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Arthropods associated with the University owned Industrial tree plantations

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Abstract

Assessment of arthropods diversity was conducted in the three ITP of Central Mindanao University in Bukidnon, Philippines. Three sampling plots consisting of 10 x 10m were randomly laid in each of the *Gmelina arborea* Juss., *Tectona grandis* L.f, and *Acacia mangium* Willd. plantations. Collection of arthropods was carried-out using the combination of light trapping, pitfall traps, sticky paste and bottle traps techniques. The environmental variables such as ambient temperature, relative humidity, soil compactness, litter fall thickness, and light intensity were also determined to explain the abundance of arthropods. Results revealed that a total of 348 individuals were recorded comprising of ten arthropod orders and 17 families. Highest arthropods diversity was observed in *G. arborea* with diversity value of (0.13) followed by *T. grandis* with (0.226) then *A. mangium* with (0.322). Among the variables, ambient temperature and relative humidity exhibit correlation on the number of species and the number of individual species. The result suggests that *G. arborea* plantation supports more arthropods compared to other industrial tree plantation in this study. This indicates that *G. arborea* plantation, with its species diversity and understory succession provides this exotic plantations' capability of providing habitat for arthropods and enhanced biodiversity.

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Introduction

There have been opposing notions on whether the use of exotic species in plantations promotes biodiversity conservation. A synthesis of this topic was thoroughly discussed by Bremer and Farley (2012). For ecologist and conservationists, exotic plantations are “green deserts” since they harbor very low levels of biodiversity (Barlow *et al.,* 2007a; Makino *et al.,* 2007), probably because no fundamental ecological relationship that binds between these species with the indigenous flora and fauna of the area. Moreover, there is likelihood that exotics, having no natural predators may become invasive and may suppress the growth and establishment of the propagules of the regenerating understory vegetation due to allelopathy and competition.

However, in contrary, there were also numerous reports that exotic plantations can play a crucial role in the conservation and restoration of species (Hartley 2002; Cusack and Montagnini 2004; Carnus *et al.,* 2006), because they exhibits structural similarities to natural forests (Brockerhoff *et al.,* 2008) thus, may promote some suitability for forest biodiversity (Lindenmayer, 2000), and enhance landscape connectivity and regional biodiversity (Cancela, *et al.,* 2013). Hence, it is in this context that the present study was conducted to evaluate the arthropod inhabitation of these exotic plantations and determine which among these plantations could provide surrogate habitat towards achieving species richness.

Materials and methods

Study site

The study was conducted at the plantation forest managed by Central Mindanao University (CMU) in Musuan, Maramag, Bukidnon (Fig. 1). The Province of Bukidnon is located at the center of Mindanao Island, southern part of the Philippines. The Province lies within the geographic coordinate 7°25' to 8°38' North, and 124°03' and 125°16' East. The climate is relatively cool and moist throughout the year, with no very pronounced maximum rain period and no dry seasons. Mean annual rainfall in the province is 2800 mm, while mean annual temperature and relative humidity ranges are 20°C–34°C and 90.86%–92.85%, respectively (Bukidnon 2016). The university has a total area of 3,080 has and 575.16 has of which is devoted to industrial tree plantation forest ie Yemane (*Gmelina arborea* Juss), Mangium (*Acacia mangium* Willd) and Teak (*Tectona grandis* L.f.). (Rojo And Paquit, 2018).

Sampling

Three sample plots measuring 10 m x 10 m were randomly distributed within each stand. Total sampling area was 300 m² for each stand. A combination of various trapping techniques for arthropods collection viz light trapping, pit-fall traps, sticky paste, and bottle traps were conducted in each sample plots. All the arthropods captured were identified and recorded accordingly.

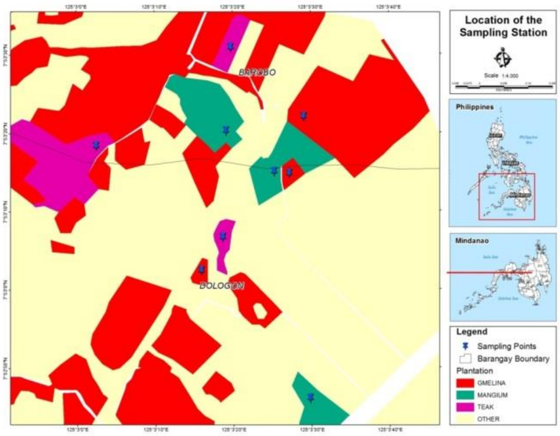

Fig. 1. Location of the sampling stations.

