



## Insect Diversity in the Pine Forest Area of Mount Nona, Ambon City

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### ABSTRACT

**Keywords :**  
Protected Forest  
Area;  
Mount Nona;  
Abundance of  
Insects;  
Insect Distribution;  
Forest Health  
Monitoring;  
Sampling Method

This study aims to determine the diversity of insects in the protected forest area of Kota Nona Ambon, as well as the diversity, abundance, and distribution of insects in the area, in order to detect the quality of forest health early. In general, this study employed a sample extraction method. An observation path was created using an inventory method to collect insect data, with a width of 20 meters and a span of 100 meters, and a distance of 10 meters between paths. Data collection on attacks was then carried out. Insects were collected directly, and pitfall traps were set at a distance of 10 meters. Another type of trap was then installed at the next 10 meters along the path. Plots measuring 20 m x 20 m were created on each insect observation path. There are 13 types of insects found in the Gunung Nona forest area, with a total of 185 individuals in 8 orders, namely Diptera, Lepidoptera, Coleoptera, Aranae, Odonata, Spiroboliida, Hymenoptera, which are spread across 10 families, namely: Calliphoridae, Nymphilidae, Pieridae, Muscidae, Culicidae, Araneidae, Alydidae, Libellulidae, Scarabaeidae, Erebididae, Fomicidae.

### INTRODUCTION

Insects are a group of animals that play a vital role in ecosystems, boasting a vast diversity of species and serving as indicators of biodiversity and ecosystem health. Insects are a highly diverse group of animals, encompassing over 1,000,000 species. They are one of the most varied animal groups in the world, with closely related relationships with individual trees in the forest (Subekti, 2012). The distribution of insects in forests plays a vital role in ecosystems, serving as pollinators and helping to pollinate plants, which enables forests to reproduce and regenerate. Factors influencing insect distribution in forests include microclimate, availability of food sources, air temperature, air humidity, soil pH, and food availability. Microclimate can influence microhabitats for insect life and insect activity. Air humidity can significantly influence insect activity, as it plays a crucial role in determining the water content of an insect's body and its overall life cycle. Air temperature can influence insect diversity, as each species has its own

unique ability to tolerate climatic factors within an ecosystem. Food availability can also affect insect distribution, as the type of mouthparts determines the kind of food an insect can consume.

Protected forests are one of the most valuable natural assets for ecosystem sustainability and human well-being (Zulkarnain *et al.*, 2021). Worldwide, protected forests play a vital role in maintaining ecological balance, providing essential natural resources, and supporting a diverse array of living organisms. However, protected forests are also often at the center of conflicts between conservation interests and human economic needs. The Gunung Nona Protected Forest is an example of nature conservation efforts aimed at preserving biodiversity and protecting the environment.

Insects have been found living in forests, but their distribution and diversity are not yet fully understood. This study aims to determine the factors influencing insect distribution in the pine forests of Ambon City, as well as the diversity, abundance, and distribution of insects in the area, to detect forest health issues early.

## RESEARCH METHODS

### Place and Time of Research

The research will be conducted in April 2024 until completion in the pine forest of Gunung Nona in Ambon City/ The tools and materials used in this research are, *trapping tools* in the form of *hand collectors*, *pit traps*, *sweep nets*, *bait traps*, microscopes, tweezers, thermohygrometers, glass bottles, pilot paper, meters, ropes, label paper, stationery, digital cameras, and key books for determining insects, including Kalshoven (1981) and Borror *et al.* (1992). The materials used in this research are 70% alcohol, water, detergent, sugar solution, and canned fish. In general, this research was conducted using the sample image method.

The observation path used for insect data collection was 20 meters wide and 100 meters long, with a distance of 10 meters between each path. Insect data were then collected. Insects were collected directly, and pitfall traps were set 10 meters apart, followed by additional traps at 10-meter intervals along the path. A 20 m x 20 m plot was established along each insect observation path.

### Sampling Techniques

Insects in the Gunung Nona Pine Forest Area, Ambon City, will be collected using four insect collection techniques: 1) Manual collection. Manual collection is a sampling carried out directly. Each type of insect found is collected by hand or tweezers and then placed in a collection bottle containing 70% alcohol. Observations are made on all kinds of insects living around low vegetation, among rocks, the surface of the ground, mounds of earth, and broken wood (Hasimoto, 2001, *in* Latumahina, *et al.* 2014); 2) Pitt Fal Trap. This trap catches insects living on the surface of the ground. Traps are installed on each observation path. Plastic cups with a

diameter of  $\pm 15$  cm are placed and planted, the surface of which is planted parallel to the surface of the ground, with a distance between pits. The 10 m pit trap is filled with clear water mixed with detergent, up to approximately 400 ml, and left for 24 hours. It is taken the next day. Caught insects are put into sample bottles; 3) Broom net. This trap is made of lightweight and strong material, such as gauze, making it easy to swing. The captured insects can be seen. Insects are caught with a net at each observation line created. The captured insects are then placed in a plastic bottle, and 4) Bait Traps. This trap is baited with a sugar solution and canned fish placed in a plastic plate. The plate containing the bait will be tied to a tree at a distance of 10 m at each observation line created and left until 17:00 WIT.

