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Diversity of Arthropods in an Oil Palm Plantation in Sabah

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ABSTRACT

Malaysia is one of the largest palm oil-producing countries in the world. Located in the Southeast Asia region, this country is also known as one of the mega biodiversity-rich countries which contains numerous species. In this study, arthropods were sampled using sticky traps at three sites within an oil palm dominated landscape. We examined how vegetation structure affects arthropod community distribution within an oil palm plantation. The number of arthropod species was significantly greater at higher vegetation complexity structures. The findings also showed that the number of arthropod species that had been recorded for the three sites had nearly reached asymptote. This study suggests that maintaining vegetation complexity through sustainable agriculture practice as recommended by the Malaysian Sustainable Palm Oil (MSPO) may be useful in supporting arthropod species within oil palm plantations.

Keywords: Biodiversity, sampling time, species composition, species richness, sustainable agriculture management

INTRODUCTION

In an ecosystem, arthropods have extensive connections to plants and animals ranging from pollination, predator-prey interaction, cycle nutrients, maintain a soil structure and composition (Adjaloo *et al.,* 2012; Forister *et al.,* 2019). They have been linked as ideal indicators of habitat loss and degradation, pesticides and pollution, invasive species, climate change (Forister *et al.,* 2019), vegetation complexity and environmental condition (Perry *et al.,* 2016). In conventional agriculture, the ecosystem structure has been simplified and reduced in vegetation complexity, and this has been associated with soil erosion, water contamination, salinization and cyclical pest outbreaks (Montanez & Amarillo-Suarez, 2014). For this reason, chemical fertilisers and pesticide practices caused a direct effect on untargeted arthropod communities. In a study comparing the effect of pesticide and bio insecticide on non-targeted species, arthropod species started to increase in abundance after seven days of spraying with bio-insecticide, whereas pesticide treatment in conventional fields had kept non-targeted arthropods at low abundance for a significant long-term effect (Anbarashan & Gopalswamy, 2013). For the past decade, the sustainable agriculture practice approach that would allow agriculture to benefit from biodiversity has received attention. This form of agriculture principles increases the need for a more environmentally friendly safe technology, products of pollutant reduction and promotes the maintenance of pests' natural enemies (Montanez & Amarillo-Suarez, 2014). Furthermore, preservation, restoration, improvise and establishment of conducive habitat would allow arthropod communities to thrive in a feasible agriculture ecosystem (Bennett & Gratton, 2013).

Studies have shown the impact on the overall richness and diversity of arthropod communities in oil palm plantation (Turner & Foster, 2009; Pashkevich *et al.,* 2020). However, the impact on arthropod communities depends on taxa, as some studies revealed different scenarios (Liow *et al.,* 2001; Hassall *et al.,* 2006). Oil palm close to the forest edge, presence of forest patches, and integration practice supposedly provide a conducive habitat for arthropod communities to certain extant. Moreover, through the implementation of Malaysian Sustainable Palm Oil (MSPO), the oil palm industry has moved towards biodiversity-friendly oil palm management (Amit *et al.,* 2021). Hence, the scenario in an oil palm ecosystem has changed from previous practice (Azhar *et al.,* 2015). Therefore, it is important to understand the arthropod communities' status for some beneficial pests species to help minimise the impact of their presences within an oil palm ecosystem (Haron & Weng, 2011). This is due to the differences in vegetation structure and complexity, and to provide vast microhabitat for many species of arthropods. In this study, we compared the diversity and abundance of arthropods in a 10-year old oil palm, a forest patch and a coffee-oil palm integration plot in an oil palm plantation. We predicted that vegetation complexity affects the number of arthropod species and abundance captured.