Environmental Variables

The environmental variables such as ambient temperature, relative humidity, soil compactness, litter fall thickness, and light intensity were determined. Ambient temperature and relative humidity were determined by using a handheld digital psychrometer and the measurements were done thrice in a day specifically at 7:00 in the morning, 12:00 noon, and 4:00 in the afternoon for a period of one week. The light intensity in every plantation was also measured using a digital photometer following the same protocols in determining AT and RH. The closure of the canopy was measured using a spherical densitometer while the humus thickness was measured using a ruler, measurements were taken from the top-most portion of the litter to the top soil.

Data Analysis

Arthropods species diversity and abundance in the canopies of the three forest plantations were analyzed using Simpsons Diversity Index and Bray-Curtis Cluster Analysis (Single Link) *via* BioPro software, while multivariate analysis was used to determine the correlations between the abundance and/or species diversity and environmental variables.

Results and discussion

Environmental Variables

In connection to its biophysical characteristics, *Tectona grandis* plantation has the highest range of relative humidity at an average of 79.17% in three sample plots, followed with *Acacia mangium* Willd. plantation having average relative humidity of 70.27% among three sampling plots, *Gmelina arborea* Juss. plantation have the least average relative humidity of 64.67% accordingly (Table 1). As relative humidity increases, arthropod individual species and diversity decreases but this vary among species' preference to humidity. In temperature, *Gmelina arborea* plantation has the highest average temperature among three sample plots (30.3˚C), followed with *Acacia mangium* Willd. having an average temperature of (26.07˚C), and the least temperature as recorded in *Tectona grandis* L.f. (25.47˚C). This result account equilibrium in temperature and species abundance and diversity. As temperature increases, arthropod species increases too, but this vary among species' preference to temperature.

For canopy characteristics, study area displayed high light intensity recorded in *Gmelina arborea* Juss. plantation, which defined canopy openness and the least light intensity recorded in *Tectona grandis* L.f. which defined canopy closeness accordingly (Fig. 2). This result for light intensity contradicts the study of Košulič (2016), which stated that functional diversity peaked at more closed canopies followed by a rapid decrease with increasing canopy openness, thus, there is a need to consider other parameters that shall affect the relationship of canopy to species abundance and diversity. Plantation development seems to affect both the abundance and species diversity of litter arthropods negatively this may be due to the fact that arthropods like mesofauna preferred an undisturbed forest ecosystem which the natural forest provides (Adeduntan *et al.,* 2012). However, some researchers report that arthropods abundance is not necessarily more in the natural forest than that in plantations (Evans, 1999).

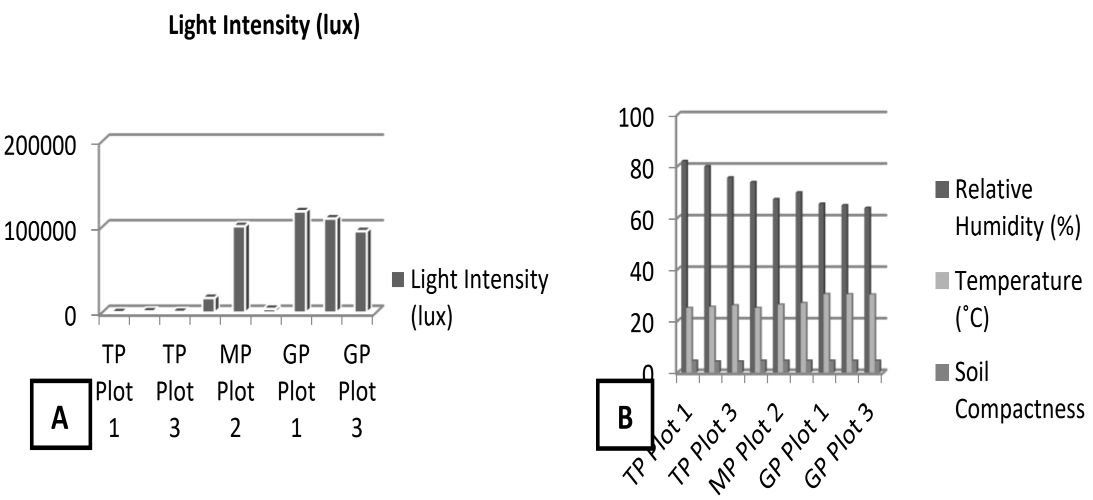

Fig. 2. A, Graph on the lux intensity of the three plantation, **B,** . Graph on the relative humidity, temperature and soil compactness (Teak, Mangium, and Gmelina).