### **Insect Identification**

Insects obtained in the field were grouped by genus. Insects whose species had been recognized were identified directly in the field. Conversely, unknown insects were determined by observing their external form (morphology) using a microscope in the silviculture laboratory of the Department of Forestry, Faculty of Agriculture, Pattimura University, using insect identification key books, including Kalshoven (1981) and Borror *et al.* (1992) in Aryoudi (2015), to the species level.

### **Insect Collection**

Identified insects will be collected using both wet and dry methods. For wet collection, specimens are placed in glass vials containing 70% alcohol, sorted based on their morphological characteristics, and labeled accordingly. For dry collection, limp insects are injected with 70% alcohol into the abdomen to prevent decomposition, then placed in dry collection media and labeled accordingly.

### **Data analysis**

The analysis was conducted using a quantitative descriptive method. Data collection used an exploratory process, namely, direct observation or sampling from the observation location. Insect data processing was carried out by calculating the Diversity Index ( $H'$ ) from Shannon-Weiner, the Abundance Index ( $K$ ), the Dominance Index ( $C$ ), and the Equality Index according to Odum (1983 in Kurniawan *et al.*, 2018), as well as the Morphisita Index.

### **Diversity Index ( $H$ )**

The Species Diversity Index compares the high and low diversity of insect and vegetation species. It uses the Shannon-Weiner index ( $H'$ ) with the following formula (Maulana, 2016).

$$H' = - \sum_{i=1}^n \frac{n_i}{N} \log \frac{n_i}{N}$$

Information:  $H$  = Shannon-Winner diversity index;  $N$  = Number of individuals of all types;  $N_i$  = Number of individuals of type  $i$ .

Based on the criteria:  $H' > 3$  = Indicates a high level of species diversity;  $1 < H' < 3$  = Indicates a high level of species diversity; and  $H' < 1$  = Indicates a low level of species diversity

### Abundance Index (K)

The Abundance Index is based on the formulation by Ludwig & Reynolds (1981).

### Dominance Index (C)

The dominant insect species in the study area were determined using the Simpson Dominance Index formula.

$$C \sum \left( \frac{n_i}{N} \right)^2$$

Information:  $N_i$  = number of individuals of a type;  $N$  = number of individuals of all types

With the criteria  $C < 0.5$ , no species dominates the others, and  $C > 0.8$ , some species dominate others.

### Equality Index (E)

Evenness can be calculated using the following formula;

$$E = \frac{N_2 - 1}{N_1 - 1}$$

Description:  $E$  = Equality Index;  $N_1$  = Number of abundant families in the sample; and  $N_2$  = Number of very abundant families

With the criteria:  $< 0.3$ : low level of species uniformity,  $0.31 > E > 1$ : medium level of species uniformity, and  $E > 1$ : high level of species uniformity.

### Morisita Index

$$I = n \frac{\sum X^2 - N}{N(N - 1)}$$

Description:  $I$  = Morphysite Index (distribution);  $N$  = total number of individuals in  $n$  plots; and  $n$  = total plots;  $\sum x_i^2$  = square of the number of individuals in the sample unit

The distribution pattern can be determined using the Morisita Index as follows:  $I = 1$  indicates a random population distribution;  $I < 1$  indicates a uniform population distribution; and  $I > 1$  indicates a clumped population distribution.

Individuals living in a habitat are distributed in specific patterns that differ from one population to another.

### General condition of the location

The Gunung Nona Forest was designated as a Protected Forest Area based on Decree of the Minister of Forestry of the Republic of Indonesia No. 430/KPTS-II/1996. The protected area began to shift its function to residential areas due to social conflict in Ambon City in early 1999, due to the destruction of public facilities and infrastructure, including community settlements. Refugees built settlements in the protected forest because the area was relatively safer, land

prices were affordable, and bureaucratic structures were already in place. The unit of analysis used was the Ambon City Regional Government through the Ambon City Forestry Service. The object of the study was the Gunung Nona protected forest area policy. The results showed that there had been deviations in the utilization of the protected area function for agriculture and plantations. The government's commitment to implementing the protected forest policy remained weak. The weak commitment of the local government was reflected in the absence of regional regulations governing the protected area, the lack of territorial boundaries, and the land's status, which remained in the form of use rights. Based on the study's results, the factors influencing the implementation of the Gunung Nona protected forest policy included communication factors, human resources, and environmental and social conflicts. Regarding the problems that have occurred, it is recommended that the Ambon City Government immediately create a Regional Regulation to regulate the jurisdiction of the Gunung Nona protected forest.

