Diversity of Insect Pest in Monoculture and Polyculture Nutmeg (Myristica fragrans Houtt.) Plantation in South Aceh District

Agustinur¹, S F Lizmah¹, and M Sarong²

¹ Department of Agrotechnology, Faculty of Agriculture, Teuku Umar University, Meulaboh-Aceh, Indonesia
² Student of Department of Agrotechnology, Faculty of Agriculture, Teuku Umar University, Meulaboh-Aceh, Indonesia

Corresponding author’s email address: agustinur.hamka@gmail.com

Abstract. Nutmeg (Myristica fragrans Houtt) is one of the most potential plantation commodities in Indonesia. Among the locations of nutmeg production is in South Aceh, and most of them are smallholder plantations. The highly fluctuation in nutmeg productivity has pushed some farmers to change their plantation type to polyculture, although the others still maintain the plantations in monoculture type. The difference of plantation type is estimated to affect toward the ecosystem composition, including the composition of insects potentially as a pest in nutmeg. This study aims to determine the diversity of insects that have the potential as pests in both types of nutmeg plantations. This research was conducted on nutmeg plantations in Samadua and Meukek Sub Districts, South Aceh District. Insect collection was carried out by using light trap, pit fall trap, and yellow pan trap. Identification of the insects order was carried out at the Laboratory of Agriculture Faculty Teuku Umar University. The results of the data analysis showed that both types of nutmeg plantations had moderate pest insect diversity levels, diversity index in monoculture plantation 1.39 and polyculture plantation 1.8, respectively, where no group of orders dominated. There are 5 orders of insects known to have potential as pest insects in monoculture plantations, while in polyculture plantations are 6 orders and 2 orders of insects as vectors of plant diseases.

Keyword: Nutmeg plantation, monoculture, policulture, insect, pest.

1. Introduction

Nutmeg (Myristica fragrans Houtt) is one of Indonesia native plants that has great potential as a trade commodity at domestic and foreign level. Nutmeg has long been known as a spice plant and has an important position as a source of essential oils that are needed in various industries, such as food industry, medicine, perfume, cosmetics, and others. Indonesia is one of the biggest nutmeg supplier countries in the world with contributions reaching 70-75%, even most of the nutmeg in Europe originates from Indonesia [1].

South Aceh Regency is one of the centers of nutmeg production in Indonesia. Nutmeg production from this region contributed greatly to fulfill domestic and overseas nutmeg needs. The total area of nutmeg in South Aceh Regency in 1994 reached 11,245 ha with an average productivity of whole nutmeg at 8.2 tons/ha. In 2003 the area decreased to 9,843 ha, the average total productivity decreased
to 1.1 tons / ha. In 2014 the average value of Aceh's nutmeg productivity declined to 0.7 tons / ha [2]. The possibility of decreasing nutmeg productivity can be caused by a variety of pests and diseases.

Most of the nutmeg plants in South Aceh Regency are community plantations which were originally planted with monoculture system. But in some places, the community switched from a monoculture planting system to a polyculture. This was done because of declining in quality of nutmeg and was followed by decreasing in nutmeg selling prices which resulted in losses to nutmeg farmers. So that many farmers sought other income by planting other crops such as dogfruit, coffee, durian, cocoa, and candlenut between the nutmeg plants. The differences of planting systems also lead to differences in the composition of the ecosystems that comprise it, including the composition of insects which could potentially be potential pests in nutmeg plants.

Various groups of insects have been known to have a role as pests in nutmeg plantations, among them are *Tenebrio molitor*, *Odontotaenius* sp. and *Batocera hercules* which are the order of Coleoptera. They found in the form of larvae that live in the stems of nutmeg plants [3], *Araecerus fasciculatus*, *Carpophilus dimidiatus*, *Oryzaephilus surinamensis* (Linnaeus) and *Tribolium castaneum*, including insects that damage fruit and nutmeg seeds [4]. This study aims to determine the diversity of insects that have the potential as pests in both types of nutmeg plantations in South Aceh District, monoculture and polyculture plantations.