Table 1. Bio-physical characteristics of the sample plots which includes the relative humidity, temperature, light intensity and soil compactness.

Study Area	Relative Humidity (%)	Temperature (˚C)	Light Intensity (lux)	Soil Compactness
TP Plot 1	82	25	340	4.5
TP Plot 2	79.9	25.4	1300	4.2
TP Plot 3	75.6	26	720	4.2
MP Plot 1	73.8	25	17100	4.5
MP Plot 2	67.2	26.3	101000	4.5
MP Plot 3	69.8	26.9	4280	4.5
GP Plot 1	65.4	30.4	118400	4.5
GP Plot 2	64.8	30.3	110000	4.5
GP Plot 3	63.8	30.2	95100	4.5

TP- teak plantation, MP- mangium plantation, GP- Gmelina Plantation

Species composition

A total of 348 individuals were accounted on the three exotic plantations comprising 20 species representing 17 families under 10 orders in 17 families (Table 2). The least abundant species in Teak plantation was *Tachycines asynamorous* with only one (1) individual, for Mangium plantation was *Pompeius verna* (Hesperiidae) and *Indet* spp (Arctiidae) and *Indet* spp. (Acrididae) with only one (1) individual and for *Gmelina* plantations the least abundant species was *Anomala* sp. (Scarabaeidae) as shown in Table 2. Adult *Anomala* sp. or anomalines adult are both nocturnal and diurnal, they are often attracted to lights at night and some of them feed little or not at all (Ritcher 1943). However, this type of species might become agricultural pests if introduced to new regions (Jameson *et al.,* 2003). The *G. arborea* plantation had the highest abundance with 188 individuals followed by *A. mangium* with 84 individuals, while the *T. grandis* had the least with only 76 individuals. The result also revealed that cockroach (*Blattodea*) was found to have the highest number of recorded individuals consisting of 104 and were found common to all plantations. However, the reason why Cockroaches (*Blattodea*) were abundant in plantations may be because they are found nearly in all types of habitats.

Table 2. The abundance of arthropods in the studied Plantations (*TP* for Teak plantation, *MP* for Mangium plantation and *GP* for Gmelina plantation).

Order	Species	Family	TP	MP	GP	Total
Orthopthera	*Indet.*	Acrididae	0	1	0	1
Orthopthera	*Indet.*	Acrididae	4	7	27	39
Orthopthera	*Tachycines asynamorous*	Rhaphidophoridae	1	0	15	13
Coleoptera	*Indet* sp.	Curculionidae	3	12	10	27
Coleoptera	*Epicauta pennsylvanica*	Meloidae	10	14	15	39
Coleoptera	*Batocerarobus*	Cerambycidae	0	0	8	1
Coleoptera	*Anomala* sp.	Scarabaeidae	0	0	1	1
Blattodea	*Blatella vaga*	Blattellidae	9	43	52	104
Orthoptera	*Indet* sp.	Tettigonidae	0	5	0	5
Orthoptera	*Indet* sp.	Tettigonidae	0	0	8	4
Lepidoptera	*Pompeiusverna*	Hesperiidae	9	1	0	10
Lepidoptera	*Indet* sp.	Arctiidae	5	1	14	13
Lepidoptera	*Ostrinia furnacalis*	Crambidae)	0	0	10	8
Polyxenida	*Narceus americanus*	Spirobolidae	2	0	0	2
Diptera	*Indet* sp.	Mycetophilidae	33	0	0	18
Orthoptera	*Melicodestenebrosa*	Acrididae	0	0	9	5
Hymenoptera	*Apisdorsata*	Apidae	0	0	5	5
Mantodea	*Hierodula* sp.	Mantidae	0	0	6	6
Aranae	*Indet* sp.	Selenopidae	0	0	6	2
Phasmatodea	*Parapachymorph aspiniger*	Phasmatidae	0	0	2	2
Total			76	84	188	348

According to Bell *et al.* (2003), that this type of species is active in the entire vertical dimension in the terrestrial environment (upper forest canopy, dead leaves, rotting logs etc.) but they are less diverse in temperate region. The work of Mondal and Rojo (2017) although in dipterocarp saplings showed much diverse arthropods with 959 individuals representing 83 families under 12 orders. Of the twenty species identified, only five (5) of the species were common to all plantations. This includes *Epicauta pennsylvanica (*Meloidae), *Blatella vaga (*Blattellidae), and three indeterminate species under the family Acrididae.