According to the Ministry of Forestry of the Republic of Indonesia No. 430/KPTS II/1996, the Gunung Nona tropical rainforest area was designated as a forest area designated as a tropical rainforest area. The function of the tropical rainforest area began to change when social conflict occurred in Ambon in early 1999. The conflict destroyed various public facilities and residential areas. Refugees built homes in this area because the area was relatively safe and land prices were affordable. This study aims to analyze the implementation of tropical rainforest policies and several factors that influence it. Edwards (in Winarno, 2002) explains that four elements affect the implementation of public policy: communication, sources, tendencies or behaviors, and bureaucratic structures. This study uses a qualitative descriptive method to describe social phenomena and various aspects of community life in the study area. Research informants consisted of officials from multiple agencies, including the Forestry Service, Bappeda, Nusaniwe Regency Office, Central Statistics Agency, and Bapedalda Ambon City. Meanwhile, informants from the community included community leaders who were familiar with the history of the community's presence in the tropical rainforest area. These community leaders, religious leaders, and village heads felt the impact of the conflict.

### **Location and Distance**

Ambon City is one of the smaller cities in Indonesia, and its territory comprises approximately 89% hilly areas. This consequence becomes a dilemma when residential development is essential for human life. However, land degradation resulting from inappropriate land exploitation is a significant obstacle. In a context where vacant land is increasingly scarce in lowland areas, attention is shifting to hilly regions as an alternative for development activities (Lasaiba, 2023). Nusaniwe District, with an area of 88.34 km<sup>2</sup>, which includes the Gunung Nona Protected Forest, with the area of Mount Nona forest in 2024 was 3,354.11 hectares, this area decreased from 2014 which reached 3,813.50 hectares, and based on the Decree of the Minister

of Forestry of the Republic of Indonesia No. 430/KPTS-II/1996 was designated as a Protected Forest Area.

## RESULTS AND DISCUSSION

### Insect Distribution in the Gunung Nona Protected Forest Area, Ambon City

Based on the results of research on insect diversity conducted in the Nona Gunung protected forest, Ambon City, in June 2024, using various techniques after identification based on morphological characteristics, insects can be classified as shown in Table 1.

