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Population Dynamics of Insect Pest on Commercial Growing of White Oyster Mushroom (*Pleurotus ostreatus*)

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Abstract

One of the main constraints in commercialization of the mushroom production was the damage caused by insect pests. One of condition for controlling insect pests properly is understanding the population dynamics of these insect pests. This study aims to analyze the dynamics of pest populations in the white oyster mushrooms growing house. The research was conducted in the white oyster mushroom growing house located in Cisarua Village Cisarua District West Bandung Regency, at an altitude of 1,350 meters above sea level, with monthly temperature between 17-24 ^{o}C. The white oyster mushrooms growing house area was 8 m x 5 m, consist of 5 shelves, with each shelf consist of 5 levels. The research method used is the survey method. The survey was conducted to collect insect samples for every week at 2-10 weeks old after planting. Insect collection was done using water yellow pan traps. The results showed that insect biodiversity in white oyster mushroom was very low (0.64). Only three species of insect pests and one predator species were found, namely *Cyllodes bifacies*, *Libnotes immaculipennis*, *Bradysia ocellaris*, *Euborellia spp*. respectively. The highest population density found at white oyster mushroom age of 2, 3, and 10 weeks, with total population densities of 249, 210, and 235 adult insects respectively, while the lowest population density found at 4 weeks with a total population density of 83. The pest population in white oyster mushroom is dominated by *B. ocellaris*, with total population of 1,036.

Keywords: insect biodiversity, domination, oyster mushroom, population fluctuation

Introduction

White oyster mushrooms (*Pleurotus ostreatus*) is one of vegetable commodity which have a strategic role in improvement of sustainable livelihoods (Marshall and Nair, 2009) through nutritional, medicinal, economic contributions and environmental sustainability. White oyster mushrooms contain Protein (10.5-30.4 %), Fat (1.7-2.2 %), Thiamin 0.2 mg, Riboflavin (4.7-4.9 mg), Niacin 77.2 mg, Calcium 314 mg, Potassium 3.8 mg, Phosphorus 717 mg, Sodium 837 mg, Iron (3.4 -18.2) mg, and Fiber (7.5 -8.7) % (Sumarni, 2006). Mushrooms have low lipid content, being considered healthy foods (Smiderle *et al*., 2008). Various *Pleurotus* species have been shown to possess a number of medicinal properties, such as antitumor, immunomodulatory, antigenotoxic, antioxidant, anti-inflammatory, hypocholesterolaemic, antihypertensive, antiplatelet-aggregating, antihyperglycaemic, antimicrobial and antiviral activities (Gregori et al., 2007).

Trade in cultivated mushrooms can provide a readily available and important source of cash income. In addition, they can become an integral part of a sustainable agriculture system utilising organic waste (Marshall and Nair, 2009). White oyster mushrooms are a good choice for inexperienced cultivators because they are easier to grow, can be grown on a small-scale with a moderate initial investment. The cost of white oyster mushrooms requires a production cost 16,600,157.10 in one production process and earned income of Rp. 19,649,842.90 (Rahmawati et al., 2017).

The demand for white oyster mushrooms is currently increasing every year because it is a commodity that is currently popular with the public. The global oyster mushroom market size was USD 47.14 billion in 2024 and the market is expected to reach USD 62.64 billion in 2033 (Business Research Insights. (2025)). Therefore white oyster mushroom cultivation has become one of the profitable business options. However, this increasing demand is not supported by production which is still relatively low and fluctuating so there is a dependence on imports (Zarkasyie et al., 2021). According to BPS (2024), the productivity of Indonesian farmers' white oyster mushrooms has only reached 279.53 tons/ha. The results of the research ...., the harvest of white oyster mushroom cultivation can reach 1,180 tons/ha. One of the factors that can cause low productivity of white oyster mushrooms is pest attacks.

In mushroom cultivation, infestation by different types of pests creates serious threats. The indoor cultivation environment, characterized by limited light and high moisture, creates ideal conditions for pests. Mushrooms are attacked by pests from spawning to harvest (Teja et al., 2021), tend to cause significant crop loss (Oyebamiji et al, 2018; Jenita *et al.*, 2021; Rizal et al., 2021; Deepthi et al., 2004), and cause extensive losses in yield and even sometimes cause total crop failure (Deepthi *et al*., 2004**).** This condition will result the decreasing of market values and ultimately the financial loss to the growers.

