# FACTORS INFLUENCING POPULATION COMPOSITION OF INSECT PESTS ASSOCIATED WITH *Acacia* PLANTATIONS IN VIETNAM

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## ABSTRACT

Large - scale plantations of *Acacia* species have been established in Vietnam for centuries due to their suitability for fuelwood, timber production, and their ecological and economic significance. However, little is known about the population structure of insect species that damage *Acacia* plantations in Vietnam. In this study, we conducted field surveys in *Acacia* hybrid, *Acacia mangium* and *Acacia auriculiformis* plantations, both older and younger than three years, located across nine ecological regions: Central Highland, Central Region of Northern Mountains, Mekong River Delta, North Central Coast, Northeast, Northeast of Southland, Northwest, Red River Delta, and South - Central Coast. From 2013 to 2014, we collected 108 insect species which were identified across six orders from 36 *Acacia* plantation: Lepidoptera (33 species), Coleoptera (32 species), Orthoptera (23 species), Hemiptera (18 species), Homoptera (1 species) and Phasmida (1 species). Non-metric multidimensional scaling (NMDS) analysis showed significant differences in insect species composition based on the age of *Acacia* plantations (Coleoptera), *Acacia* species (Hemiptera and Lepidoptera) and ecological regions (Coleoptera and Lepidoptera).

Keywords: *Acacia species, tree age, ecologial region, population structure, NMDS.*

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## 1. INTRODUCTION

Industrial plantations play an important role in the forestry sector from both economic and environmental perspectives [1, 2]. Among the fast - growing species, *Acacia* is particularly favored in industrial forest plantations in the tropics, especially in Asian and Southeast Asian (SE) countries [3, 4] due to its rapid growth, adaptability to various soil types and ability to fix nitrogen in the soil [5, 6]. The estimated areas of *Acacia* plantations in SE Asia include approximately 800,000 hectares in Indonesia, 49,000 hectares in Malaysia, around 20,000 hectares in Thailand and 1,100,000 hectares in Vietnam [7].

Exotic *Acacia* species were introduced from Australia to southern and northern Vietnam in the early 1960s and 1980s, respectively, as part of afforestation and reforestation efforts, particularly in areas with degraded or deforested land [8, 9]. In Vietnam, large - scale *Acacia* plantations have been widely established for various purposes, including timber, pulpwood, fuelwood, tannin, charcoal production and solid wood products [2, 4]. By 2022, the total area of *Acacia* plantations was estimated at 500,000 hectares, with an annual increase of 30,000 - 35,000 hectares [8] Acacias are increasingly favored over eucalyptus as large -

scale plantation species due to their perceived environmental benefits, such as nitrogen fixation and the production of leaf litter that protects the soil [9]. Additionally, *Acacia* plantations provide vital ecosystem services, employment opportunities and stable incomes for rural communities, particularly in areas where alternative livelihoods are limited [10].

Insects are among the most hyperdiverse and critical components of forest ecosystems [11]. While some insects play crucial ecological roles in controlling plant populations, dispersing seeds, pollinating plants, cycling nutrients, and providing a food source for diverse taxa [12], many others cause significant damage to forest health and productivity [13]. The population of insect species in forests is composed of various taxonomic groups that interact with each other and their host plants in complex ways [14]. Several factors influence the diversity patterns of forest insect populations, including tree species diversity, plant adaptations to low soil fertility, the size and dryness of the host plant's geographic range, forest age, canopy cover, climate change, topography and the introduction of exotic invasive insects and natural enemies [15, 16, 17, 18]. Additionally, human activities such as land use changes, overuse of pesticides and other management practices further affect forest insect populations [19, 20, 21]. Identifying the factors that determine insect population diversity in forests is essential for controlling pest outbreaks, promoting forest health, productivity, conserving beneficial insects sustainably and environmentally friendly.