Table 3 presents the arthropods species diversity values of the area using the Simpson's Diversity (D) and (1/D). The Simpson diversity index, which allows comparison of trend of dominance with the bigger the value of D the lower the diversity, was greater in the mangium plantation suggesting that a few numbers of species were dominating the area than the teak and Gmelina plantations. Gmelina plantation had lesser value of diversity compared to the teak plantation signifying that it has greater number of species dominated in the area. These results were graph and showed in (Fig. 3).

Table 3. Results of the Simpson's Diversity (D, 1/D) using Biodiversity Pro.

Index	TP	TP	TP	MP	MP	MP	GP	GP	GP
Simpsons Diversity (D)	0.173	0.212	0.293	0.252	0.257	0.457	0.15	0.137	0.092
Simpsons Diversity (1/D)	5.769	4.71	3.409	3.963	3.889	2.19	6.653	7.292	10.88

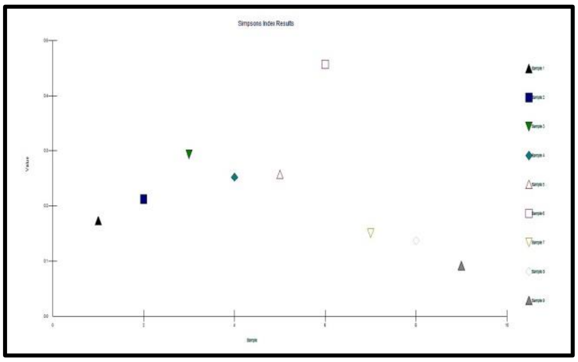

Fig. 3. Simpsons Diversity Results of the sample plots in the three plantations. Sample 1-3, 4-6 and 7-9 represents the teak, mangium and gmelina plantations, respectively.

The three plantations exhibit their closeness and likeness in arthropods species diversity but still exhibit uniqueness with percent similarity index of 38.89% (Fig. 4).

Correlation coefficients are statistics that quantify the relation between X and Y in unit-free terms. The sign of the correlation coefficient determines whether the correlation is positive or negative. The magnitude of the correlation coefficient determines the strength of the correlation. In Table 4, there is a significant negative correlation between relative humidity and temperature *r (7) = -0.845, p= 0.004*, that means that when temperature drops, relative humidity increases.

And also, temperature is significant and is positively correlated to number of species and number of individuals*, r (7) = 0.824, p= 0.006*. This means that when the temperature increases the number of individual species also increases. Simpsons diversity is negatively correlated to the number of species, *r (7) = -0.838, p= .005*.This means also that when the value of the Simpson's diversity is higher, the lower is the number of species (low diversity). The data in Table 4, shows a negative correlation at (0.01 level) of number of species to Simpsons Diversity Index *r (7) = -0.838, p= 0.005*, and also the number of individuals to the latter *r (7) = -0.803, p=0.009*.

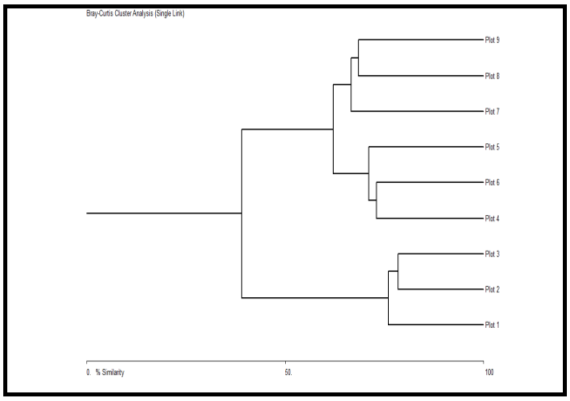

Fig. 4. Percent similarity of arthropods diversity in Teak, mangium and Gmelina plantations. Sample 1-3, 4-6 and 7-9 represents the teak, mangium and gmelina plantations, respectively.

Table 4. Correlations of the bio-physical characteristics using Pearson Correlation.