According to Suhunan (2006), during the cultivation of white oyster mushrooms in Cisarua Village Cisarua District West Bandung Regency, can be attacked by 8 types of pests, namely *B. ocelaris, L. immaculipennis, C. rostamani, C. fuscipes, Mucophia sp, M. tamilnaduensi* (Order Diptera), *C.bifacies* and *Iscchyrus sp*. (Order Coleoptera). In addition, one type of natural enemy was also found, namely *Euborellia spp.* (Order Dermaptera). The attack of sciarids, cecids, and phorids were found to cause 17-26, 26-33 and 46% loss in yield, respectively. The economic threshold of the Sciarid, *Lycoriella auripila* is virtual zero (Limbule et al., 2021). In order to prevent this problem, insecticides are commonly used during mushroom cultivation. Thr farmers believe that the use of synthetic insecticides is the best way to control pest attacks. The use of insecticides on white oyster mushrooms is quite risky, because the fungus is very sensitive to some insecticides. The insecticides used also can cause poisoning of the mycelium/fruiting body of the mushroom, residues in the harvest, and changes in pest status (resistance, resurgence, secondary pests, etc.). Spraying insecticides in closed spaces is quite dangerous for workers. Several research results show that residue of insecticides carbaryl (Erdong et al., 2016 and Pumnuan, et al., 2021), chlorpyrifos, cypermentrin, and methomyl were detected in oyster mushrooms, the 10% of the samples contained residues exceeding the MRL (Pumnuan, et al., 2021). In Europe, America, Canada and Australia, it is known that several pests of white oyster mushrooms have resistance to the insecticides diazinon, organophosphates and pyrethroids (Babar et al., 2012).

To reduce the negative impacts, the use of insecticides must be carried out based on the development of pest populations, namely sustainable pest management method or green pest management. One method to meet these requirements is the use of insecticides based on population dynamics. Population dynamics refers to the study of changes in species composition and numbers over time. Study pest population dynamics during the crop growing season could be used by crop producers, ecologists, agricultural economists, researchers and consultants for efficient and effective insect pest control (Djaman et al., 2019). Insect pest population dynamics could be used to forecast the insect populations and it is vital to warrant timely vigilance to deal with future pest problems and prevent crop losses. This study aims to analyze the dynamics of pest populations in the white oyster musroom growing house. To date, there is very little research-based information on the population dynamics of insect pests in white oyster mushroom cultivation. It is hoped that this study can provides information and evidence on the dynamics of white oyster mushroom insect pests at the farmers (commercial) white oyster mushroom cultivation at Cisarua Village Cisarua District West Bandung Regency.

Research Method

The research method used was the survey method. The survey was conducted to collect insect samples for every week at 2-10 weeks old (9 times). Insect collection was done using water yellow pan traps (figure 1). Insects sampling was conducted in farmer oyster mushroom cultivation house located in Cisarua Village Cisarua District West Bandung Regency, with an altitude of 1350 meters above sea level, and air temperature between 17-24 ^{o}C. The mushroom house used has an area of 8 m x 5 m, consist of 5 shelves, and each shelf consist of 4 level. The total number of bag logs planted was 10,000 bag logs.

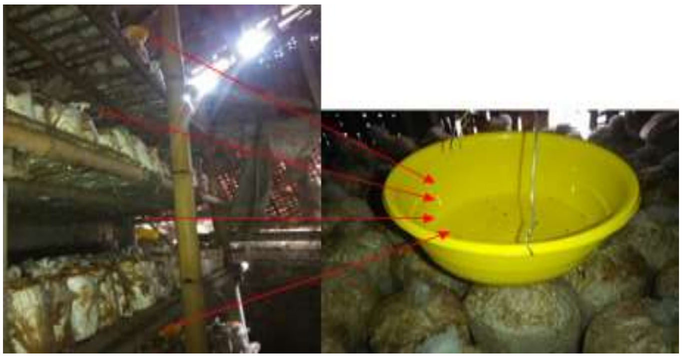

Figure 1. Layout of water yellow pan traps on each level of the white oyster mushroom rack

The captured insect specimens were identified at Laboratory of Pesticide and Environmental Toxicology, Department of Pests and Plant Diseases Faculty of Agriculture Universitas Padjadjaran. The insect identification process was carried out using the morphospecies method. The population density data obtained is used to calculate the diversity index, species richness index, evenness index, dominace index, and distribution patterns.

