparently causes the high number of Formicidae visiting the flowering plant [28]. This need to be highlighted as the presence of *T. ulmifolia* in oil palm plantation might be use to address the issue of ant biodiversity in oil palm plantion. It was reported that the expansion of oil palm plantation leads to a dramatic reduction ant species richness as the microclimate of the plantation are not fit for the ants [29]. Ant plays a vital role in predatory, soil turnover, nutrient cycling and seed dispersal. It also has a positive effect on reducing the number of herbivory on plant as the patrolling activity of the ant delays foraging of hervivory larvae [30]. This will indirectly helps in protecting the crops from herbivory pests. The placement of *T. ulmifolia* in oil palm matrices will be one of the ways to provide a more suitable microclimate with a reliable source of food for the ant to thrive in the plantation.

Based on the clustering analysis, the insect community visiting both flowering plants can be generally separated into three major groups; 1) Insect pollinator and parasitoid, 2) Insect pest and predator and 3) Herbivorous insect**.** The insect community presences on *M. malabathricum* were highly similar regardless of day and night where its overlapping value is 100%. In contrast to that, the overlapping value of insect community on *T. ulmifolia* for day and night is only at 73% showing differences in insect visitation according to the time of the day (Figure 2).

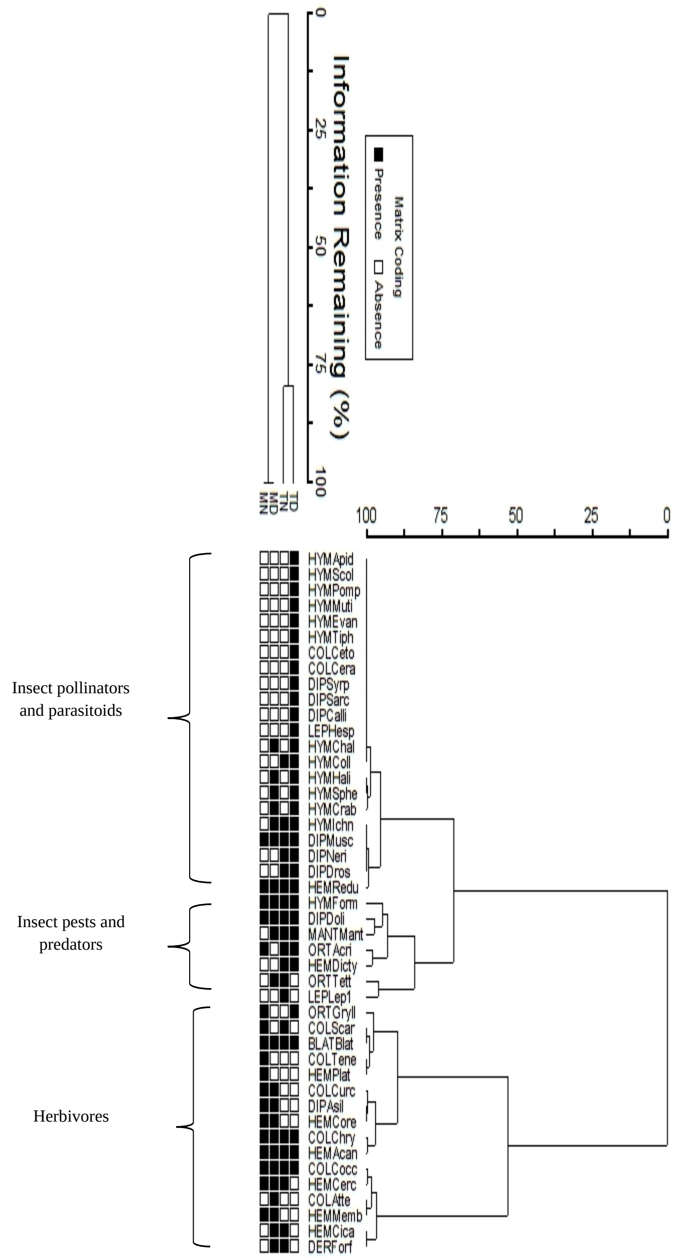



**Figure 2:** Clustering of insect guilds on *T. ulmifolia* and *M. malabathricum* at night and day.

Notes:
- TD = Insect community on *T. ulmifolia* at daytime
- TN = Insect community on *T. ulmifolia* at night
- MD = Insect community on *M. malabathricum* at daytime
- MN = Insect community on *M. malabathricum* at night