**Table 1.** Types of insects found at the research location

| Tracking/<br>Package<br>Number | Local name             | Type                           | Family         | Order       | Individual |
|--------------------------------|------------------------|--------------------------------|----------------|-------------|------------|
| 1                              | Green Fly              | <i>Lucilia sericata</i>        | Calliphoridae  | Diptera     | 10         |
|                                | House fly              | <i>Musca domestica</i>         | Muscidae       | Diptera     | 7          |
|                                | Sulphur butterfly      | <i>Eurema hecabe</i>           | Pieridae Birds | Lepidoptera | 1          |
|                                | Glass Tiger Butterfly  | <i>Parantica aglea</i>         | Nymphalidae    | Lepidoptera | 2          |
|                                | Brown butterfly grass  | <i>Maniola jurtina</i>         | Nymphalidae    | Lepidoptera | 1          |
|                                | Garden spider          | <i>Argiope appensa</i>         | Araneidae      | Araneae     | 3          |
|                                | Spider web golden ball | <i>Nephila pilipes</i>         | Araneidae      | Araneae     | 1          |
|                                | Bark beetle            | <i>Dendroctonus ponderosae</i> | Curculionidae  | Coleoptera  | 2          |
|                                | Straight web dragonfly | <i>Neurothemis ends</i>        | Libellulidae   | Odonata     | 1          |
|                                | Horn Sound             | <i>Oryctes rhinoceros</i>      | Scarabaeidae   | Coleoptera  | 2          |
|                                | Polka dot bee moth     | <i>Sintomeida epilais</i>      | Erebidae       | Lepidoptera | 1          |
|                                | Black Ants             | <i>Dolichoderus thoracicus</i> | Fomicidae      | Hymenoptera | 5          |
|                                | Rusty centipede        | <i>Trigoniulus corallinus</i>  | Trigoniulidae  | Spirobolide | 2          |
| 2                              | Sulphur butterfly      | <i>Eurema hecaba</i>           | Pieridae Birds | Lepidoptera | 1          |
|                                | Glass Tiger Butterfly  | <i>Parantica aglea</i>         | Nymphalidae    | Lepidoptera | 1          |
|                                | Brown meadow butterfly | <i>Maniola jurtina</i>         | Nymphalidae    | Lepidoptera | 1          |
|                                | House fly              | <i>Musca domestica</i>         | Muscidae       | Diptera     | 8          |
|                                | Green Fly              | <i>Lucilia sericata</i>        | Calliphoridae  | Diptera     | 6          |
|                                | Horned beetle          | <i>Rhinoceros Oryctes</i>      | Scarabaeidae   | Coleoptera  | 2          |
|                                | Polka dot bee moth     | <i>Sintomeida epilais</i>      | Erebidae       | Lepidoptera | 2          |
|                                | Garden spider          | <i>Argiope appensa</i>         | Araneidae      | Araneae     | 2          |
|                                | Spider web golden ball | <i>Nephila pilipes</i>         | Araneidae      | Araneae     | 1          |
|                                | Black Ants             | <i>Dolichoderus thoracicus</i> | Fomicidae      | Hymenoptera | 4          |
|                                | Dragonfly              | <i>Neurothemis ends</i>        | Libellulidae   | Odonata     | 1          |
|                                | Straight Net           |                                |                |             |            |
|                                | Bark beetle            | <i>Dendroctonus ponderosae</i> | Curculionidae  | Coleoptera  | 2          |
|                                | Rusty centipede        | <i>Trigoniulus corallinus</i>  | Trigoniulidae  | Spirobolide | 2          |
| 3                              | Horn Sound             | <i>Rhinoceros Oryctes</i>      | Scarabaeidae   | Coleoptera  | 1          |
|                                | Polka dot bee moth     | <i>Sintomeida epilais</i>      | Erebidae       | Lepidoptera | 3          |
|                                | House fly              | <i>Musca domestica</i>         | Muscidae       | Diptera     | 8          |
|                                | Green Fly              | <i>Lucilia sericata</i>        | Calliphoridae  | Diptera     | 6          |
|                                | Glass Tiger Butterfly  | <i>Parantica aglea</i>         | Nymphalidae    | Lepidoptera | 2          |
|                                | Sulphur butterfly      | <i>Eurema hecaba</i>           | Pieridae Birds | Lepidoptera | 2          |
|                                | Brown meadow butterfly | <i>Maniola jurtina</i>         | Nymphalidae    | Lepidoptera | 1          |
|                                | Straight web dragonfly | <i>Neurothemis</i>             | Libellulidae   | Odonata     | 1          |
|                                | Bark beetle            | <i>Dendroctonus ponderosae</i> | Curculionidae  | Coleoptera  | 1          |
|                                | Garden spider          | <i>Argiope appensa</i>         | Araneidae      | Araneae     | 1          |
|                                | Golden ball spider web | <i>Nephila pilipes</i>         | Araneidae      | Araneae     | 1          |
|                                | Black Ants             | <i>Dolichoderus thoracicus</i> | Fomicidae      | Hymenoptera | 5          |
|                                | Rusty centipede        | <i>Trigoniulus corallinus</i>  | Trigoniulidae  | Spirobolide | 2          |
|                                |                        |                                |                |             |            |
| 4                              | Glass Tiger Butterfly  | <i>Parantica aglea</i>         | Nymphalidae    | Lepidoptera | 1          |
|                                | Sulphur butterfly      | <i>Eurema hecaba</i>           | Pieridae Birds | Lepidoptera | 1          |
|                                | Butterfly              |                                |                |             |            |
|                                | Chocolate meadow       | <i>Maniola jurtina</i>         | Nymphalidae    | Lepidoptera | 1          |
|                                | Horn Sound             | <i>Rhinoceros Oryctes</i>      | Scarabaeidae   | Coleoptera  | 2          |
|                                | Polka dot bee moth     | <i>Sintomeida epilais</i>      | Erebidae       | Lepidoptera | 2          |
|                                | House fly              | <i>Musca domestica</i>         | Muscidae       | Diptera     | 13         |
|                                | Green Fly              | <i>Lucilia sericata</i>        | Calliphoridae  | Diptera     | 10         |
|                                | Golden ball spider web | <i>Nephila pilipes</i>         | Araneidae      | Araneae     | 2          |
|                                | Garden spider          | <i>Argiope appensa</i>         | Araneidae      | Araneae     | 2          |