a. Diversity index (H') is calculated using the Shanon formula (Margurran, 2004), as follows: $H' = \sum_{i=1}^{n} \text{pi} \ln \text{pi}$
Where: H' - diversity index; ni - the number of individuals of each species; N - the total number of individuals. The determination of species diversity takes into classification the following criteria. If H'>3, the species diversity is extremely high. If H' is between 1.6 and 3, the species diversity is high. If H' is between 1 and 1.5, the species diversity is moderate. If H'<1, species diversity is low

b. Evenness index (E) is calculated using the Pielou (1966) formula (Bismark, 2011) formula, as follows: E = H'/ln S
Where: E = Evenness index; H' = Species diversity index; S = Number of species observed. The evenness index value ranges from 0-1. A value of 1 indicates perfect evenness, meaning all species are equally abundant, while a value of 0 indicates that all individuals belong to a single species. If E: 0.90-1.00 = Very high evenness (extremely balanced community); If E: 0.70-0.89: High evenness (well-balanced community); If E: 0.50-0.69: Moderate evenness (somewhat unbalanced); If E: 0.25-0.49: Low evenness (unbalanced community); If E: 0.00-0.24: Very low evenness (highly dominated community

c. Dominance index is calculated using the formula , as follows $D = \sum \left[\frac{Pi}{N}\right]^2$
Where D= Dominance Index, Pi= The proportion of individu, i= 1, 2…, n, N = number of species observed. Index values range from 0 - 1 by the following categories: 0 < C < 0,5 = Low Dominance. 0,5< C ≤ 0,75 = Moderate Dominance. 0,75< C ≤ 1,0 = High Dominance

d. Species Richness Index. The formula used to determine the Species Richness Index uses the Margalef Index (Magurran, 2004), as follow R = (S-1)/ln N
Where R = Species richness index, S = Number of species observed, N = Total number of individuals of all species, Ln = Natural logarithm. The magnitude of the species richness index (R) is determined using the following categories. R <3.5 indicates low species richness, R between 3.5 - 5.0 is classified as moderate species richness and R> 5.0 is classified as high (Magurran, 2004)

e. Distribution pattern is calculated using the Morisita formula index (Morisita 1962 in Krebs, 1998), as follows: $Id = \frac{n\Sigma Xi^2 - N}{N(N-1)}$
Where Id = Morisita Index, N = total number of individuals, n = number of rack, Xi2 = square of the number of individuals in rack i. From the calculation results above, the following results will be obtained: I_d = 1, then the population distribution is uniform; Id < 1, then the population distribution is random, and Id > 1, then the population distribution is clustered.

Results and Discussion

Insects Pest population Density

The overall abundance of the pests and beneficial insects captured on the water yellow pan traps on white oyster mushroom indicated three insect pests and one insect predator species. These species were identified as follows i.e. *Cy. bifacies* (Coleoptera), *L. immaculipennis*, *B. ocellaris* (Diptera), and insect predator *Euborellia spp.* (Dermaptera) (Figure 1). This number of spesies found is less than Suhunan (2006) which found 9 insect species, consisting of 8 pest and one predator. The predator species found in this research was *Euborellia spp.*, it is the same predator species found by Suhunan (2006).

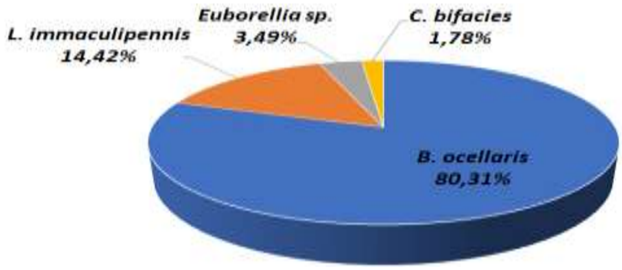

Figure 2. Number of insect captured on the water yellow pan traps.

B. ocellaris is the most dominant species compared to the other three species, with a total population of 1,036 individuals (80,31%), while *C. bifacies* was the least abundant (1,78%). *B.ocellaris* is an insect that can live in bushes and grasses as well as organic waste (used media) found around the mushroom house, so that this insect can live well. According to Menzel et.al (2003) insects of the Family of Sciridae live a lot on the stems and leaves of bushes and grasses where their larvae can live in organic matter so that *B.ocellaris* can live outside. *B.ocellaris* is an insect that can live in bushes and grasses as well as organic waste (used media) found around the mushroom house, so that this insect can live well. Insects of the Sciridae family live a lot on the stems and leaves of bushes and grasses where their larvae can live in organic matter so that *B.ocellaris* can live outside . This is also in accordance with Rijal et al. (2021) which states that flies are the serous insect pests of mushroom, which infest different types of mushrooms throughout the world. Fly maggots' outbreak mostly seen especially in the next year of mushroom cultivation.

