Hymenoptera diversity on porang (Amorphophallus muelleri) in Sukabumi

Susilawati, M Puspitasari, G Indriati, and D Pranowo

Indonesian Industrial and Beverage Crops Research Institute, Indonesian Agency for Agricultural Research and Development (IAARD), Jalan Raya Pakuwon Km 2, Parungkuda, Sukabumi, Indonesia 43357

Corresponding author email: susilawatisp.ss@gmail.com

Abstract: Amorphophallus muelleri (porang) is a potential plant as a source of glucomannan. Glucomannan is beneficial as raw material in the sector of food, health, beauty, and industry manufacture so that it has a high economic value. The research objective was to study the diversity of Hymenopteran in the porang plantation. The study conducted at Pakuwon Experimental Garden and Indonesian Industrial and Beverage Crops Research Institute (IIBCRI) Integrated Laboratory from January to July 2020. The insect collection method was installed pitfall trap (PT) and yellow pan trap (YPT) on porang field. There were 12 pitfall traps, and Yellow Pan traps installed on porang plants and set for 24 hours while observed with intervals of 2 weeks. The collected insect was identified into morphospecies. The results showed that Hymenopteran on porang plants consisted of 100 morphospecies. The dominant morphospecies was Anoplolepis gracillepes. The diversity index (H') of Hymenopteran insect was 2.28 and the evenness (E) was 0.50. Collected Hymenopteran identified as pollinators, predators, and parasitoids. The pollinators were Apidae and Halictidae, the predators were Formicidae and Sphecidae, while the parasitoid insects found were 13 families i.e Braconidae, Scelionidae, and Ceraphronidae, etc.

1. Introduction

Amorphophallus muelleri, also known by the common name Porang, is a type of plant that produces roots. Porang plants were reported to have been cultivated in Malang, East Java with a distribution of 12 locations in 8 sub-districts [1]. Porang roots contain very high glucomannans (polysaccharides from the Mannan family) with various benefits. One of them is as a raw material in the sector of food, health, beauty, and industry manufacture so that it has a high economic value. In addition, glucomannan reported can improve the digestive system and lowers cholesterol.

The presence of insects cannot be separated from porang cultivation, because of their function as phytophagous, pollinator, decomposer, and natural enemy. The results showed insects on porang plants were found as decomposers, litter transformers, and predators [2]. It was further explained that the number of decomposer insects found in porang plants was sufficient to result in faster decomposition of organic matter, both from animals and plants (litter). The results of this decomposition process will be beneficial for fertility and improve soil structure in Porang plantations.

Insects as natural enemies usually come from the order Hymenoptera, Coleoptera, Diptera, Mantodea, Hemiptera. Natural enemies play a role in suppressing the population of pests or phytophagous insects on agricultural land. Natural enemy insects are divided into predatory insects and parasitoid insects. The insects that worked as predators were found on porang plantation from the
Formicidae and Coleoptera families [2]. Ants (Oecophylla smaragdina and Dolichoderus spp.) were reported as predators of pests of the order Hemiptera on cashew crops [3]. In addition, Anoplolepis gracilipes, Solenopsis geminata, and Paratrechina longicornis were also said to have the potential to suppress pest populations [4]. The parasitoid insects found in porang plantations, it was from the Phoridae family [5]. It was reported that phorid parasitoids attack the leaf-cutting ant with a parasitization rate of up to 35% [6].

Hymenopteran has an important role in the cultivation of the crop, such as parasitoids, predators, decomposers, and pollinators. Research on the diversity of phytophagous and terrestrial insects on porang plants has been carried out and several dominant insects have been reported from Hymenoptera [5, 7]. It was further explained that the insects found in porang plantations functioned as predators (Anoplolepis sp.) and phytophagous (Gryllus sp and family Aphididae). Therefore, data exploration was carried out to determine the diversity of Hymenoptera insects on porang plants.

2. Methods
The research was conducted in the porang plantation, Experimental Garden (KP) Pakuwon (60 49’19.5” S 106 44’20.7” E) Indonesian Industrial and Beverage Crops Research Institute (IIBCRI), Sukabumi, from January to July 2020. Porang plantations were divided into four plots measured 95m x 0.6m. Porang were observed 30 days after planting (DAT) with an observation interval of 2 weeks. Porang planted with Kemiri Sunan (Reutealis trisperma) as the shading trees. Insect sampling was carried out using two methods, namely the Pitfall trap (PT) and yellow pan trap (YPT) (Figure 1) [8].