The insect community visiting *M. malabathricum* were highly similar (100%) regardless of day and night depicting that the time of the day does not influence the family of insect visiting this flowering plant. This is related to the fact that *M. malabathricum* blooms all day and flowered throughout the year attracting common insects irrespective of day and night [31]. The insect visiting *M. malabathricum* are mainly of the spatio-temporally dominant family that is Formicidae which correspond to a high number of treehopper (Membracidae). The treehoppers are commonly associated with ant and found in open and sunny areas such as the roadsides [32]. Both ant and the treehoppers are binded by a mutualistic interaction where the treehoppers are getting protection by the ant in return of sharing the honeydew gotten from the plant that the treehoppers feed on [33].

The result suggests that *M. malabathricum* are able to produce the honeydew which the treehoppers and ants depend on. *M. malabathrcum* also attracted several family of insect herbivores acting as pest namely Plataspidae, Coreidae, Tenebrionidae, Chrysomelidae, Scarabaeidae, Tenebrionidae, Curculionidae and Coccinellide beetle [34]. These insects are known to be a common insect pest which feed on the plant stem, seed and leaves [34]. The Chrysomelid beetle for instance was reported to be a main pest of oil palm plantation in south-west region of Cameroon causing severe defoliation on oil palm fronds [35]. Nevertheless, Chrysomelid beetle is consired as a pollinator in tropical rain forest where it is attracted by the ordor of Annonaceae and enters the floral chamber, carrying pollen on their bodies when leaving the chamber [36]. It is important to further investigate the role of the Chrysomelid species attracted by *M. malabathricum* in the ecosystem.

On the other hand, the overlapping of insect community visiting *T. ulmifolia* is lower (72%) as the flower blooms only from 9.00 a.m to 12.00 p.m causing variations in insects visitation at different time of the day. Flowering plant may only be pollinated in a restricted time at a certain level of temperature and production of nectar [37]. Most beneficial insect such as pollinators, parasitoids and natural enemies were collected on *T.ulmifolia* during the day. Result from this study shows that pollinators of *T. ulmifolia* visit between 9.00 a.m to 11.00 p.m where the temperature relatively at 28$^{o}$C to 33$^{o}$C. Parasitoid and natural enemies such as Ichneumonidae, Chalcididae, Scoliidae and Reduviidae are also presence in abundant during the same period of time. The adult parasitoids are mostly active during daytime especially on warm and sunny days [38]. At this time, flower is observed to perfectly flourish, attracting visitation of insect. As the time reaching 12.00 p.m, flowers of *T. ulmifolia* close their petals again until it blooms the next morning. However, parasitoid species coming from Chalcididae family which is known to be diurnal may also attack its prey at night [39]. The Chalcididae is one of Hymenopterans parasitoid crucial in controlling the bagworms of different species namely *Metisa plana* and *Mahasena corbetti* [40]. Based on study, natural enemy such as Reduviidae is also an important predator preying for *M. plana* as *Sycanus dichotomus* are use well in controlling bagworm population in Malaysia as well as Indonesia [41,42].

Result of this study proved that *T.ulmifolia* is successful in attracting benefical insects especially the parasitoids and natural enemies which are use in controlling the population of insect pest in agroecosystem though it is limited to certain period of time. A well planned manipulation of the flowering plant as hedgerows in plantation surely may attract diverse of insect with high ecological value that can enhance crop productions and reduce the use of chemicals in environment.

**4. CONCLUSION**

The significant variation of insect communities on the two plant species, *T. ulmifolia* and *M. malabathricum* indicated that *T. ulmifolia* is more effective than the *M. malabathricum* in attracting parasitoid. The *M. malabathricum* tend to attract herbivory insect and not the parasitoid. Higher abundance of insect community in the *T. ulmifolia* during the daytime than the night time indicated that the effectiveness of this species in pest control is limited. Therefore, we are hoping that there would be further studies to identify alternative native plant species that are more effective as beneficial plants in monoculture plantations of Malaysia.

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**REFERENCES**

[1] Goulson, D. 1999. Foraging strategies of insects for gathering nectar and pollen, and implications for plant ecology and evolution. Perspectives in Plant Ecology, Evolution and Systematic, 2,(2), 185-209.

[2] Schoonhoven, L.M., Jermy, T., van Loon, J.J.A. 1998. Insect-Plant Biology. London: Chapman and Hall.