*Acacia* plantations in Vietnam are established across various ecological regions where conditions such as an average temperature of 25 - 28°C and annual rainfall of 1,500 - 2,000 mm are favorable for their growth. The most popular species include *Acacia mangium*, *Acacia auriculiformis*, and their natural hybrid (*Acacia mangium* x *Acacia auriculiformis*), covering approximately 500,000 hectares out of the total 2 million hectares of forest plantations. However, these plantations face challenges due to severe declines in growth and yield caused by infestations of various insect pests. Understanding the factors influencing insect diversity in *Acacia* plantations is crucial for developing sustainable pest management strategies. The objective of this study was to identify effects of tree age, tree species and ecological regions on insect species composition in *Acacia* plantations in Vietnam. The findings are expected to provide potential information for protecting *Acacia* species plantations.

## 2. RESEARCH METHODOLOGY

### 2.1. Study sites and field surveys

The current study was conducted in eleven provinces/cities spanning nine different ecological regions of Vietnam. The provinces included Hoa Binh, Yen Bai, Tuyen Quang, Vinh Phuc, Ha Noi, Quang Ninh, Quang Tri, Thua Thien Hue, Kon Tum, Dong Nai and Ca Mau, of which Hoa Binh is located in the Northwest (NW); Yen Bai, Tuyen Quang and Vinh Phuc are in the Central Region of North Mountains (CRNM); Ha Noi is in the Red River Delta (RRD); Quang Ninh is in the North East (NE); Quang Tri is in the North Central Coast (NCC); Kon Tum is in the Central Highlands (CH); Dong Nai is in the South Central Coast (SCC); Ca Mau is in the Mekong River Delta (MRD).

A total of 36 study plots were established across eleven provinces in nine different ecological regions of Vietnam. For each of the three *Acacia* species (*Acacia mangium*, *Acacia auriculiformis* and their hybrid), two study plots were created. One plot represented *Acacia* plantations aged one to three years, while the other represented plantations older than three years. Each representative study plot covered an area of 3,000 $m^2$ (50 x 60 m). Within each study plot, five smaller sampling plots (each 400 $m^2$, or 20 x 20 m) were established: One in each of the four corners and one in the center. From 2013 to 2014, the latitude and longitude of each representative study plot were determined using a GPS locator (GPS eTrex Legend HCx, Taiwan).

Eight typical trees in each sampling plot were selected for collecting insect pests, resulting in a total of 40 sampling trees per representative study plot. The survey was conducted over two consecutive years (2013 and 2014). Each year, the survey spanned nine months, from January to December, with investigations conducted at 30 - day intervals.

Insects were collected using three different methods, tailored to the biological and habitat characteristics of each insect family and order. For insects from the Scolytidae and Cerambycidae families, which belong to the Coleoptera order, trees showing symptoms of infestation were cut down and taken to the laboratory. These trees were then divided into small pieces to locate adults or reared in net cages under laboratory conditions to observe their growth stages and collect adults. Lepidopteran larvae were collected directly in the field and transported to the laboratory, where they were fed *Acacia* leaves daily to monitor their development until they reached adult stage. Additionally, a sweep net was used to capture butterflies and other flying insects. A digital camera (Canon Kiss X7, Japan) was used to photograph insects both in the field and during laboratory observations.

### 2.2. Identification

Insect species were identified to the species level based on morphological descriptions, Individuals that could not be identified to the species name were classified by their genera or families and sorted into specimens for further study.

### 2.3. Data analysis

Differences in the composition of insect species among various factors such as tree age, *Acacia* species and ecological regions were visualized using Non-metric Multidimensional Scaling (NMDS), based on the relative percentages of peak areas of the compounds. The NMDS analysis was performed utilizing the vegan package in R software version 3.4.1.

## 3. RESULTS

A total of 108 insect species were collected from *Acacia* plantations in 36 sampling plots, which were located in ten provinces of Vietnam. These identified insects were classified into 6 orders, with the following distribution: Lepidoptera (33 species), Coleoptera (32 species), Orthoptera (23 species), Hemiptera (18 species), Homoptera (1 species) and Phasmida (1 species).

Overall, the highest number of insect species belonged to the order Lepidoptera, followed by Coleoptera, Orthoptera and Hemiptera. Homoptera and Phasmida each had only one species identified. This pattern was consistently observed across all three *Acacia* species sampled (Figure 1).