The yellow pan trap was a yellow container approximately 10 cm high and 15 cm in diameter. The traps were filled with soap solution up to one-third of the container height and set for 1x24 hours in the field. In each plot, three yellow pan traps were installed in a row by forming a straight line (Figure 2) so that 12 yellow pan traps were used. The insect sample was put in a plastic bottle filled with 70% ethanol and labeled with the date of the sample collection, the type of trap, and the plot number.

The pitfall trap (PT) used was 9.2 cm in diameter and 10 cm in height. PT was assembled between porang plants filled to a third of their capacity with soapy water and set for 1x24 hours. Soapy water is filled up to a third of the plastic cup. Plastic cups were assembled by making holes between porang plants so that their height is the same as the ground. It aims to record insects that are active on the soil surface. The traps were covered by fiber plastic as a roof to protect them from rainwater. Insect samples were separated from water and put into collection bottles containing 70% alcohol and labeled.

Figure 1. Yellow pan trap (right) and pitfall trap (left).
Collected insects were identified as morphospecies and some insects as species in the laboratory. The identification was using identification book, Insects of Australian volume 1 and 2 [9,10], Hymenoptera of the world: An identification guide to families[11], Identification guide to the ant genera of Borneo [12]. The identified insects were tabulated into a database in Excel format. Insect diversity was represented by the number of morphospecies, the diversity index (H), and the evenness index (E) of Hymenoptera. The statistical analysis was using the R statistics software [13].

Relative Abundance is calculated by the formula of Shannon Wiener [14]:

$$R = \frac{n_i}{N} \times 100 \%$$

Annotation:

R = Relative Abundance
ni = Number of individual every species of Hymenoptera
N = Number of individual
Diversity Index (H')

Diversity Index of Hymenoptera is calculated by formula Shannon-Wiener [14]

$$H' = - \sum P_i \ln P_i$$

Annotation:

H' = Shannon-Wiener Diversity Index
Pi = Individual Proportion found in I family
ni = Number of individuals at I Family
N = Total number of Individual
Indicator of Index Shannon-Wiener:
H' < 1,5 = low level of diversity
1,5 ≤ H' ≥ 3,5 = medium level of diversity
H' > 3,5 = high level of diversity.
Evenness Index (E)
The Evenness Index is used to assess the evenness of each species in each community [14].

\[ E = \frac{H'}{\ln S} \]

Annotation:
E = Evenness index
H' = diversity index
\( \ln \) = logaritma natural
S = Number of morphospecies Hymenoptera.
Indicator of Evenness Index: E > 1: high level Evenness; While E < 1: low level Evenness

3. Results and discussion

3.1 The diversity and abundance of Hymenoptera insects
A total of 831 Hymenoptera individuals from 17 families and 99 morphospecies were collected from porang plantations in the Pakuwon experimental garden from January to March 2020. In general, the Hymenoptera families found in this study can be grouped into three functional groups, namely the parasitoid group consisting of 13 families, 65 morphospecies and 127 individuals, predators of two families, 23 morphospecies, and 679 individuals, as well as pollinators of two families, 11 morphospecies and 25 individuals (Table 1).

The results of the analysis showed that the diversity index (H') of Hymenoptera insects on porang plants was 2.28. The value of H' is medium-level diversity due to it ranges between 1.35 and 3.5. The high value of species diversity is an indicator of the stability of a habitat. High stability indicates a high level of complexity which causes the habitat to have a high level of tolerance for disturbances that will occur within the habitat component. The high and low diversity of insects in agricultural land is affected by various factors such as plant vegetation [2, 15], shade trees, [16], presence of natural habitats [17], landscape structures [18]. In the porang plantation, there is a kemiri sunan as a shade tree that will affect the temperature and light intensity. It will also affect the microclimate in porang plantations which are thought to affect the optimum conditions for insect life, according to research that shade plants with wide canopies, flat branches, and many leaves allow some insects to prefer the habitat [19].