[3] Mohd Basri Wahid, Norman Hj Kamarudin. 2002. Cassia cobanensis as a beneficial plant for sustenance of parasitoid in bagworm control. MPOB Information Series, 132, 1-2.

[4] Risch, S.J. 1981. Insect herbivore abundance in tropical monocultures and polycultures: an experimental test of two hypotheses. Ecology, 62,(5), 1325-1340.

[5] Sakai, S. 2002. General flowering in lowland mixed dipterocarp forests of South-East Asia. Biological Journal of the Linnean Society, 75, 233-247

[6] Bronstein, J.L., Alarcon, R., Geber, M. 2006. The evolution of plant-insectmutualism. New Phytologist, 172, 412-428.

[7] Ghazoul, J. 2005. Pollen and seed dispersal among dispersed plants. Biological Review, 80, 413-443.

[8] Hisyam, N.H., Muhammad Rizuan, R. Z., Suhaidi, H. 2013. Control measures and integrated approach for major pests of oil palm in felda. MPOB Palm Oil Congress, 1–21.

[9] Desmier De Chenon, R., Hasibuan H.F., Sudharto P.S., Purba R.Y. 2002.Enhancing oil palm industry development through environmentally friendly technology. Proceedings of Agriculture Conference, International Oil Palm Conference, 520 – 528.

[10] Baki Haji Bakar. 2004. Invasive weed species in Malaysian agro-ecosystems: species, impact and management. Malaysian Journal of Science, 23, 1-42.

[11] Schlindwein, C., Medeiros, P.C.R. 2006. Pollination in Turnera subulate, Turneraceae: unilateral reproductive dependence of the narrowl oligolectic bee Protomeliturga turnerae, Hymenoptera, Andrenidae. Flora, 201, 178-188.

[12] Heywood, V.H. 1978. Flowering Plants of the World. 2nd Edition. Oxford: Oxford University Press.

[13] Schappert, P.J., Shore, J.S. 2000. Cyanogenesis in Turnera ulmifolia, Turneraceae: II. developmental expression, heritability and cost ofcyanogenesis. Evolutionary Ecological Research, 2, 337-352.

[14] Ismail Saidin, I. 1977. Bunga-Bungaan Malaysia. Kuala Lumpur, Dewan Bahasa dan Pustaka.

[15] Henderson, M.R. 1961. Common Malayan Wildflowers. Kuala Lumpur. Longmans.

[16] Whitmore, T.C. 1972. Tree Flora of Malaya. London, Longman

[17] Faszly, R. 2008. Community ecology of termites and pest insidences in converted oil palm plantation on peat in Malaysia. PhD thesis, UKM.

[18] Triplehorn, C.A., Johnson, N.F. 2005. Borror and Delong's Introduction to the study of insects. USA, Peter Marshall

[19] Norman, K., Arshad, O. 2016. Diversity of insect natural enemies of the bagworm, Pteroma pendula, Lepidoptera: Psychidae in relation to the oil palm environment, in Perak, Malaysia. Journal of Oil Palm Research, 28, (3), 296–307.

[20] Halim, M., Muhaimin, A.M., Syarifah Zulaikha, S.A., Nor Atikah, A.R., Masri, M.M.M. 2017. Evaluation of infestation in parasitoids on Metisa plana Walker (Lepidoptera: Psychidae) in three oil palm plantations in Peninsular Malaysia. Serangga 22(2):135-149.

[21] Arbo, M.M. 2007. Turneracea. http://www.biologia.edu.ar/botanica/catedra/.../Arbo%20en%20Kubitzki2007.pdf [Acessed on 31 March 2011].

[22] Chittka, L., Raine, N. 2006. Recognition of flowers by pollinators. Current Opinion in Plant Biology, 9, 428-435.

[23] Muhammad Faheem, Muhammad Aslam, Muhammad Razaq. 2004. Pollination ecology with special reference to insect: a review. Journal of Research, Science, 15, 395-469.

[24] Harborne, J.B., Dey, P.M. 1989. Methods in Plant Biochemistry. London, Academic Press.

[25] Molina, J., Yap, S. 2004. Floral Structure and pollinator visitation in Melastoma malabathricum. Proceedings of International Field Biology Course. Anjuran Center for Tropical Forest Science – Arnold Arboretum Asia Program, hlm, 72-80.