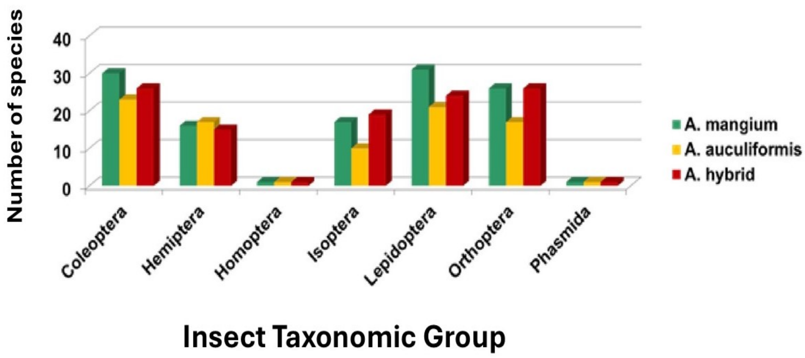


Figure 1. Insect species occurrence in *Acacia mangium*, *Acacia auriculiformis* and *Acacia* hybrid in various ecological regions of Vietnam

Analysis of insect occurrence in all *Acasia* plantations using non - metric multidimensional scaling (NMDS) method has revealed a significant difference in the species composition of Coleopteran insects between *Acacia* plantations older than three years and those younger than three years. In contrast, there was no difference in the species composition of Hemipteran and Lepidopteran insects between the younger and older Acacia plantations (Figure 2).

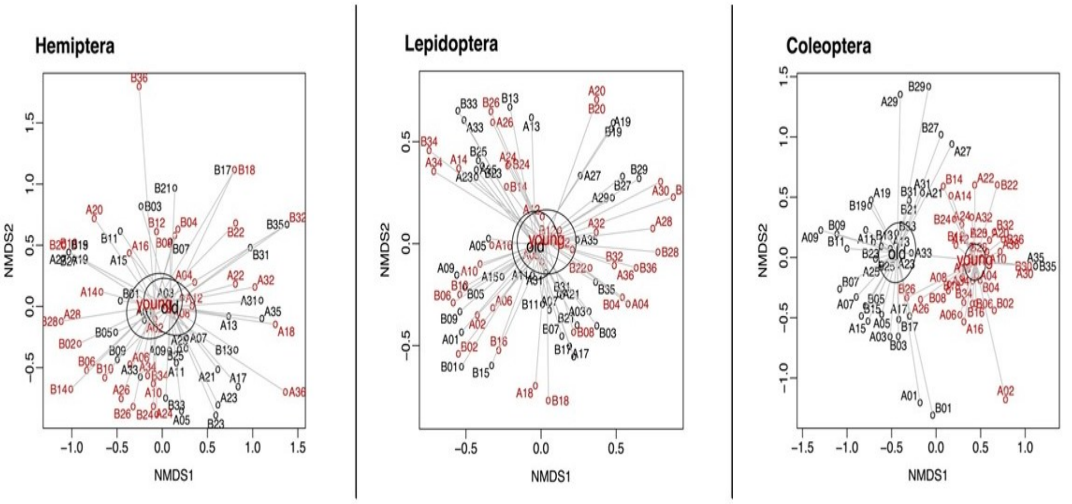


Figure 2. Non - metric multidimensional scaling (NMDS) analysis of insect pest's occurrence by *Acacia* ages. Each point represents the composition of insect species collected in more than three - year - old *Acacia* plantations (black) and each red point represents less than three – year - old *Acacia* plantations (red). The uppercase letters along with numbers show the abbreviations of the insect species identified (data not shown). Insect orders are grouped by *Acacia* tree age. a. Hemiptera; b. Lepidoptera; c. Coleoptera

Analyses of non - metric multidimensional scaling analysis showed a significant difference in the composition of Hemipteran and Lepidopteran insects among *Acacia mangium*, *Acacia auriculiformis* and *Acacia* hybrid. In contrast, there was no difference in the composition of Coleopteran insects among three *Acacia* species (Figure 3).