The abundance of the Hymenoptera insect family with a high number of individuals from a family can cause a family to dominate the habitat. The Hymenoptera insect's Evenness value (E) of 0.50 shows that the value is less than 1, indicating that there are only one or two dominating species in porang plantations. The results showed that the family Formicidae that had a high relative abundance was Anopolepis gracillipes. The high population of A. gracillipes is due to the fact that insects are sociable insects that reside in groups, making them easier to catch. In addition, human activities will increase the population of ants that is A. gracillipes [20].

3.2 Functions of Hymenoptera insects in porang plantations
Hymenoptera insects found in porang plantations consisted of 17 families and 99 morphospecies were divided into three groups, namely parasitoids, predators, and pollinators. Parasitoid insects are insects that, in the larval stage, live and eat from other insects, usually plant-eating insects[24]. Parasitoids can prey on eggs, pupae, and adult insects (imago). In porang plantations, it found that families preyed on the eggs and larvae of phytophagous insects, such as Braconidae, Ichneumonidae, Ceraphronidae [25] (Figure 3). In addition, the families, Scelionidae, Platygastriidae, Eulophidae are egg parasitoids [26] (figure 2). One of the parasitoids that can be identified up to the genus is Apanteles sp. which is a larval parasitoid of caterpillar pests whose imago is either a butterfly or a moth [25].

Predatory insects are insects that eat smaller or herbivores insect so that they are beneficial to control pests that can harm plants. Predatory insects found on porang plants consisted of families Formicidae and Spechidae. The Formicidae insects found on porang plants were A. gracillipes reported as predators for smaller insects such as thrips and mealybugs, while Paratrechina sp. includes in the predators of predators fruit borer pests [16, 27]. Pest control using predators can reduce crop damage, based on
research showing that ants can minimize damage caused by *Helopletis pernicialis* pests significantly by almost 80% on cashew crops[3, 28, 29].

**Table 1.** Number of Family, morphospecies, and individuals of Hymenoptera found on Porang plantation.

| No | Family   | Number of morfospecies | Number of Individuals | R     | The role of insect* |
|----|----------|-------------------------|-----------------------|-------|---------------------|
| 1  | Apidae   | 10                      | 23                    | 2.77  | Pollinator          |
| 2  | Bethylidae | 1                      | 1                     | 0.12  | Parasitoid          |
| 3  | Braconidae | 3                      | 4                     | 0.48  | Parasitoid          |
| 4  | Ceraphronidae | 6                      | 17                    | 2.05  | Parasitoid          |
| 5  | Chalcididae | 1                      | 1                     | 0.12  | Parasitoid          |
| 6  | Cinyphidae | 5                      | 7                     | 0.84  | Parasitoid          |
| 7  | Diapriidae | 7                      | 19                    | 2.29  | Parasitoid          |
| 8  | Encyrtidae | 3                      | 4                     | 0.48  | Parasitoid          |
| 9  | Eulophidae | 8                      | 10                    | 1.20  | Parasitoid          |
| 10 | Formicidae | 22                     | 677                   | 81.47 | Predator            |
| 11 | Halictidae | 1                      | 2                     | 0.24  | Pollinator          |
| 12 | Mymaridae | 4                      | 7                     | 0.84  | Parasitoid          |
| 13 | Platygastridae | 4                      | 10                    | 1.20  | Parasitoid          |
| 14 | Scelionidae | 21                     | 44                    | 5.29  | Parasitoid          |
| 15 | Sphecidae | 1                      | 2                     | 0.24  | Predator            |
| 16 | Ichneumonidae | 1                      | 1                     | 0.12  | Parasitoid          |
| 17 | Evaniidae | 1                      | 2                     | 0.24  | Parasitoid          |
| Jumlah | 99      | 831                     |                       |       |                     |

* [21–23] and assuming that Formicidae as a predator

Pollinator insects are insects that support the pollinating process of plants. The results showed that two families of pollinator insects found were Apidae and Halictidae families in porang plantations. The abundance of pollinator insects in porang plantations was still low due to the observations were made in the vegetative phase, because porang plantations were three months old. While the flowering period of porang plants is 3-4 years old [30]. The use of seeds in porang plant propagation results in more uniform roots, faster harvesting ages, and easier seed handling [31].

