Identification of insects associated with ebony (*Diospyros celebica* Bakh.) as an endemic tree to Sulawesi

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Abstract. The population of ebony trees in Sulawesi has decreased and has been included in Appendix II Cites, which means it can only be traded based on quotas. Insect studies on ebony stands are still limited, especially in South Sulawesi. This study aims to determine the diversity and association of ebony with insects found in ebony stands in the Hasanuddin University Education Forest, Maros Regency. This activity was carried out in June 2021. Sampling was carried out using the light trap method for winged insects with nocturnal activity and pitfall traps for insects crawling on the ground. Data analysis to determine the diversity of insect species was carried out using the Shannon-Wiener (H') species and the Margalef index. The results showed that the insects found were 8 orders, 20 families, and 28 species from 128 individuals. Based on analysis of their functional role, the insect complexes consist of 34% herbivores, 50% predators, 8% parasitoids, 14% detritivores and 2% transient species. The diversity of species was classified as moderate, namely 2.71, while the richness index value of 5.56, which was classified as high richness in Ebony Stands.

1. Introduction

Ebony (*Diospyros celebica* Bakh.) is the name of a beautiful and durable wood-producing tree as well as being one of the endemic trees on the plains of the island of Sulawesi. Its beautiful and durable quality makes ebony a wood that has a high commercial value [1,2]. In addition, natural distribution of ebony is found in areas such as Poso, Donggala and Parigi (Central Sulawesi), Gowa, Maros, Barru, Sidrap, Luwu (Central Sulawesi), Mamuju and Gorontalo [3].

In recent years, there has been a decline in ebony production in Sulawesi [4,5]. Currently, ebony is included in the rare category and has been included in Appendix II of CITES, which means that it can only be traded on a quota basis [6]. There are several factors that influence growth, including genetic, environmental, and human activity factors. Environmental factors are divided into two, namely biotic factors (pests, diseases, weeds, soil microorganisms) and abiotic factors (sunlight, wind speed, humidity, rainfall, and soil fertility).

Insects are one of the indicators to determine productivity and conditions in an environment. This is because several types of insects act as pollinators (pollinators), decomposers (decomposers), predators, parasitoids, and insect pests in ebony stands. Environmental characteristics in a habitat can affect the presence of insects. Insect responses to environmental characteristics greatly affect their presence in a habitat [7]. Therefore, this study was conducted to determine the diversity and association of ebony with insects found in ebony stands in the Unhas Education Forest, Maros Regency.
2. Methods
The sample was obtained from the Ebony Stand of the Educational Forest, Hasanuddin University, Cenrana District, Maros Regency, South Sulawesi Province. Sample identification and data management were carried out at the Integrated Laboratory, Faculty of Forestry, Hasanuddin University, Makassar.

2.1. Method of collecting data
The sampling technique used in this study was the Pitfall Trap (PT) method to catch insects that were actively crawling on the ground and Light traps to determine the distribution and diversity of insects that were active at night [9]. These traps are adapted to the behavior and activities of insects. Light sources are basically divided into two, namely natural light and artificial light [10].

2.2. Data analysis
Data analysis was carried out by identifying the Shannon-Wiener (H') diversity index and the Margalef Index to determine species diversity.

2.2.1. The Margalef index formula is as follows:

\[ H' = -\sum (P_i \ln P_i) \quad P_i = \frac{n_i}{N} \quad (1) \]

Information:
- H’ = Shannon-Wiener diversity index
- P_i = Number of species (n_i/N)
- n_i = Number of individuals of type i
- N = Total number of individuals of all species

Shannon-Wiener Index Criteria:
- < 1.5 : then low species diversity
- 1.5 - 3.5 : then the species diversity is moderate
- < 3.5 : then high species diversity

2.2.2. The Shannon-Wiener (H') diversity index formula is as follows:

\[ D_{mg} = \frac{(S-1)}{\ln N} \quad (2) \]

Information:
- D_{mg} = Margalef Index (Margalef Diversity Index)
- S = Number of Species
- N = Number of Individuals

Margalef index criteria:
- D_{mg} < 3.5 : then low species diversity
- 3.5 < D_{mg} < 5 : then the species diversity is moderate
- D_{mg} > 5 : then high species diversity

3. Result
3.1. Description of research site
This research was conducted in July 2021 at the Hasanuddin University Education Forest, Cenrana District, Maros Regency, South Sulawesi Province. Sample identification was carried out at the Integrated Laboratory, Faculty of Forestry, Hasanuddin University.
3.2. Environmental factor
Environmental conditions in the forest stand type have the lowest air temperature ranging from 24-31°C while the humidity is around 88-98%.

Table 1. Condition of environmental factors

| Location       | Environmental factor | Air temperature (°C) | Humidity (%) |
|----------------|----------------------|----------------------|--------------|
| Ebony Stand    |                      | 24-31                | 88-98        |

Table 1 shows that the air temperature ranges from 24°C to 31°C, with humidity ranging from 88% to 98%. Air temperature and humidity under vegetation are affected by the penetration of sunlight that enters through the canopy and reaches the soil surface. The results of observations at the location showed that the canopy of the ebony stands was quite wide and dense so that the penetration of sunlight that reached the soil surface in natural forests was generally very little. This gave conditions of lower air temperature and higher humidity. According to Swibawa et al., (2006) stated that the dense cover of the soil surface by plants causes the humidity of the air and soil to be higher [11].

Abiotic factors such as wind speed play a role in helping the spread of small insects, and the appropriate temperature will affect the growth of other organisms that become food sources for insects. Temperature becomes influential because the growth of insects is exothermic, which means that temperature has a major impact on individual growth. At certain temperatures, soil insect activity is high, but at other temperatures, it will decrease (decrease) [12]. Vegetation greatly determines soil moisture, and soil moisture determines the presence of soil insects. Vegetation is not only a shelter but also a provider of food [13].