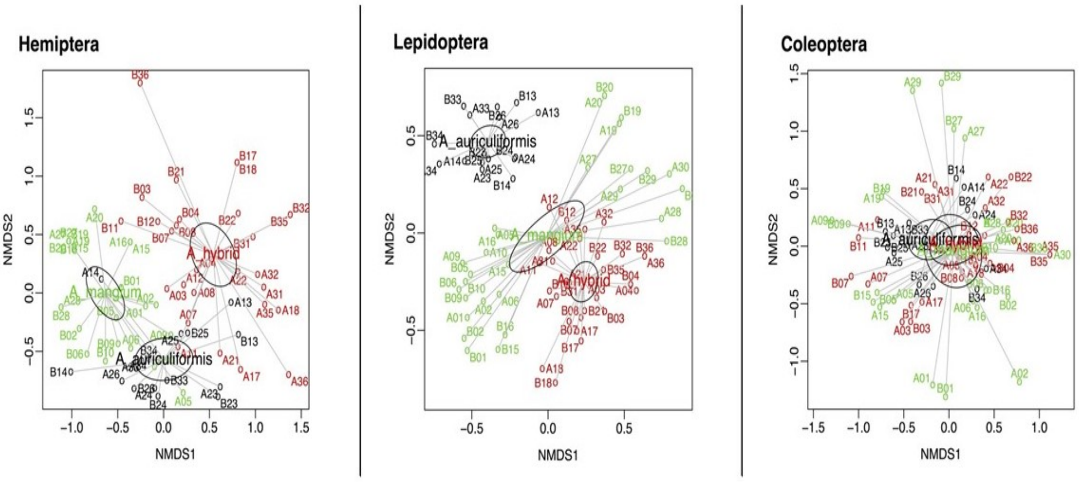


Figure 3. Non - metric multidimensional scaling (NMDS) analysis of major insects' occurrence in all study sites. Each point represents the composition of insect species in the order Hemiptera, Lepidoptera and Coleoptera collected in *Acacia mangium* (green), *Acacia auriculiformis* (black) and *Acacia* hybrid (red). The uppercase letters along with numbers show the abbreviations of the insect species identified (data not shown)

Analyses of non - metric multidimensional scaling analysis showed a significant difference in the species composition of Lepidopteran and Coleopteran insects among nine ecological regiones including Central Highland, Central Region of Northern Mountains, Mekong River Delta, North Central Coast, Northeast, Northeast of Southland, Northwest, Red River Delta and South-Central Coast. In contrast, there was no difference in the composition of Hemipteran insects among three *Acacia* species (Figure 4).