**Table 1.** Insect species ... (Continued)

|              |                        |                                |                |             |     |
|--------------|------------------------|--------------------------------|----------------|-------------|-----|
|              | Bark beetle            | <i>Dendroctonus ponderosae</i> | Curculionidae  | Coleoptera  | 1   |
|              | Black Ants             | <i>Dolichoderus thoracicus</i> | Fomicidae      | Hymenoptera | 5   |
|              | Rusty centipede        | <i>Trigoniulus corallinus</i>  | Trigoniulidae  | Spirobolide | 1   |
|              | Straight web dragonfly | <i>Neurothemis ends</i>        | Libellulidae   | Odonata     | 1   |
| 5            | Garden spider          | <i>Argiope appensa</i>         | Araneidae      | Araneae     | 1   |
|              | Golden ball spider web | <i>Nephila pilipes</i>         | Araneidae      | Araneae     | 2   |
|              | Green Fly              | <i>Lucilia sericata</i>        | Calliphoridae  | Diptera     | 7   |
|              | House fly              | <i>Musca domestica</i>         | Muscidae       | Diptera     | 12  |
|              | Polka dot bee moth     | <i>Sintomeida epilais</i>      | Erebidae       | Lepidoptera | 1   |
|              | Horned beetle          | <i>Rhinoceros Oryctes</i>      | Scarabaeidae   | Coleoptera  | 1   |
|              | Sulfur butterfly       | <i>Eurema hecabrae</i>         | Pieridae Birds | Lepidoptera | 1   |
|              | Brown meadow butterfly | <i>Maniola jurtina</i>         | Nymphalidae    | Lepidoptera | 1   |
|              | Glass Tiger Butterfly  | <i>Parantica aplea</i>         | Nymphalidae    | Lepidoptera | 1   |
|              | Bark beetle            | <i>Dendroctonus ponderosae</i> | Curculionidae  | Coleoptera  | 1   |
|              | Black Ants             | <i>Dolichoderus thoracicus</i> | Fomicidae      | Hymenoptera | 6   |
|              | Straight web dragonfly | <i>Neurothemis ends</i>        | Libellulidae   | Odonata     | 1   |
|              | Rusty centipede        | <i>Trigoniulus corallinus</i>  | Trigoniulidae  | Spirobolide | 3   |
| TOTAL NUMBER |                        |                                |                |             | 185 |

**Table 1** shows that at the research location from the entire path made for sampling, 185 species of live insects were found consisting of 29 bean flies, 48 house flies, nine banana spiders, seven goldball web spiders, eight polka dot wasp moths, eight horn beetles, five straight web dragonflies, seven leather beetles, 25 black ants, 6 sulfur butterflies, 5 brown meadow butterflies, 7 glass tiger butterflies, 10 rusty centipedes with a total of 185 individuals on the entire path of 185 species. With the most species found from the Diptera Order of the Muscidae family, and the fewest species found were from the Odonata Order of the Libellulidae Family, the Lepidoptera Order of the Pieridae Family, the Spirobolida Order of the Tetigoniidae Family, and the Aranea Order, the Aranaeidae Family. The order Diptera, family Muscidae, is a family commonly found at the research location.

**Figure 1.** *Musca domestica*

Houseflies have compound eyes, antennae, front wings, and rear wings modified into dumbbells that function as balancers. Their mouthparts can be used for sucking and piercing, or for licking and absorbing. Female flies are typically larger than males. Adult flies are winged and mobile, while larvae develop in confined habitats (e.g., compost piles or foul odors). When adult flies emerge from their nesting sites, they begin to fly long distances depending on many factors. Generally, flies can fly no more than 50 m from their nesting sites. In addition to food availability, humidity, and a safe egg-laying site, wind speed, odor, and light also influence fly flight. Adult

flies are more intrusive, but from a positive perspective, fly larvae are needed by nature because they are decomposers (Dewi, 2007).



**Figure 2.** *Lucilia sericata*

The common green bottle fly is a green fly found in most regions of the world and is the best known of the various green bottle fly species. Its body measures 10–14 mm (0.39–0.55 in) long – slightly larger than a house fly – and has a brilliant metallic, blue-green or gold color with black markings. The green bottle fly or *Lucilia sericata* undergoes complete metamorphosis that begins with the egg stage, a larva consisting of three instar stages, a pupa, and an imago (adult fly). The entire life cycle of the green bottle fly naturally lasts about 11–14 days. Various factors can influence the length of the green bottle fly's life cycle, including temperature and the type of media used (Kurnia *et al.*, 2019).



**Figure 3.** *Neurothemis ends*

Dragonflies can be found in various places, including rice fields, gardens, forests, lakes, and rivers, and can even live on the coast and at altitudes above 3,000 meters above sea level. The diversity of dragonfly species is influenced by several factors, including differences in habitat types within an area (Herlambang *et al.*, 2016). Several environmental factors influence the presence of dragonflies, including temperature, air humidity, food availability, and water conditions. The presence or absence of water also affects the presence of dragonflies in a habitat. This factor is closely related to the dragonfly life cycle because, when laying eggs, female dragonflies require a moist or watery environment where the eggs are laid in water or among

aquatic plants (Setiyono *et al.*, 2017). Dragonflies also have slender bodies with two pairs of wings and have interconnected veins. In addition, dragonflies also have short, hair-like antennae, well-developed legs, chewing-type mouthparts, large compound eyes, and a long, slender abdomen (Borror *et al.*, 1992). Dragonflies are widely distributed in forests, gardens, rice fields, rivers, lakes, and yards, as well as in urban environments. They can be found from coastlines to altitudes of over 3,000 meters above sea level. Some species, particularly dragonflies, are skilled fliers and have a wide range of terrain (Rizal *et al.*, 2015).