2. Methods

2.1. Determination of Research Locations

The research location chosen was the community-owned nutmeg plantation with an area about 100 m² randomly. Based on the survey results, 2 locations were determined. They are plantation in Samadua District representing plantation that use monoculture system and plantation in Meukek District that represent plantation with polyculture system.

2.2. Insect Sampling

Insect sampling was carried out using the trap method, namely light trap, pit fall trap, and yellow pan trap [5].

2.2.1. Light trap. This trap is installed a unit for each location. It is in the form of a series of devices consisting of a container containing a mixture of detergent, water, and alcohol in a ratio of 1: 2: 1, EC / DC lamps as a light source, lampshades (small umbrellas) and small nylon ropes as hanging devices. Light trap was installed at each location for 3 consecutive days starting at 16:00 PM.

2.2.2. Pit fall trap. Pit fall trap is the trap set at the ground surface. It was installed 5 units at each location randomly. The trap is made of 250 ml plastic cups which are inserted into the digging hole to the lip of the glass. Next the glass is filled ¾ part with a solution of a mixture of detergent, water, and alcohol in a ratio of 1: 2: 1. Trapping is installed every day for three consecutive days, from 08.00 AM to 05.00 PM. The collected insects are separated from the litter using a sieve, then put into a container using a pair of tweezers and a small brush.

2.2.3. Yellow pan trap. Yellow pan trap is a trap that uses a yellow tray or pan to attract insects. This trap was installed 5 units randomly at each location of research. The trap is made of 250 ml plastic cups which are inserted into the digging hole to the lip of the glass. Next the glass is filled ¾ part with a solution of a mixture of detergent, water, and alcohol in a ratio of 1: 2: 1. Trapping is installed every day for three consecutive days, from 08.00 AM to 05.00 PM. The insects obtained were filtered and put into collection bottles that contained alcohol 70% as preservatives. Then, the sample is taken to the laboratory for identification.

2.3. Research Parameters

The parameter observed was the number of species, based on Shannon-Wiener Diversity Index (H’ ) [6].

\[
H' = -\sum \pi \ln \pi
\]

Where H’ is Shannon-Wiener diversity index, \(\pi = ni / N\), ni is total of individual insect, N is total number of individuals found and ln is natural logarithm.
Table 1. Diversity index categories [7][8]

| Categories | Interpretation |
|------------|----------------|
| $H' < 1.0$ | Poor diversity, very low productivity as an indication of heavy pressure and unstable ecosystems |
| $1.0 < H' > 3.322$ | Medium diversity, sufficient productivity, fairly balanced ecosystem conditions, moderate ecological pressure |
| $H' > 3.322$ | High diversity, stable ecosystem stability, high productivity, resistant to ecological stress |

Evennes between species or Evennes index (E) [6].

$$E = \frac{H'}{\ln(S)}$$

Where E is Evennes index, $H'$ is Shannon-Wiener diversity index, S is total species found and ln is natural logarithm.

2.4. Data analysis
All data obtained is presented in tables, figures and graphs. Data is processed using Microsoft Excel.

3. Results and Discussions
Based on the result of the research, a number of insect orders were obtained in both locations. In the plantations in samadua sub-district, 6 orders of insects were obtained, namely Orthoptera (grasshoppers and crickets), Hemiptera (ladybugs), Coleoptera (beetles), Diptera (fruit flies), Hymenoptera (bees and wasps) and Lepidoptera (butterflies). While in plantations located in the sub-district of Meukek which is a polyculture type plantation, there were obtained 11 orders of insects. Six of these orders are the same orders as those in monoculture type nutmeg plantations in Meukek District (Table 2). Among the orders, it was reported that the Coleoptera order was a group of insects which caused very serious damage to the Nutmeg plant. Larvae of *Batocera herculis* which is one of the members of the Coleoptera order is able to attack the nutmeg plant by digging holes in the stem of the nutmeg. The attack hole is round and there is wood shavings. The larvae are 8-10 cm in size and can be found between the bark and wood of the stem. While cocoons can be found in the upper hole of the tree [9].

