Research article

Assessment of Insect Damage and Growth Performance of Dipterocarps Planted at Rainforestation Demonstration Farm at VSU, Baybay City, Leyte

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Received 30 December 2020 Accepted 16 May 2021 (*Corresponding Author)

Abstract Assessment of associated insects and leaf damage caused by insects is essential concerning decisions to contribute to developing suitable rehabilitation techniques. Few studies have been done to identify the insect species associated with dipterocarp species and determine the damage caused by insects and their growth performance. Six species of dipterocarps, namely: *Dipterocarpus alatus* (hairy leaf apitong), *Hopea philippinensis* (gisok-gisok), *Shorea malibato* (malibato), *Shorea assamica* (manggasinoro), *Shorea polita* (malaanonang), and *Shorea almon*, were studied. This study was conducted to determine the insect-associated fauna using the visual and handpicking method of insect collection, leaf damage assessment using the Bioleaf app, and the morphological traits (i.e., basal diameter and plant height) on the growth performance of dipterocarps. There were eight orders of insects associated with the dipterocarps: Coleoptera, Diptera, Hemiptera, Heteroptera, Hymenoptera, Lepidoptera, Odonata, and Orthoptera. There was a significant difference ($p \leq 0.05$) in the leaf damage among the six dipterocarps species after 25 months from planting. *Shorea assamica* had the highest leaf damage (8.68% ± 0.09), and *Shorea almon* had the least leaf damage (2.57% ± 0.09). In terms of basal diameter, the species with the highest significant increment ($p \leq 0.05$) was *Shorea polita* (2.49 ± 0.67 mm), while *Shorea almon* had the least growth increment (0.98 ± 0.67 mm) 25 months after planting. *Dipterocarpus alatus* grows faster for the plant height than other species with a significant increment ($p \leq 0.05$) of 32.90 ± 0.19 cm, while *Shorea assamica* had the least increment of (4.95 ± 0.19) cm. The study indicated eight orders of insects associated with the dipterocarps showing significant damage on the *S. assamica*. Despite the insect association, the plants grow significantly with the rapid increase observed on *D. alatus*.

Keywords dipterocarp, defoliation, insect fauna, leaf damage, bioleaf

INTRODUCTION

Herbivorous species, mostly insects, are a significant global biodiversity component, comprising approximately 25% of all described species. Insect herbivores are among the many biotic factors known to help maintain forest diversity through selective predation on vulnerable tree species' seedlings altering forest community composition (Norghauer and Newbery, 2013). Insect herbivores, directly and indirectly, influence plant community composition by altering the recruitment, mortality, or individual growth rates of plant species, as supported by Maron and Crone, 2006.

Dipterocarps are known worldwide because of their economic and ecological functions. It has a good timber quality exported to other countries in finished products such as plywood and sawn timber (Corlett and Primack, 2005). According to Langenberger (2005), some species of dipterocarps are indicators for site suitability in local reforestation programs. Moreover, insect herbivores increase tree seedling recruits (Dyer et al., 2010). Annual rates of leaf damage are higher in tropical forests than in temperate broad-leaved forests (Coley and Barone, 1996). In the natural Dipterocarp forest, insects are the primary source of damage as leaf feeders, borers, suckers, and gall formation (Appanah, 1998).

Despite the knowledge about the damages caused by the insects' attack, few studies have been done in the Philippines to identify the insect species associated with *Dipterocarpus alatus* (hairy leaf apitong), *Hopea philippinensis* (gisok-gisok), *Shorea malibato* (malibato), *Shorea assamica* (manggasinoro), *Shorea polita* (malaanonang), *Shorea almon* and its growth performance. These species were chosen because of their conservation status according to the Updated National List of Threatened Philippine Plants and Their Categories by the Department of Environment and Natural Resources Administrative Order No. 2017-11. Assessing the damage caused by the insect is essential concerning assisting experts to make better decisions to contribute to efforts of developing suitable rehabilitation techniques and to recommend favorable dipterocarp species that can stand insect herbivory. Furthermore, the study used a novel approach in assessing leaf damage i.e., using the Bioleaf app for the first time on dipterocarps which in the literature has been commonly used in assessing leaf damage on soybean (Machado, 2016)

OBJECTIVES

1. To identify the insect species associated with the dipterocarps planted in the dipterocarp germplasm and;
2. To assess the leaf damage of insects and growth performance of dipterocarps planted in the dipterocarp germplasm of VSU, Baybay City, Leyte, Philippines.