MATERIALS AND METHODS

Samplings were conducted between 15th January and 15th June 2022 at three vegetation types, namely, a five-hectare forest patch, one-hectare coffee integration plot and a 10-year old oil palm plot within an oil palm plantation in Lahad Datu, Sabah, Malaysia (5^{o}01'49" N, 118^{o}25'03" E). Within the plantation, there are 90% mature and 10% immature oil palm trees, as well as 3% of forests and 1% integration area. For each habitat type, 10 sticky traps with a size of 25 cm × 20 cm were set up one meter above ground level, and at 10 meters distance apart. Sticky traps were left at 0830 hours and replaced every seven-days with 10 replicates for each vegetation type, respectively. Specimens captured on the sticky traps were brought back to the laboratory, sorted at morpho-species, photographed and segregated to Order-level with the aid of microscope (Olympus AZX7, Japan). Identification of arthropods was done following illustrations and photographs by Hill and Abang (2005), Braack (2009), Yusof (2012), Unno (2016), Maryati *et al.* (2017) and Siti-Azizah *et al.* (2019).

Shannon-Wiener and Simpson diversity index were used to calculate the species richness, evenness and abundance. Then, the Kruskal-Wallis test and Dunn's post-hock test were used to determine the difference in arthropod species among the three vegetation types. Meanwhile, to illustrate the completeness of sampling efficiency, Chao 1 was generated to estimate the completeness and species-based rarefaction curves were plotted. These statistical analyses were performed using PAST software version 3.11.

RESULTS

Samplings of arthropods were conducted in three different types of vegetations to compare the diversity and abundance of arthropods in these areas. Total samplings using sticky traps resulted in the capture of 16,055 individuals from 11 orders and 64 species (Table 1). The species diversity index calculated shows that the forest patch has the highest diversity of arthropods (Shannon–Wiener, H' = 2.879) compared to coffee-oil palm (Shannon-Wiener, H' = 2.791) and 10-years old oil palm (Shannon–Wiener, H'= 2.651). Species richness is the highest in forest patch (Dmn = 0.8867), followed by coffee-oil palm (Dmn = 0.8832) and 10-year old oil palm (Dmn = 0.8699). The difference among groups calculated showed significant differences among the three types of vegetations (Kruskal-Wallis: df = 2, $p = 0.010$). Dunn's post-hock test carried out on each pair of vegetation types showed that oil palm and forest patch had a very small chance of having the same distribution ($p = 0.002$), and thus is significantly different. However, oil palm and coffee-oil palm have a higher probability of having the same distribution ($p = 0.179$). Moreover, Chao-1 estimated 47 species for oil palm, 58 species for coffee-oil palm and 60 species for forest patch. The estimated richness is very close to the observed richness (Table 2).

Species-based rarefaction curves present the accumulation of newly recorded species over the increase of individuals captured at three sampling sites. The curves for the forest patch and 10-year old oil palm plantation were almost reaching an asymptote compared to the coffee-oil palm plantation with a slightly increasing curve. A similar trend occurred for the diversity estimates. Nevertheless, it was estimated that about 93%, 89% and 91% of arthropod species have been sampled for oil palm, coffee-oil palm and forest patch respectively (Figure 1).