![Figure 3. Parasitoid Braconidae and Scelionidae.](image-url)
4. Conclusion
Insect of Hymenopteran found on porang plants was consisted of 100 morphospecies and 17 families. The dominant morphospecies was *Anoplolepis gracillepes*. The diversity index \( H' \) of Hymenopteran insects was 2.28, while the evenness \( E \) was 0.50. Collected Hymenopteran identified as pollinators, predators, and parasitoids. The pollinators were Apidae and Halictidae while the predators were Formicidae and Sphecidae, the parasitoid insects were 13 families i.e. Braconidae, Scelionidae, and Ceraphronidae, etc.

Acknowledgments
The authors would like to thank Ms. Euis and Nisa, who have assisted in conducting the research and collecting the observation data both in the field and in the laboratory.

Reference
[1] Alifianto F, Azrianingsih R and Rahardi B 2013 Peta persebaran porang (Amorphophallus muelleri Blume) berdasarkan topografi wilayah di Malang raya *J. Biotropika* 175–9
[2] Maulana F 2015 Peran Komunitas Arthropoda Tanah dalam Upaya Pelestarian Agroforestri Berbasis Sengon dengan Tanaman Budidaya Porang (Amorphophallus muelleri Blumei) *Rawa Sains J. Sains Stiper Amuntai* 5 6–13
[3] Karmawati E and Wikardi E 2004 Peranan Semut (Oecophylla smaragdina dan Dolichoderus sp.) dalam pengendalian Helopeltis spp., dan Sanurus indecora pada jambu mete *J. Littri* 10 1–7
[4] Adhi L S, Hadi M and Tarwojto U 2017 Keanekaragaman dan kelimpahan semut sebagai predator hama tanaman padi di lahan sawah organik dan anorganik *Klaten Bioma* 19 125–35
[5] Puspitasari M, Susilawati, Indriati G and Pranowo D 2020 Komposisi Serangga Fitofag pada Pertanaman Porang (Amorphophallus muelleri Blume) dengan Jarak Tanam yang Berbeda *Plant Protection Day dan Seminar Nasional 4 “Inovasi Masa Kini dan Tantanangan Masa Depan Perlindungan Tanaman”* ed E Yulia, F Widianinti, W Kurniawan, Rizkie Lilian and I Nurul Bari (Jatinangor: UNPAD PRESS) pp 81–4
[6] Elizalde L and Folgarait P J 2011 Biological attributes of argentinian phorid parasitoids (Insecta: Diptera: Phoridae) of leaf-cutting ants, acromyrmex and atta *J. Nat. Hist.* 45 2701–23
[7] Susilawati, Puspitasri M and Pranowo D 2020 Keanekaragaman Serangga Teresterial pada tanaman Porang (Amorphophallus muelleri) dengan sistem budidaya tanaman yang berbeda di Sukabumi *Seminar Nasional Peragi “Peran PERAGI dalam memeperkuat inovasi dan petani milenial untuk mewujudkan pertanian tangguh dan berdaya saing”* (Yogyakarta)
[8] Bestelmeyer B T, Agosti D, Alonso L., Brandão C R F, Brown J W, Delabie J H C and Silvestre R 2000 Field techniques for the study of ground-dwelling ants: an overview, description and evaluation *Ants Stand. methods Meas. Monit. Biodivers.* xix, 280 p.
[9] Commonwealth Scientific and Industrial Research Organization (CSIRO) 2000 *The Insect of Australia: A textbook for students and research Workers* (Victoria: Melbourne University Press)
[10] Commonwealth Scientific and Industrial Research Organization (CSIRO) 2000 *The Insect of Australia: A textbook for students and research Workers* (Victoria)
[11] Goulet H and Huber J T 1993 *Hymenoptera of the World: An identification Guide to Famillies* (Ottawa: Research Branch Agriculture Canada)
[12] Hashimoto Y 2003 *Inventory and collection: total protocol for understanding of biodiversity. Identification Guide to The Ant Genera of Borneo* (Kinabalu: Research and Education Component, BBEC Programme)
[13] Felipe de M 2015 *agricolae tutorial* (Version 1.2-3) *Agricolae tutorial (version 1.3-3)* pp 1–81
[14] Magurran A 2004 *Measuring Biological Diversity* Blackwell Publ. 256
[15] Bandung S 2012 *Struktur Komunitas parasitoid Hymenoptera di perkebunan Kelapa Sawit, Desa Pandu Senjaya, Kecamatan pangkalan Lada Kalimantan Tengah*
[16] Susilawati and Indriati G 2020 Pengaruh Agroekosistem Pertanaman Kopi Terhadap the Effect of Coffee Plantations Agroecosystem on Diversity and JTIIDP 7 9–18