METHODOLOGY

Location of the Study Site

The study site was located at the Dipterocarp germplasm of the Terrestrial Ecosystems Division (TED), Institute of Tropical Ecology and Environmental Management (ITEEM) field laboratory established near the Rainforestation Research Training Center (RRTC), Visayas State University-Main Campus, Baybay City, Leyte, Philippines (Fig. 1). It has a total area of approximately 1.80 hectares planted to 30 species of dipterocarps. The seedlings were randomly planted with a planting distance of 5 meters x 5 meters, constituting 21 seedlings per species. Six species of dipterocarp trees are randomly selected among the species of dipterocarps planted in the germplasm.

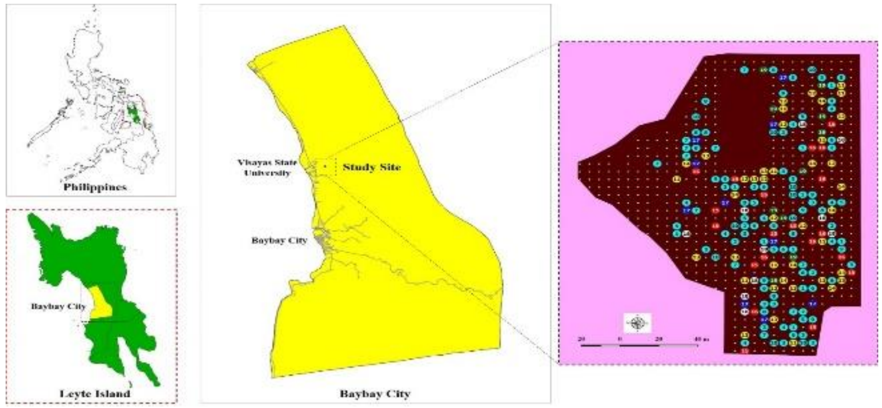

Fig. 1 The study site is located in Visca, Baybay City, Leyte, Philippines.

Assessment of Insect Fauna Associated with Dipterocarps

To identify the insect species inflicting damage on the trees and affected their growth performance, visual observation and handpicking was used as an insect collection method (Fig. 2). This included documenting all insects encountered and their damage among the sample plants. Insects observed were photographed, documented, and were collected by handpicking. They were brought to the laboratory to validate and identify the type of damage to the tree species. Insects that were collected were identified according to Order level. Sampling was done every morning (6:00 to 8:00 a.m.) and afternoon (3:00 to 5:00 p.m.). Samples were separately placed in jars with a killing agent and brought to the laboratory for processing, identification, and recording. Insects collected from each sample tree were separately kept for counting and sorting (Fig. 3). The different arthropod species were classified according to the following categories (Wall work, 1976 as cited by Ceniza, 1995). Insects can be considered "accidental" if the species occurs in 1-24 % of samples; "accessory" if the species occurs in 25-49% of samples; "constant" if the species occurs in 50-74% of samples; and "absolute" if the species occurs in 75-100% of samples.

Fig. 2 Visual and handpicking

Fig. 3 Sorting of insects in labeled plastic wares and vials

Assessment of Leaf Damage Using the Bioleaf App

The study followed the methodology on insect herbivory assessment by Herve et al. 2017, which is suitable for this study. Measures were made on a fixed number of leaves per tree, choosing two facing opposite branches at the top and two facing opposite branches at the middle, and two facing opposite branches bottom of the tree crown. Ten leaves were randomly chosen at the top of a branch, ten at the middle, and ten leaves at the bottom per tree per species. If there were not enough leaves on the branch, one could choose another branch at the same height. If there are not enough branches, one can use the main axis. Assessed leaves were different from one assessment to the next because some may fell, some may have appeared, and damage may have accumulated. Bioleaf foliar analysis was used to estimate the damage (Machado et al., 2016), a professional mobile application to measure foliar damage caused by insect herbivory, developed by a Brazilian team of researchers released in 2016. It then estimated the defoliation percentage related to the total area using images captured from the camera or loaded from the photo gallery. Pictures of the leaf images taken from the field were loaded into the bioleaf app, automatically reading the injured leaf regions caused by insect herbivory and estimating the total area's defoliation percentage (Fig. 4).