**Figure 4.** *Nephila pilipes*

The Araneae order of the Araneidae family is the second most common species found at the research site, using hand collection techniques. Approximately 43,678 spider species with 3,600 genera have been identified. Spiders exhibit diverse forms, ranging from variations in body color, shape, habitat, and web structure. Like other types of arthropods, spiders have a wide distribution pattern. Spiders are found almost everywhere on the Earth's surface, from tropical climates to polar regions. Spiders can also live underwater. The spider species that can live underwater is *Argyroneta aquatica*. This spider has air bubbles enclosed in its silk sac (Gumira, 2021). The *Nephila pilipes* spider belongs to the Nephilidae family, a family of orb-weaving spiders similar to the Araneidae family, but in a larger size. Its body length is about 1-1.5 inches and it has eight small eyes arranged in 2 rows (Roni, 2016).



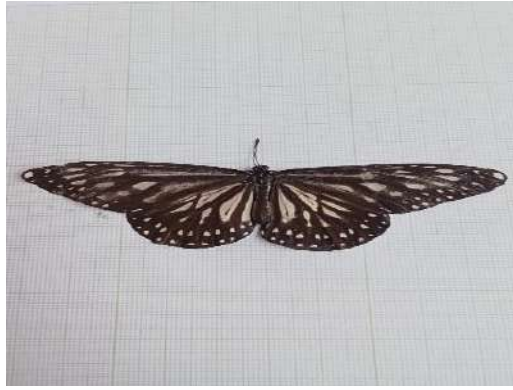
**Figure 5.** *Argiope appensa*

The spider species found at the research site and captured using traps (*manual collection*) belong to the order Araneae, family Araneidae. *Argiope appensa* is a spider found on several islands in the Western Pacific Ocean. This spider has been introduced to Hawaii and is found in Taiwan and New Guinea. This spider inhabits a wide range of habitats, from beaches to forests. Females reach a body length of up to 6 cm and are black and yellow, while males are brown and about 2 cm long. In Hawaii, this spider is called the garden spider. *Argipoe appensa* can be found in various countries, such as Indonesia. Some locals refer to it as the banana spider's ability to adapt to its environment, which stems from the need and goal of survival. Furthermore, they thrive on the abundant protein sources available for web-building, which they use to catch prey or pests.



**Figure 6.** *Rhinoceros Oryctes*

The Eoptera order, specifically the Scarabaeidae family, is represented by a species found at the research location. Beetles are widely distributed. They can be found in all important habitats, except the oceans. They interact with their ecosystems in various ways. Some beetle species produce detritivory, breaking down dead animal and plant tissue, consuming certain types of carrion, and feeding on garbage. Some species feed on fungi. Some species feed on flowers and fruit. The rhinoceros beetle, or bangbung, is a type of beetle widespread in Southeast Asia, east of New Guinea, and north of Formosa. Adult beetles are black or dark brown. Their bodies are 3.5–4.5 cm long and have horned heads. The rhinoceros beetle's life cycle varies depending on its habitat and environmental conditions. Dry climates and low food intake can disrupt larval development, which can last up to 14 months, resulting in smaller adult sizes. The ideal temperature for larval development is 27°C, with a relative humidity of 85–95%. The life cycle of this pest, from egg to adult, takes approximately 6–9 months (Susanto *et al.*, 2012).



**Figure 7.** *Parantica aglea*

The order Lepidoptera, family Nymphalidae, was found at the study site. Butterflies are more attractive and beautiful than other insects, distinguishing them from other Lepidoptera orders. Butterflies help pollinate by flying from one plant to another. Most butterfly species are seasonally specific and prefer specific habitats (Kunte, 1997). The base color of this species is bluish-black with bluish-white subhyaline lines and spots. On the forewing, the 11th vein anastomoses with the 12th vein. In addition, the first gap of the upper forewing has two relatively long and wide lines that converge at the base, which are truncated externally. The cell contains broad, slightly grooved lines crossed by two fine black lines. Gaps 2 and 3 display basal spots, an irregular discal series of three spots, two longitudinal lines, and a subterminal spot. Both of these series curve inward opposite the wing apex, with the latter continuing along the apical part of the costa. Eventually, replacing the much smaller spots, paired terminal rows appear (Stoll, 1782).