[17] Susilawati, Damayanti B, Akhmad R and Pudjianto 2017 Pengaruh keberadaan habitat alami terhadap keanekaragaman dan kelimpahan serangga pengunjung bunga mentimun J. Entomol. Indones. 14 51–60

[18] Ulina E S, Rizali A, Manuwoto S, Pudjianto and Buchori D 2019 Does composition of tropical agricultural landscape affect parasitoid diversity and their host–parasitoid interactions? Agric. For. Entomol. afe.12334

[19] Rasiska S and Khairullah A 2017 Efek Tiga Jenis Pohon Penaung terhadap Keragaman Serangga pada Pertanaman Kopi di Perkebunan Rakyat Manglayang, Kecamatan Cilengkrang, Kabupaten Bandung Agrikultura 28 161–6

[20] Hasriyanty, Rizali A and Buchori D 2015 Keanekaragaman semut dan pola keberadaannya pada daerah urban di Palu J. Entomol. Indones. 12 39–47

[21] Hamdi S, Sapdi and Husni 2015 Komposisi dan struktur komunitas parasitoid hymenoptera antara kebun kopi yang dikelola secara organik dan konvensional di Kabupaten Aceh Tengah J. Floratek 10 44–51

[22] Manuwoto S, Buchori D, Hidayat P and Budiprasetyo L 2006 Analisis Spasial Lanskap Pertanian dan Keanekaragaman Hymenoptera di Daerah Aliran Sungai Cianjur Spatial Analysis of Agricultural Landscape and Hymenoptera Biodiversity at Cianjur Watershed 13 137–44

[23] Yaherwandi, Manuwoto S, Buchori D, Hidayat P and Prasetyo L 2008 Struktur Komunitas Hymenoptera parasitoid pada tumbuhan liar di sekitar petanaman padi di daerah aliran sungai (DAS) Cianjur, Jawa Barat HPT Trop. 8 90–101

[24] Godfray H C J 1994 Parasitoid Behavioral and Evolutionary Ecology (New Jersey (US): Princeton University Press.)

[25] Mifsud D, Farrugia L and Shaw M R 2019 Braconid and ichneumonid (hymenoptera) parasitoid wasps of lepidoptera from the Maltese Islands Zootaxa 4567 47–60

[26] Hamid H, Buchori D and Triwidodo H 2003 Keanekaragaman parasitoid dan parasitasi pada pertanaman padi di kawasan Taman Nasional Gunung Halimun Hayati 10 85–90

[27] Bustillo A E, Cárdenas R and Posada F J 2002 Natural enemies and competitors of Hypothenemus hampei (Ferrari) (Coleoptera: Scolytidae) in Colombia Neotrop. Entomol. 31 635–9

[28] Peng R K, Christian K and Gibb K 1995 The effect of the green ant, Oecophylla smaragdina (Hymenoptera: Formicidae), on insect pests of cashew trees in Australia Bull. Entomol. Res. 85 279–84

[29] Symondson W O C, Sunderland K D and Greenstone M H 2002 D Diffusion of E Ffective B Ehavioral Annu. Rev. Entomol. 47 561–94

[30] Santosa E, Kurniawati A, Sari M and Lontoh A P 2016 Agronomic Manipulation on Flowering of Iles-iles (Amorphophallus muelleri Blume) to Enhance Seed Production J. Ilmu Pertan. Indones. 21 133–9

[31] Zhang D, Wang Q and George S 2010 Mechanism of staggered multiple seedling production from Amorphophallus bulbifer and Amorphophallus muelleri and its application to cultivation in Southeast Asia Trop. Agric. Dev. 54 84–90