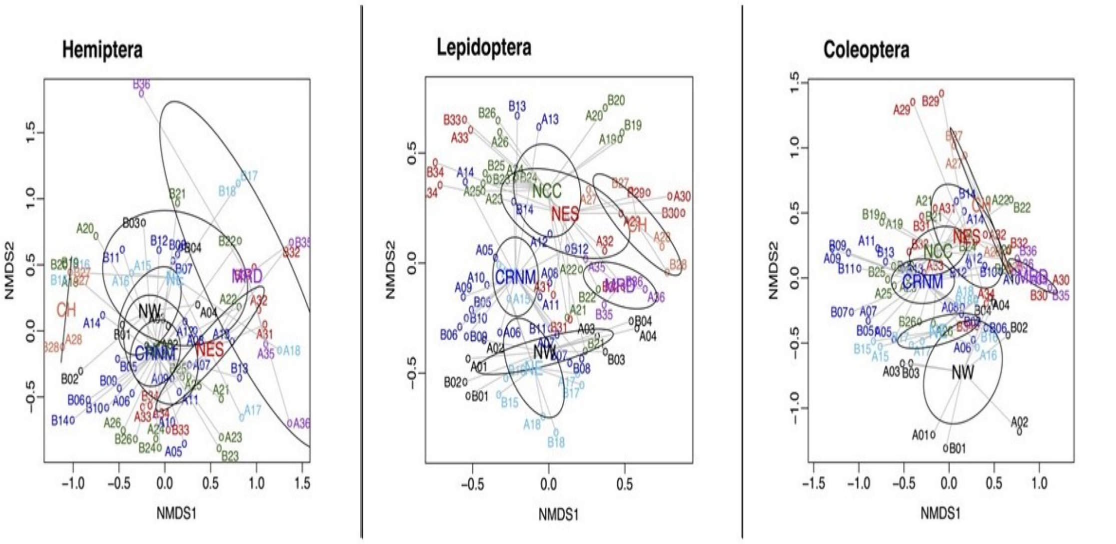


**Figure 4. Non - metric multidimensional scaling (NMDS) analysis of major insects' occurrence in selected study sites representing diferent ecological zones of Vietnam. Each point represents the composition of insect species in the order Hemiptera, Lepidoptera and Coleoptera collected in Central Highland (orange), Central Region of Northern Mountains (blue), Mekong River Delta (pink), North Central Coast (dark green), Northeast (light blue), Northeast of Southland (red), Northwest (gray), Red River Delta (dark green) and South - Central Coast (yellow). The uppercase letters along with numbers show the abbreviations of the insect species identified (data not shown)**

## 4. DISCUSSION

This study is the first to provide comprehensive information on insect species damaging *Acacia* species and to clarify the factors determining the composition structure of insect species in *Acacia* plantations in Vietnam. A total of 108 insect species belonging to six different orders were identified as pests of *Acacia* trees. Additionally, the study revealed significant differences in the species composition of Coleoptera between two age levels of *Acacia*, in the species composition of Hemiptera and Lepidoptera among the three *Acacia* species, and in the species composition of Coleoptera and Lepidoptera across nine different ecological regions.

The significant difference in the species composition of Coleoptera between different age levels of *Acacia* suggests that varying physiological characteristics may be responsible for this outcome. The highest numbers of insect species was found in *A. mangium* and the lowest in *A. auriculiformis* indicating that the former is more susceptible to insect pest species than the latter. Furthermore, the significant differences in the species composition of Hemiptera and Lepidoptera among the three *Acacia* species suggest that the resistance of each tree species, along with morphological features (such as thickness and hardness) and/or chemical components of plant tissue, may influence host tree selection and result in differences in species composition of Hemiptera and Lepidoptera among these orders.

In recent years, promoting reforestation with exotic tree species, especially fast-growing ones, has been prioritized by the Vietnamese government. The total estimated plantation area of *A. mangium*, *A. auriculiformis*, and *Acacia* hybrids has reached two million hectares [22], accounting for nearly half of the country's total forest plantation estate [23]. The export of all wood products was worth US$13.2 billion in 2020, largely derived from *Acacia* plantations. However, *Acacia* plantations in Vietnam are vulnerable to damage from various insect pests [22]. Over time, the composition of insect pests and their impacts on *Acacia* trees have become more pronounced. The expansion of *Acacia* plantation areas, coupled with climate change, is likely to contribute to the rapid development of different insect pest populations. Outbreaks of insect pests pose a threat not only to *Acacia* plantations but also to other associated forest plantation species, causing significan concerns for the forestry sector.

## 5. CONCLUSION

This study identified a total of 108 insect species in *Acacia* plantations across eleven provinces of Vietnam, with Lepidoptera, Coleoptera, and Orthoptera being the most prevalent. The composition of insect species varied significantly between different *Acacia* species, plantation ages, and ecological regions. *A. mangium* was found to be more susceptible to pests than *Acacia auriculiformis*, likely due to differences in tree resistance and physical or chemical traits. Additionally, the composition of Coleoptera insects differed between younger and older plantations, while Hemiptera and Lepidoptera species varied across *Acacia* species but not with respect to plantation age.

The results underscore the need for targeted pest management strategies based on tree species, plantation age, and regional differences. With the growing expansion of *Acacia* plantations in Vietnam, understanding these factors remains esential for mitigating pest impacts and ensuring sustainable forest management in the face of climate change.

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