The order of Orthoptera, Hemiptera and Lepidoptera also have the potential to damage nutmeg plants, especially in the leaf organs. The group has biting mouthparts that is used to eat Nutmeg leaves, especially the shoots. In the Lepidoptera order, the role of pests is carried out during the larvae, while as adults they take on the role of pollinating insects [10]. According to the research of Hammer *et al.* (2014) [11] each stage in the metamorphosis of lepidoptera such as the butterfly has different eating roles and activities. This is evidenced also through the association of bacterial communities that live in the body of the insect itself. However, these bacteria do not belong to a group of pathogens against plants.

While the other two orders, Diptera and Hymenoptera, are neutral insects whose potential as pests is smaller than the other orders. In the type of polyculture plantation, the Blattodae and Thysanoptera orders are also found. they have the potential to become vectors of plant diseases. Those insects are able to transfer pathogens in such as fungi, bacteria and viruses. The pathogen transfer process is carried out by insects through mobility that causes direct contact with plants and feeding activities, especially in insects that have the shape of a piercing and sucking mouthparts [12, 13].

**Table 2.** Insect populations that have the potential to become pests in nutmeg plantations

| Order         | Location              |
|---------------|-----------------------|
|               | Samadua sub-district  |
|               | Meukek sub-district   |
In Table 2 it is also seen that the number of orders and the number of individual insects on plantations with polyculture types is greater than those in monoculture plantations by comparison as shown in Figure 1. This is expected because the differences of vegetation in both of plantations cause differences in insect abundance which is a member of the ecosystem in it. This allegation is reinforced by the results of research Herlinda (2000) [14] and Lizmah et al. (2015) [15] which states that the diversity of plants in a landscape is a factor supporting the high and low insect population in the habitat. As an illustration, nutmeg plantations in Meukek Subdistrict have heterogeneous habitat types, where in addition to being planted with nutmeg plants, there are also planted with other crops such as dogfruit, coffee, durian, cocoa, and candlenut. In addition, nutmeg plants found at this location have varying plant ages, between 5-40 years. While Nutmeg plantations in Samadua District tend to be homogeneous. At this location only planted nutmeg plants with nutmeg aged around 40-60 years.

| Order          | Monoculture | Polyculture |
|---------------|-------------|-------------|
| Orthoptera    | 2           | 7           |
| Hemiptera     | 14          | 29          |
| Coleoptera    | 11          | 57          |
| Diptera       | 27          | 95          |
| Hymenoptera   | 2           | 19          |
| Embioptera    | 0           | 4           |
| Lepidoptera   | 3           | 12          |
| Tricoptera    | 0           | 17          |
| Psocoptera    | 0           | 1           |
| Blattodea     | 0           | 4           |
| Thysanoptera  | 0           | 4           |
| Total         | 59          | 249         |

Table 3. Diversity and evenness index of the orders and individual insects

Both monoculture and polyculture plantations have moderate insect diversity (1.0 < H’ < 3.322), with H’ index values on monoculture plantations 1.39 and index H’ values on polyculture plantations 1.8 (Table 3). While the species evenness index (E) in both locations shows a number less than 1. This can be interpreted that from a number of insect orders found at both locations, there is no order that dominates.
According to the research of [16], insect diversity indexes in physically controlled ecosystems tend to be low and high in natural ecosystems. Besides, the development or abundance of an insect is influenced by weather factors, food availability and population density. In an ecosystem, insects have the ability to adapt to their environment and insects can also avoid the extreme circumstances of an environment. Umasangaji et al. (2012) [3] also said that insect attacks, especially the Coleoptera order on nutmeg plants were influenced by several factors including fertilization systems and pesticide application, plant age, spacing, types of weeds and other plants that exist around nutmeg plants and the condition of nutmeg plantations. Plantations that are rarely treated so that weeds and other types of plants are grown allow microclimates that are suitable for pest insect development. This condition occurs in nutmeg plantations in Meukek sub-district which are not only planted with nutmeg crops but also jengkol, coffee, durian, cocoa and candlenut plants.