Table 1. List of morpho-species at three vegetation types

Order	Name	Species	Number of Individuals		
			Oil Palm	Coffee	Forest
Diptera	Stilt-legged flies	Sp. 1	689	398	743
Diptera	Fruit fly	Sp. 2	64	64	82
Diptera	Black fly	Sp. 3	811	1114	747
Diptera	Black Soldier Fly	Sp. 4	9	21	3
Diptera	Cecidomyiidae fly	Sp. 5	515	330	458
Diptera	Crane fly	Sp. 6	54	44	50
Diptera	Crane fly (striped)	Sp. 7	41	36	56
Diptera	Blow fly	Sp. 8	76	136	184
Diptera	Anopheles	Sp. 9	69	47	321
Diptera	Flies (brown)	Sp. 10	85	71	161
Diptera	House fly	Sp. 11	84	99	100
Diptera	Banana stalk fly	Sp. 12	56	66	64
Diptera	House fly (yellow)	Sp. 13	15	15	90
Diptera	House fly (striped abdomen)	Sp. 14	8	69	76
Diptera	Black anopheles	Sp. 15	5	170	310
Diptera	House fly (black abdomen)	Sp. 16	8	13	37
Diptera	Blue bottle fly	Sp. 17	5	1	68
Diptera	Aedes	Sp. 18	0	0	517
Diptera	Flies (rare)	Sp. 19	0	0	4
Coleoptera	Brown eucinetidae	Sp. 20	43	97	49
Coleoptera	Small round brown beetle	Sp. 21	29	40	58
Coleoptera	Black eucinetidae	Sp. 22	90	91	120
Coleoptera	Small round black beetle	Sp. 23	90	84	89
Coleoptera	Fungus beetle	Sp. 24	23	11	0
Coleoptera	Lady bird	Sp. 25	11	15	11
Coleoptera	Orange beetle	Sp. 26	0	0	8
Coleoptera	Black beetle (brown mole)	Sp. 27	3	6	1
Coleoptera	Brown head black body beetle	Sp. 28	1	0	0
Hymenoptera	Red carpenter ant	Sp. 29	49	74	177
Hymenoptera	Red carpenter ant (wings)	Sp. 30	9	27	41
Hymenoptera	Black carpenter ant	Sp. 31	78	114	270
Hymenoptera	Black carpenter ant (wings)	Sp. 32	10	34	34
Hymenoptera	Black fire ant	Sp. 33	12	1018	2221
Hymenoptera	Bee (striped)	Sp. 34	0	3	4
Hymenoptera	Wasps	Sp. 35	40	37	20
Hymenoptera	Black garden ant	Sp. 36	13	1	41
Hymenoptera	Black garden ant (wings)	Sp. 37	7	0	22
Hymenoptera	Fire ant	Sp. 38	7	181	155
Hymenoptera	Black bee	Sp. 39	0	5	13
Hymenoptera	Green sweet bee	Sp. 40	2	7	7
Hymenoptera	Bee (rare)	Sp. 41	0	0	2
Blattodea	Cockroaches	Sp. 42	30	21	34
Blattodea	Cockroaches (black yellow)	Sp. 43	3	5	0
Lepidoptera	Moths (brown)	Sp. 44	13	23	49
Lepidoptera	Moths (white)	Sp. 45	42	17	41
Lepidoptera	Moths (yellow brown)	Sp. 46	10	6	20
Lepidoptera	Moths (blue)	Sp. 47	0	6	29
Lepidoptera	Moths (green)	Sp. 48	0	1	8
Lepidoptera	Moths (black)	Sp. 49	0	1	5
Odonata	Dragon fly (green)	Sp. 50	0	0	21
Odonata	Black dragon fly	Sp. 51	3	0	3
Isoptera	Rhinotermitidae	Sp. 52	91	24	37
Dermaptera	Earwig	Sp. 53	56	58	36
Dermaptera	Earwig (black)	Sp. 54	0	3	0
Hemiptera	Brown	Sp. 55	6	0	0
Hemiptera	Cosmolestes	Sp. 56	0	41	10
Hemiptera	True bugs	Sp. 57	0	36	38
Hemiptera	Lantern bug	Sp. 58	0	0	1
Orthoptera	Grasshopper (brown)	Sp. 59	0	19	28
Orthoptera	Grasshopper (yellow)	Sp. 60	0	8	11
Orthoptera	Grasshopper (black)	Sp. 61	0	5	46
Orthoptera	Grasshopper (green)	Sp. 62	6	10	28
Orthoptera	Grasshopper (striped)	Sp. 63	0	0	1
Pseudoscorpiones	Pseudoscorpion	Sp. 64	1	0	0
Total number of individuals/sites			3372	4823	7860
Total number of individuals				16,055	

Table 2. Species diversity, richness and evenness at the three vegetation types

	Oil palm	Coffee-oil palm	Forest patch
Taxa	46	52	58
Individuals	3372	4823	7860
Simpson, Dmn	0.8699	0.8832	0.8867
Shannon, H’	2.651	2.791	2.879
Evenness	0.3079	0.3135	0.3069
Chao-1	47	58	60