		RH	SC	Temp	Species	Individual	Diversity Index
	Correlation	1	-.535	-.844**	-.627	-.623	.209
RH	Sig. (2-tailed)		.137	.004	.071	.073	.590
	N	9	9	9	9	9	9
	Correlation	-.535	1	.381	.268	.369	-.145
SC	Sig. (2-tailed)	.137		.311	.486	.328	.710
	N	9	9	9	9	9	9
	Correlation	-.844**	.381	1	.914**	.828**	-.498
Temperature	Sig. (2-tailed)	.004	.311		.001	.006	.173
	N	9	9	9	9	9	9
	Correlation	-.627	.268	.914**	1	.921**	-.748*
#ofspecies	Sig. (2-tailed)	.071	.486	.001		.000	.020
	N	9	9	9	9	9	9
	Correlation	-.623	.369	.828**	.921**	1	-.609
#ofindividuals	Sig. (2-tailed)	.073	.328	.006	.000		.082
	N	9	9	9	9	9	9
DiversityIndex	Correlation	.209	-.145	-.498	-.748*	-.609	1
	Sig. (2-tailed)	.590	.710	.173	.020	.082	
	N	9	9	9	9	9	9

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed).

From the results in (table 2), 348 individuals of arthropods were encountered in the study areas with 20 species. Highest values were recorded for species diversity in *Gmelina arborea* plantation. *Acacia mangium* plantation was next in the number of individuals but least in species diversity (84 individuals and 8 species). In connection to its biophysical characteristics (table 4), *Tectona grandis* plantation has the highest range of relative humidity at an average of 79.17 percent in three sample plots, followed with *A. mangium* plantation having average relative humidity of 70.27% among three sampling plots, *G. arborea* plantation have the least average relative humidity of 64.67% accordingly. As relative humidity increases, arthropod individual species and diversity decreases. In temperature, *G. arborea* plantation has the highest average temperature among three sample plots (30.3˚C), followed with *A. mangium* having an average temperature of (26.07˚C), and the least temperature as recorded in *T. grandis* (25.47˚C) (table 1). This result account equilibrium in temperature and species abundance and diversity.

As temperature increases, arthropod species increases too, but this vary among species' preference to temperature. For canopy characteristics, study area displayed high light intensity recorded in *G. arborea* plantation, which defined canopy openness and the least light intensity recorded in *T. grandis* which defined canopy closeness accordingly. This result for light intensity contradicts the study of Košulič 2016, which stated that functional diversity peaked at more closed canopies followed by a rapid decrease with increasing canopy openness, thus, there is a need to consider other parameters that shall affect the relationship of canopy to species abundance and diversity. Plantation development seems to affect both the abundance and species diversity of litter arthropods negatively this may be due to the fact that arthropods like mesofauna preferred an undisturbed forest ecosystem which the natural forest provides (Adeduntan *et al.,* 2012). However, some researchers report that arthropods abundance is not necessarily more in the natural forest than that in plantations (Evans, 1999).

Gmelina arborea species are relatively drought tolerant, tolerating annual precipitation in the range of 700-4500 mm (NAS 1980). This has made *G. arborea* an attractive species for the establishment of plantations both in countries where it is native and as an exotic throughout the tropics including the Philippines (NAS 1980). *G. arborea* stand facilitated higher number of native woody regeneration than the native Bangkal stand (Casas *et.al* 2017) this may be the one of the cause of insect diversity in Gmelina plantations. It was found that exotic *G. arborea* plantation had significantly better species diversity (H = 1.06 ± 0.10) and species richness (42 species, 959 individuals) as compared to that of Bangkal (H= 0.52 ± 0.27, 9 species, 584 individuals), where majority of the species found in *G. arborea* are trees (64%), while Bangkal was dominated (90%) by herbaceous plants. They also stress out that it is important that the existing number of native woody regeneration are able to grow into the canopy and create appropriate canopy structure similar to natural forest to be more stable. This indicates that *G. arborea* plantation, with its species diversity and understory succession provides this exotic plantations' capability of providing habitat for arthropods and enhanced biodiversity.

Related study to Adeduntan *et al.,* 2012, Gmelina plantation has least abundance in terms of litter arthropods and Teak plantations accounts also for the least species diversity. Canopies of wild teak had greater insect biodiversity than plantation; however, the number of potential insect pollinators in the plantation canopies was greater than the wild trees (Tangmitcharoen *et.al*, 2006). These studies relate to idea that forest plantations can be a potential surrogate habitat for arthropods species.

Conclusion

There is a positive relationship between diversity of plants and the diversity of arthropods. The trees serve as a habitat for the arthropods. The result of the study suggests that the plantation of exotic species in the country is important not only for timber purposes but also as a potential surrogate habitat of many arthropods. It is a good indicator that the diversity of the area in terms of fauna will also recover in the near future, since arthropods are considered to be a keystone species in an ecosystem.

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Conflict of interest

The author declares that there is no conflict of interests regarding the publication of this manuscript.

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