**Figure 8.** *Maniola jurtina*

The Lepidoptera order of the Nymphalidae family found at the study site, *Maniola jurtina*, or the brown meadow butterfly, *Maniola jurtina*, varies greatly in size and markings. In males, the upper forewings feature a distinct orange band, accompanied by an eyespot that sometimes exhibits two pupils or two separate eyespots. The lower forewings of males have an orange area divided into a lighter outer and a darker inner area, separated by a distinct dark line. The upper hindwings of females typically have an orange patch, and the lower hindwings of females are paler, with a wavy line separating the darker base from the paler outer area. Several smaller

eyesspots are usually found on the underside of the hindwings. These can number up to twelve per butterfly, up to six on each wing, but sometimes none at all. The factors governing this polymorphism remain unclear, although several theories have been proposed (Stevens, 2005).

The order Lepidoptera includes species found at the research site. Butterflies are easily recognizable biotic components in the ecosystem due to their attractive shapes and colors. The ecological role of butterflies in the ecosystem is not only as herbivores, but also as an important component of pollination (Subahar *et al.*, 2007). *Eurema Hecabe* belongs to the Pieridae family. The morphological characteristics of *Eurema Hecabe* have bright yellow wings and black edges on the edges of their wings. Female *Eurema Hecabe* are larger and have a pale yellow base color of the wings. This species is characterized by two cell spots found on the cross section of the lower wing (Ruslan *et al.*, 2020).



**Figure 9.** *Eurema hecabe*



**Figure 10.** *Syntomeida epilais*

The order Lepidoptera includes the species found at the study site, specifically the adult stage of the oleander caterpillar, also known as the Polka-Dot Wasp Moth. Wasp moth is the common name given to the subfamily of arctiid moths to which this species belongs (ctenuchines) because of its resemblance to wasps such as sphecids and pompilids. The moth's body and wings are a beautiful, shiny blue/green. Small white dots are found on the body, wings, legs, and antennae, and the tip of the abdomen is red/orange. Males and females are quite similar in

appearance and have a wingspan of 45 to 51 mm. These moths are slow-flying and active during the day, distinguishing them from other moth species that are typically nocturnal (Bratley, 1932).



**Figure 11.** *Trigoniulus korallinus*

The families Spirobolidae and Trigoniulidae are the orders found at the study site. Rust centipedes generally have cylindrical bodies and are usually found in leaf litter or under tree trunks. When disturbed, they curl up and release a toxic chemical to ward off predators. They can be distinguished from other centipedes by having only one (rather than two) pair of legs on the fifth segment. The male reproductive organs are located in a pouch. Their bodies are reddish-cylindrical and often curl up into a coil when disturbed. This species grows to a length of about 5 cm. *Rigoniulus Corallinus* has thirty or more segments. They are tubular in shape. This species is more commonly known as a millipede, although it has fewer than a thousand segments. The seventh pair of legs is a modified form known as gonopods (Bugguide.net, 2003).



**Figure 12.** *Dendroctonus Ponderosae*

Bark beetles are an order found in the study area. Bark beetles play an important role in maintaining ecosystem balance. Bark beetles have slender bodies, measuring 6-8 mm in length, and are generally brown or black, with short, knee-like antennae that are tipped with a circular club. These beetles live in tree bark and feed on succulent phloem tissue and dead plant parts. Some bark beetle species can infect living trees, especially conifers (Triplehorn & Johnson, 2005). Some Scolytinae beetle species bore into stems, especially in the larval stage (Kalshoven,

1981). These beetles have a close relationship with terrestrial plants, contributing to nutrient cycling, biodiversity, soil structure, hydrology, and plant succession of bark beetle species. Bark beetles can provide useful information about the importance of ecological boundaries based on species spatial diversity (Follet, 2013).



**Figure 13.** *Dolichoderus thoracicus*

Ants, belonging to the order Hymenoptera and the family Formicidae, are easily recognizable, although other insects closely resemble them. Ant colonies are divided into three castes: queens, males, and workers. Queens are larger than the other castes and usually have wings, although they are shed after mating (Elzinga, 1987). Ants are the most dominant group of terrestrial animals in the tropics, playing important roles in ecosystems as predators, scavengers, herbivores, detritivores, and granivores. They also play unique roles in their interactions with plants and other insects. Since their emergence, ants have become the most dominant creatures in terrestrial ecosystems. Of the 750,000 insect species worldwide, 9,500, or 1.27%, are ants (Holldobler & Wilson, 1990). Habitat changes significantly affect the presence of ants. Ants' highly sensitive responses to habitat changes make them appropriate bioindicators of habitat disturbance, including the effects of pesticide applications on community structure through competitive mechanisms. The existence of suitable nesting sites also influences the existence of ants (Agosti *et al.* 2000).