4. Conclusions
From the results of the study it can be concluded that the two types of nutmeg plantations both monocultures in samadua sub-district and polyculture in Meukek sub-district have moderate pest insect diversity levels, with diversity indexes of 1.39 and 1.8 respectively, where there are no order groups which dominates. In monoculture nutmeg plantations there are 6 orders of insects with 4 orders including Orthoptera, Hemiptera, Coleoptera and Lepidoptera potentially as pests of Nutmeg. While in the polyculture type nutmeg plantations there are 11 orders of insects with 5 orders including Orthoptera, Hemiptera, Coleoptera, Embioptera and Lepidoptera potentially as pests in Nutmeg plants, and 2 other orders, namely Blattoda and Thysanoptera potentially as vectors of diseases in nutmeg plants.

Acknowledgments
We are very grateful to Direktorat Riset dan Pengabdian Masyarakat (DRPM) from Kementerian Ristek Dikti for funding this research through the skim Penelitian Dosen Pemula (PDP).

References
[1] CBI 2018 Exporting Nutmeg to Europe Centre for the promotion of imports Ministry of foreign affairs
[2] Dishutbun Aceh Selatan 2014 Dinas Perkebunan dan Kehutanan Pedoman Pengamatan dan Pengendalian Hama pada Tanaman Pala Tapaktuan Aceh Selatan
[3] Umasangaji A, Patty J A dan Rumakamar A A 2012 Kerusakan Tanaman Pala Akibat Serangan Hama Pengerek Batang (Batocera hercules) Agrologia 1 163-169
[4] Dharmaputra O S, Sunjaya Retnowati I dan Nurfadila N 2018 Keanekaragaman Serangga Hama Pala (Myristica Fragrans) dan Tingkat Kerusakannya di Penyimpanan J. Entomologi Indonesia 15 57-64
[5] Leather SF 2008 Insect Sampling in Forest Ecosystem (Chicago: Wiley-Blackell)
[6] Magurran 2004 Measuring Biological Diversity (USA: Blackwell Science Ltd.)
[7] Apriliyanto E dan Sarno 2018 Pemantauan Keanekaragaman Hama dan Musuh Alami pada Ekosistem Tepi dan Tengah Tanaman Kacang Tanah (Arachis hypogaea L.) Majalah Ilmiah Biologi Biosfera: A Scientific Journal 35 69-74
[8] Restu I W 2002 Kajian Pengembangan Wisata Mangrove di Taman Hutan Raya Ngsrah Rai Wilayah Pesisir Selatan Bali Tesis Bogor Institut Pertanian Bogor
[9] Kalay A M , Lamerkebel J S A dan Thenu F J L 2015 Kerusakan Tanaman Pala Akibat Penyakit Busuk Buah Kering dan Hama Penggerek Batang Pala Di Kecamatan Leihitu Kabupaten Maluku Tengah. J. Agroekotek 7 138-146

[10] Roubik D 2018 *The Pollination of Cultivated Plants* (Rome: Food and Agriculture Organization of the United Nations)

[11] Hammer T J, Mcmillan O and Fierer N 2014 Metamorphosis of a Butterfly-Associated Bacterial Community *Plos One* 9 1-8

[12] Sarwar S And Sarwar M 2018 Involvment of Insects (Insecta: Arthropoda) in Spreading of Plant Pathogens and Approaches for Pest Management *American J. of Microbiol. and Immunology*. 3 1-8

[13] Vazirianzadeh B, Mehdinejad M and Dehghani R 2009 Identification of Bacteria hich Possible Transmitted by Polyphaga aegyptica (Blattodea: Blattidae) in the Region of Ahvaz, S Iran. *Jundishapur J. of Microbiology*. 2 36-40

[14] Herlinda 2000 Analisa komunitas arthropoda penghuni lanskap di daerah Cianjur *Skripsi*. Bogor Institut Pertanian Bogor

[15] Lizmah F L 2015 Pengaruh struktur lanskap terhadap keanekaragaman *Hymenoptera* parasitika pada lahan mentimun *Tesis* Bogor Institut Pertanian Bogor

[16] Michael P 1995 *Metoda ekologi untuk penyelidikan lapangan dan laboratorium* (Jakarta: Universitas Indonesia Press)