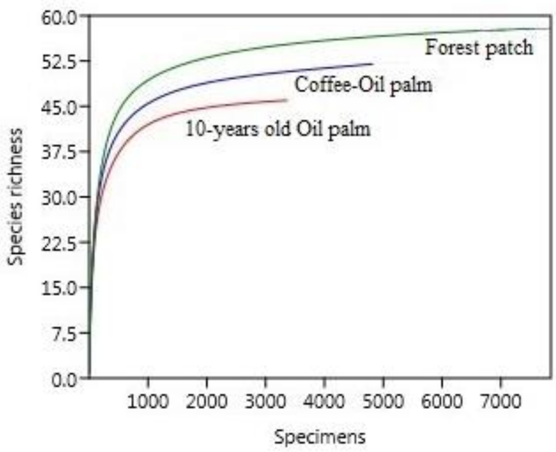

Figure 1. Rarefaction-based accumulation curve indicating the number of species relative to the number of individuals captured throughout the study

DISCUSSION

Arthropod species that do well within oil palm plantations are species that are common in a wider agricultural landscape, and so are considered to be less important than forest specialists, which may have been lost (Turner & Foster, 2009). Some arthropod species that survive in the oil palm ecosystem has an important function to balance the ecosystem including preying on pests, act as a food source for predators, aiding decomposition, recycling waste and acting as pollinators (Turner & Foster 2009; Pashkevich *et al.*, 2020). These arthropod species do not show a negative response to habitat alteration probably due to species-specific difference in tolerance to agricultural ecosystem (Turner & Foster, 2009).

The importance of High Conservation Value (HCV) including forest patches in oil palm plantations has shown that structurally complex vegetation can preserve and increase various fauna species (Azhar *et al.*, 2015). This study indicates the importance of preserving forest patches to support a greater number of arthropod species. This is due to the increase in the structural, and vegetation complexity of the area and providing variation in microhabitats (Jose, 2009; Ashraf *et al.*, 2018). Interestingly, agricultural area that has high vegetation complexity close by would support a greater number of arthropod species where many of the recorded species were predators, that plays an important role to suppress pest species (Perfecto *et al*., 1996). This is probably the reason that this oil palm plantation has no pest outbreak condition.

Meanwhile, recent agriculture has proven that practicing polyculture farming in oil palm contributes significantly to support the number of arthropods species (Ashraf *et al.*, 2018). For instance, Ghazali *et al.* (2016) identified that polyculture had significantly greater arthropod species than monoculture farming practice. It is evident that this present result on polyculture of oil palm-coffee practice could affect the number of arthropod species. Although the oil palm-coffee uses pesticides to control pests as its normal practice, the application was not done throughout this study period. However, the consequences of the application may directly affect arthropod species. Nevertheless, improving polyculture practice should become one of the key management strategies to increase the number of arthropod species and functions within the oil palm ecosystem (Ashraf *et al.*, 2018).

In oil palm plantation, structural complexity is closely related to different ages of oil palm stands, whereby mature oil palm stands support a greater number of species due to more complex structure, opportunities for undergrowth to develop and suitable microclimate (Luskin & Potts, 2011; Luke *et al.*, 2014; Ghazali *et al.*, 2016) which have some benefits for arthropod species. In this study, a 10-year old oil palm which has simplified vegetation complexity with very little undergrowth, has a smaller number of arthropod species. However, besides the oil palm age, sustainable agriculture practices such as planting of cover crops (Pashkevich *et al.*, 2020), maintaining lower understorey temperature and providing a layer of mass organic matter and epiphytes (Ganser *et al.,* 2016) could provide microhabitat for arthropod species, and hence boost the number of species.

CONCLUSION

The results show that vegetation structure complexity supports a greater number of arthropod species as they provide suitable microhabitats, food sources, the place to breed and shelter within oil palm plantations. This implies that Malaysian Sustainable Palm Oil certification is a way forward to promote sustainable management practice in order to protect and promote biodiversity-friendly oil palm plantation.

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