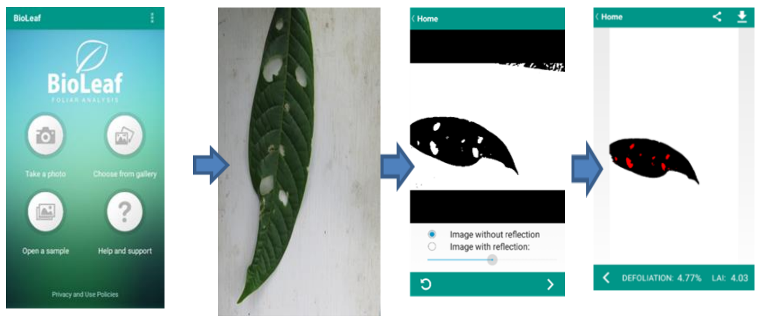

Fig. 4 Process flow for the bioleaf foliar analysis

Growth Performance of Dipterocarp Species

Ten sample plants per species of dipterocarp were measured every three months. The basal diameter (mm) was measured at the base of the stem using a Vernier caliper. The sample plants' base was marked with white ink to ensure a permanent measurement point from the present to the following data collection (Fig. 5). Meanwhile, the plant height (cm) was measured using a meter stick. It was taken from the stem's base up to the stem's tip (Fig. 6).

Fig. 5 Measuring the basal diameter

Fig. 6 Measuring the total plant hight

Data Encoding and Statistical Analysis

All data gathered were collated, encoded, and summarized using an electronic spreadsheet editor, Microsoft Excel 2013. The data were analyzed using the Statistical Package for Social Science (SPSS version 20). The mean of basal diameter and plant height variability were analyzed using the one-way analysis of variance (ANOVA). Moreover, in a case where the significant variations at $p \leq 0.05$ were identified, Tukey and Least Squares Differences (LSD) were carried out to compare means.

RESULTS AND DISCUSSION

Insect Species Associated with Dipterocarp Species

Table 1 shows the list of insect orders associated with the dipterocarps. It included eight insects, namely, Coleoptera, Diptera, Hemiptera, Heteroptera, Hymenoptera, Lepidoptera, Odonata Orthoptera. These groups were composed of chewers and suckers, the major groups causing damage to the dipterocarp species.

Table 1 List of insect order associated with the dipterocarp species

Dipterocarp species	Insect orders with constancy class
Dipterocarpus alatus	Orthoptera-(Ab), Coleoptera- (A), Hemiptera- (A), Lepidoptera (Ab), Odonata (A)
Hopea philippinensis	Orthoptera-(C), Coleoptera- (Ac), Hemiptera- (Ac), Lepidoptera (Ab)
Shorea almon	Orthoptera-(A), Coleoptera- (A), Hemiptera- (A), Lepidoptera (Ab)
Shorea assamica	Orthoptera-(Ab), Coleoptera- (Ab), Hemiptera- (Ab), Lepidoptera (Ab), Heteroptera (Ab), Diptera (C), Hymenoptera (Ab), Odonata (Ac)
Shorea malibato	Orthoptera-(C), Coleoptera- (Ac), Hemiptera- (Ac), Lepidoptera (Ab)
Shorea polita	Orthoptera-(C), Coleoptera- (A), Hemiptera- (A), Lepidoptera (Ab)

Note: Accidental 1-24% Ac- Accessory 25-49% C- Constant 50-74% Ab- Absolute 75-100%

Leaf Damage

The leaf damage samples of six dipterocarp species were shown in Fig. 7. The statistical analysis results showed significant ($p \leq 0.05$) differences in the leaf percentage damage among the six dipterocarps species during the data collection 25 months after planting. Fig. 8 shows the results on the leaf percentage damage of dipterocarp species in the three sampling periods. *Shorea assamica* had the highest leaf damage (8.68% ± 0.087), and *Shorea almon* had the least leaf percentage damage (2.57% ± 0.087).