[26] Mishra, R.M., Gupta, P., Yadav, G.P. 2004. Intensity and diversity of flower-visiting insects in relation to plant density of Zizyphus mauritiana Lamk. Tropical Ecology, 46, (2), 263-270.

[27] Scriven, L.A., Sweet, M.J., Port, G.R. 2013. Flower density is more important than habitat type for increasing flower visiting insect diversity. International Journal of Ecology. doi:10.1155/2013/237457

[28] Cuautle, M., Rico-Gray, V., Diaz Castelazo, C. 2005. Effects of ant behavior and presence of extraflora nectarines on seed dispersal of the Neotropical myrmecochore Turnera ulmifolia, Turneraceae. Biological Journal of the Linnean Society, 86, 67-77.

[29] Fayle, T.M., Turner, E.C., Snaddon, J.L., Chey, V.K., Chung, A.Y.C., Eggleton, P., Foster, W.A. 2010. Oil palm expansion into rain forest greatly reduces ant biodiversity in canopy, epiphytes and leaf-litter. Basic and Applied Ecology, 11, (4), 337–345.

[30] Cuautle, M. 2003. The effect of wasps and ants on the reproductive success of the extra oral nectaried plant. Functional Ecology, 417–423.

[31] Jofrry, S.M., Yob, N.J., Rofiee, M.S., Meor Mohd Affandi, M.M.R., Suhaili, Z., Othman, F., Abdah, M.A., Mohd Desa, M.N., Zakaria, Z.A. 2011. M. malabathricum (L.) Smith ethnomedicinal uses, chemical constituent and pharmacological properties, a review. Evidence- based complimentary and alternative medicine.

[32] Del-Claro, K., Oliveira, P.S. 1999. Ant-homoptera interactions in a NeotropicalSavanna: the honeydew-producing treehopper, Guayaquila xiphas (Membracidae) and it associated ant fauna in Didymopanaxrinosum (Araliaceae). Biotropica 31, (1), 135-144.

[33] Styrsky, J.D., Eubanks, M.D. 2006. Ecological consequences of interaction between ants and honeydew-producing insects. The Royal Society, 274, (1607), 151-164.

[34] Daly, H.V, Doyen, J.T., Purcel III, A.H. 1998. Introduction to Insect Biology and Diversity. New York, Oxford University Press.

[35] Constantin, M., Ntsefong, G. N., Ebongue, N., Frank, G., Nchu, W. A., Parh, I. A., Luc, D. 2013. Spatio-temporal distribution of Cœlaenomenodera minuta Uhmann (Coleoptera: Chrysomelidae), a serious insect pest of oil palm (Elaeis guineensis Jacq.) in the south-west region of Cameroon. Albanian Journal of Agricultural Science, 12, (3), 2013.

[36] Momose, K. 1994. Beetle Pollination in Tropical Rain Forests, 104–110.

[37] Bradbar, N. 2009. Bees and their role in forest livelihoods, a guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Food and Agriculture Organization of the United Nation.

[38] Praslicka, J., Dobai, S.A., Huszar, J. 2003. Hymenopteran parasitoids (Hymeoptera: Aphidiidae) of cereal aphid (Sternorrhyncha: Apinoideulin) in winter wheat crops in Slovakia. Plant Protect Science, 39, (3), 97-102.

[39] Woelke, J.B., Bukovinszky, T., Huigens, M.E. 2017. Nocturnal parasitism of moth eggs by Trichogramma wasps. Biocontrol Science and Technology, 27, (6), 769–780.

[40] Norman, K., Walker, A.K., Wahid, M.B., LaSalle, J., Polaszek, A. 1996. Hymenopterous parasitoids associated with the bagworms Metisa plana and Mahasena corbetti (Lepidoptera: Psychidae) on oil palms in Peninsular Malaysia. Bulletin of Entomological Research, 86,(4), 423.

[41] Syari, J., Muhamad, R., Norman, K., Idris A.B. 2011. Laboratory rearing of Sycanus dischotomus Stal. (Hemiptera: Reduviidae) insect predator of oil palm bagworm, Metisa plana Walker (Lepidoptera: Psychidae). Sains Malaysiana 40, (10), 1129-1137

[42] Ahmad Saleh, Ameilia Zuliyanti Siregar, A.Z. 2017. Impact of natural enemies to leaf eating caterpillar population on oil palm in North Sumatra, Indonesia. International Journal of Scientific and Technology Research, 6, (8), 189-192