3.3. Number of insects found in research in unhas educational forest on ebony stands
Figure 1 shows observations in ebony stands found as many as 128 individuals from 8 orders and 20 families. Based on the highest percentage of insects in the Ebony Stand, 55 species came from the Formicidae family and the lowest percentage was from the Bostrichidae, Reduviidae, Miridae, Chrysomelidae, Culicidae, Syrphidae, Coccinellidae families as much as 1%. The abundance of insect populations in a habitat is determined by the diversity and abundance of food sources and other resources available in that habitat. In addition, the presence of insects is also influenced by factors of reproductive ability, self-defense, life cycle [14]. Furthermore, Borror et al., (1992) stated that forest conditions that have high humidity are one of the preferred habitats for ground surface insects [15]. In addition to the following factors, there are factors that affect the abundance of insects to be reduced, namely when food sources, shelter, mating places and other environmental factors are insufficient.
3.4. The role of insects found in ebony stands

Table 2. The role of insects found in ebony stands in the education forest of Unhas, Maros Regency.

| Order      | Family       | Role     | Number of Individuals (%) |
|------------|--------------|----------|---------------------------|
| Hymenoptera| Formicidae   | Predator | 43                        |
|            | Apidae       | Herbivora| 18                        |
| Coleoptera | Bostrichidae | Detritivor| 1                         |
|            | Scarabaeidae | Detritivor| 11                        |
|            | Cerambycidae | Herbivora | 1                         |
|            | Lucanidae    | Herbivora | 2                         |
|            | Chrysomelidae| Herbivora | 1                         |
|            | Coccinellida | Predator  | 1                         |
|            | Carabidae    | Predator  | 4                         |
|            | Curculionida | Herbivora | 2                         |
| Hemiptera  | Cicadidae    | Herbivora | 2                         |
|            | Reduviidae   | Predator  | 1                         |
|            | Miridae      | Herbivora | 1                         |
| Trichoptera| Leptoceridae | Other insects| 2                         |
| Diptera    | Tipulidae    | Herbivora | 2                         |
|            | Culicidae    | Herbivora | 1                         |
|            | Syrphidae    | Predator  | 1                         |
| Orthoptera | Rhaphidophoridae | Herbivora | 4                         |
| Blattodea  | Blattidae    | Detritivor| 2                         |
| Zygentoma  | Lepismatidae | Parasitoid| 4                         |
Table 2 shows the ecological role of insects that dominates, namely predators 50%, both herbivores 34%, parasitoids 8%, detrivores 14 and the smallest percentage of other insects 2%. According to Ormor et al., (1992), food webs formed in a community can be used as an indicator of stability [15]. The more food chains there are, the bigger the food webs that are formed and cause higher stability.

3.5. Diversity index (Shannon Winner) and wealth index (Margalef)

The value of the Diversity index is 2.71 in the medium category (Table 3). The smaller the number of species and the variation in the number of individuals of each species, the smaller the diversity of an ecosystem. Circumstances like this can cause an ecosystem imbalance in the event of disturbance or pressure from the environment, which means that only certain species are able to survive [16]. Meanwhile, the Richness index value is 5.56 in the high category. The greater the number of species found, the greater the wealth index. The Margalef richness index divides the number of species by the natural logarithm function which indicates that the increase in the number of species is inversely proportional to the increase in the number of individuals. This also shows that usually, a community that has many species will have a small number of individuals in each species [17].

Table 3. Range of diversity index (Shannon Winner) and Wealth index (Margalef)

| Criteria            | Tall   | Currently | Low   | Result |
|---------------------|--------|-----------|-------|--------|
| Diversity Index     | H’ > 3 | H’ < 3    | H’ < 1| 2.71   |
| Wealth Index        | Dmg > 5| 3.5 < Dmg < 5| Dmg < 3.5| 5.56 |

3.6. Discussion

The index value of insect species diversity can be seen in Table 3 which is found in ebony stands classified in the medium category, in the Shannon-Wiener index range 1.5-3.5 with a value of H’ = 2.71 while the species richness of Margalef is classified in the high category because it is at the index value of 5.56 (Table 4). The species richness index shows the magnitude of the value that is influenced by the number of species and the number of individuals in an area [18]. The more the number of species, the better or higher the diversity tendency [19]. Species richness is influenced by biotic and abiotic factors. The biotic factors include population growth, interactions between species in the form of competition and predators, while abiotic factors include humidity, temperature, and altitude, which are support for life [20].

4. Conclusion

1. The results showed that there were 128 individual insects divided into 8 orders, 28 species from 20 families 128. consisting of: Formicidae, Bostrichidae, Cicadidae, Reduviidae, Lepismatidae, Leptoceridae, Tipulidae, Miridae, Scarabaeidae, Cerambycidae, Rhaphidophoridae, Blattidae, Lucanidae, Chrysomelidae, Apidae, Culicidae, Syrphidae, Coccinellidae, Carabidae and Curculionidae. The total number of individuals found in the study was 137 individuals from 19 insect species. The results of data analysis showed that the diversity of Shannon-Wiener species was classified as moderate, namely 2.71 while the Diversity Index value was 5.56 which was classified as high in Ebony Stands.

2. Insects associated with ebony stands varied from the orders Hymenoptera, Coleoptera, Hemiptera, Trichoptera, Diptera, Orthoptera, Blattodea, and Zygentoma. In addition, insects that dominate from an ecological role are predators, both herbivores, parasitoid detrivores and the smallest percentage of other insects. The more food chains there are, the bigger the food webs that are formed and cause higher stability.
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