### **Species Diversity, Species Abundance, Species Dominance, Species Uniformity**

Based on the results of calculations of Species Diversity, Species Abundance, Species Dominance, Species Uniformity, and Morisita species in protected forest areas in Table 2. The insect diversity index, 0.219, is considered moderate (Table 2). The diversity index value is an indicator of the abundance of insect species in a given area. Many species exhibit high and low levels of diversity. The highest diversity index value, or maximum  $H'$ , is expressed as  $\ln S$ . The maximum  $H$  value in this study was 1.644. Furthermore, the abundance index obtained is

equivalent to a moderate diversity index, namely 0.219. Abundance is the number represented by each species out of all individuals in a community (Campbell, 2010).

**Table 2.** Results of calculations of Species Diversity, Species Abundance, Species Dominance, Species Equality, and Morisita insect species.

| Index Value                  |                             |                      |                       |                 |
|------------------------------|-----------------------------|----------------------|-----------------------|-----------------|
| Diversity of species<br>(H') | Abundance of species<br>(K) | They dominate<br>(D) | Equality index<br>(E) | Morisita<br>(M) |
| 1,644                        | 0.219                       | 0.03                 | 0.219                 | 0.320           |

Based on this understanding, it can be concluded that abundance is the number of individuals in a given area within a community, and the dominance index obtained is 0.03, which is relatively low. The dominance index is a parameter that indicates the degree of centralization of dominance or control of a species in a community. The dominance index is displayed on a scale of 0–100, with higher values indicating greater dominance of the species in that area. The equivalence index is considered moderate because it determines how evenly the abundance of individual species is distributed within a community. The equivalence index can describe the balance between two communities. High species equality occurs when all species in a sample have the same abundance. Meanwhile, evenness approaching zero occurs when relative abundance varies. The Morisita Index is classified as a clustered distribution pattern, and its distribution pattern can be determined using the Morisita Index as follows:  $I = 1$  indicates a random population distribution.  $I < 1$ , then the population distribution is uniform.  $I > 1$ , then the population distribution is clumped because individuals in a population living in one habitat are distributed with different patterns between one population and another. The value of the insect diversity index in the Gunung Nona Protected Forest Area of Ambon City is 1,644, which falls within the category. This is in accordance with the literature regarding the diversity index criteria, as outlined by Krebs (1978), which are as follows:  $H > 3$  = High,  $1 < H < 3$  = Medium, and  $H < 1$  = Low. A physically stable environment consists of a diverse range of species, whereas an unstable environment is characterized by a relatively small number of species. High diversity indicates that a community has high complexity, as it involves a high level of interaction among species. In a community with high diversity, species interactions involve energy transfer (food webs), predation, competition, and niche division, which are theoretically more complex (Soegianto, 1994). According to Krebs (1978), six interrelated factors determine the degree of increase and decrease in species diversity: a) Over time, community diversity increases, meaning that older communities that have developed over a long time have more organisms than young communities that have not yet developed. Time can run in shorter ecologies or up to tens of generations; b) Spatial heterogeneity is more heterogeneous. The more complex the flora and fauna community in a place, the higher the species diversity; c) Competition occurs when several organisms utilize the same resource that is lacking, or even though its availability is sufficient.

However, competition occurs when organisms utilize the resource, one attacks the other, or vice versa; d) Predators that maintain the community of competing species populations below their respective carrying capacities and increase the possibility of Coexistence, thereby increasing diversity. If the intensity of predation is too high or too low, it can reduce species diversity; e) Climate stability: The more stable the temperature, humidity, salinity, and pH in an environment, the more stable environmental species there are in that environment, the greater the possibility of evolution; f) Productivity can also be an absolute requirement for high diversity. The merit index value of insect species in the Gunung Nona Protected Forest Area, Ambon City, is classified as moderate, with an index value of 0.219, indicating that it is closer to 1, and thus falls within the balanced category. The smaller the E value or the closer it is to zero, the more uneven the distribution of organisms in a community dominated by a particular species. The evenness value indicates the distribution pattern of a species within a community; the greater the value, the more balanced the distribution pattern of that species within the community, and vice versa. According to Oka (1995), the equivalence value tends to be high if the number of individuals in one family does not significantly outnumber the population of another family; conversely, equivalence tends to be low if a family has a population that significantly exceeds the number of individuals in other families. In the Gunung Nona protected forest area, Ambon City, a moderate equivalence index was obtained, indicating that one family does not dominate the population of another; there is the same or nearly the same abundance, as it is assumed that the ecosystem is balanced due to the absence of chemical control.

## CONCLUSION

Based on the research results, it can be concluded that there are 13 types of insects found in the Nona mountain forest area, with a total of 185 individuals in 8 orders, namely Diptera, Lepidoptera, Coleoptera, Araneae, Odonata, Spirobolida, Hymenoptera, which are spread across 10 families, namely Calliphoridae, Nymphilidae, Pieridae, Muscidae, Culicidae, Araneidae, Alydidae, Libellulidae, Scarabaeidae, Erebididae, Fomicidae.

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