Fig. 7 Leaf damage samples of six dipterocarp species

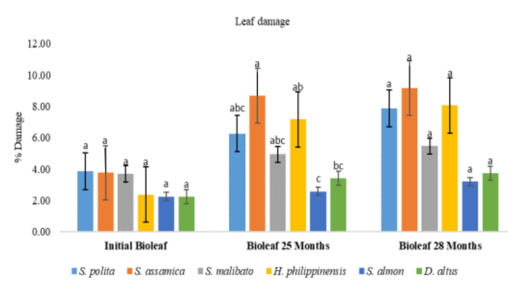

Fig. 8 Percentage damage of leaves of six dipterocarp species

Note: Values in the figure with different letters (a-b) designation across treatments during data collection periods are statistically significant at p ≤ 0.05. N = 10 in total for all treatments per species per period.

Basal Diameter and Plant Height

The different dipterocarp species' growth performance showed increments and variations after a 3-month sampling period, 25 months after planting. Increments are used as a measure of performance in our forest stands for a particular period (Assmann, 1970). This was calculated as the difference between the initial growth of the height and basal diameter of the plant at 22 months and its growth after 3months and 6 months.The most significant growth increment was *the Shorea polita* (2.49 mm ± 0.67) regarding basal diameter. At the same time, *Shorea almon* had the least growth increment (0.98 ± 0.67). However, it can be seen from the results that regardless of the dipterocarp species, there was an increase in the growth of the basal diameter between the periods of the first three months and six months (Fig. 9). At least one species in every Dipterocarp genus differed in terms of basal diameter among other species. There was a significant increase in dipterocarp species for the plant height after six months of data collection, 28 months after planting (Fig. 10). There is evidence that at least one species in each Dipterocarp genus differs in plant height among other species. Notably, *Dipterocarpus alatus* (32.90 cm ± 0.19) had a considerable increment in plant height, while *Shorea assamica* (4.95 cm ± 0.19) had the least increment, 28 months after planting.

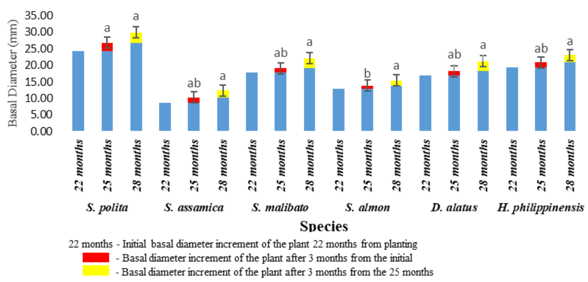

Fig. 9 Basal diameter increment of six dipterocarp species

Note: Values in the figure with different letters (a-b) designation across treatments during data collection periods are statistically significant at $p \leq 0.05$. N = 10 in total for all treatments per species per period.

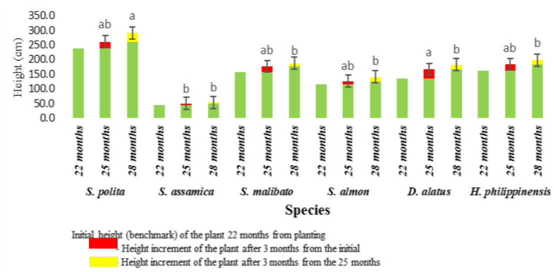

Fig. 10 Height increment of six dipterocarp species

Note: Values in the figure with different letters (a-b) designation across treatments during data collection periods are statistically significant at $p \leq 0.05$. N = 10 in total for all treatments per species per period.

CONCLUSION

There are eight orders of insects associated with dipterocarps: Coleoptera, Diptera, Hemiptera, Heteroptera, Hymenoptera, Lepidoptera, Odonata, and Orthoptera, showing significant damage on the *S. assamica*. There was a significant difference ($p \leq 0.05$) in the leaf damage among the six dipterocarps species during the data collection 25 months after planting. *Shorea assamica* had the most significant leaf damage, and *Shorea almon* had the least leaf damage. The different dipterocarp species' growth performance showed significant increments ($p \leq 0.05$) and variations after a 3-month sampling period, 25 months after planting. In terms of basal diameter, the species with the most significant growth increment was *Shorea polita*. At the same time, *Shorea almon* had the least growth increment. Dipterocarpus alatus grow significantly ($p \leq 0.05$), which had the largest increment for the plant height despite the insect association, while *Shorea assamica* had the least increment. The assessment of associated insects is more relevant in assessing the damage of insects. Thus, it is suggested that a further detailed study and analysis on the family and species level of other groups should be conducted to enhance the recent findings.

ACKNOWLEDGEMENT

This study was supported by the Environmental Leadership and Training Initiative (ELTI) and Visayas State University (VSU).

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