B. ocellaris is the main pest that always attacks white oyster mushrooms cultivation in the world (Rijal et al., 2021 and Menzel et al. 2003). *B. ocellaris* are pests that can always be found in mushroom cultivation areas and have the highest population levels (Menzel, 2003). The *B.ocellaris* fly is a new pest in oyster mushroom cultivation whch become an important insect pest of oyster mushroom at Bandung (Rostaman, 2003). This is also in accordance with Menzel et al. (2003), the *B.ocellaris* fly is one of main pest in oyster mashrooms and widespread throughout the world, except Antarctica. *C. bifacies* widespread throughout Asia Tenggara dan Asia Selatan. Distribution of *L. immaculipennis* more limited, only spread in Indonesia (Sumatra, Java, Mentawai, Simeulue), Japan (Nansei, Ryukyu), Malaysia (Penins., Borneo: Sarawak), and Sri Lanka (Catalogue of the Craneflies of the World, 2025). In. Srilangka, *C. bifacies* was distributed in about 96 per cent of the farms visited causing serious damage up to 82 % (Gnaneswaran and Wijayagunasekar, 1999). *C. bifacies* beetles are a type of beetle that is often found in mushroom barns owned by farmers. These beetles can act as vectors carrying other pathogenic organisms, such as fungi and bacteria. The genus *Euborellia* is much more speciose and is represented by four species in Europe, inluding *E. annulata*, *E. annulipes*, *E. arcanum*, and *E. moesta*. Only *E. moesta* seems to be indigenous to the area, while *E. annulipes* is considered a cosmopolitan species (Kalaentzis et al., 2021). *E. annulipes* (Dermaptera: Anisolabididae), a species with a wide geographic distribution. It is predatory potential at different stages of life of agriculturally important insect pests (Arroyo et al., 2023). *E. annulipes* is a voracious predator of larvae and pupae of various insects (da Silva Nunes, 2020).

Insect population dynamic (population fluctuation)

Population dynamics refers to the study of changes in species composition and numbers over time. Pest population dynamics information when studied over multiple years can provide insight into periods when the populations of specific pests peak and dip. This data can inform the use of planting date as a method of eliminating/reducing synchrony between peak pest populations and the most vulnerable stages of the crop. Understanding the seasonality of pest population dynamics is essential to implementing integrated pest management (IPM) strategies to reduce dependence on pesticide applications and preserve ecosystem services while ensuring food security (Parees et al., 2022).

All of four species *(L. immaculipennis* and *B.ocellaris*), were caught in each weeks trapping. While This species was found, two species is in accorthance with Rijal et al. (2021) who state that mushrooms are attacked by abundance of pests from spawning to harvest. Since mushrooms are grown mostly in an enclosed environment, the risk of insect pests and diseases spreading rapidly within the crop are high. one of the factors that causes this condition is that Sciarids are initially attracted to the fermentation odors being emitted during cool down of peak heated compost (Sharma, et al., 2019). The variation in the abundance of the three insects pest and one insect predator under this study were recorded in Figure 3 and Figure 4.

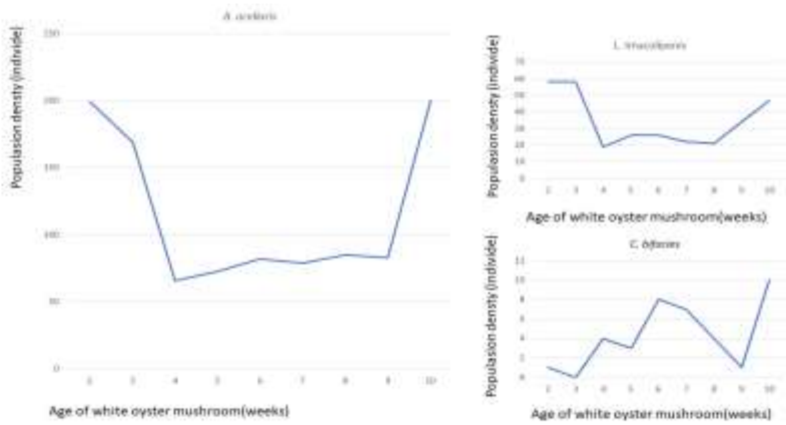

Figure 3. Population fluctuation of *B. ocellaris, L. immaculipennis,* , and *C. bifacies*

In Figure 3 above, it can be seen that the population of C. *bifacies* is the most fluctuating compared to *B. ocellaris* and *L. immaculipennis*. The population fluctuations of *B. ocellaris* and *L. immaculipennis* can be said to have the same pattern, that is high at the age of 2-4 Weeks After Planting (WAP), decreasing at 5-7/8 WAP, and increasing again at 7/8 – 10 WAP. In contrast, the population of *C. bifacies* tends to increase continues to, except at 9 WAP. High population trapped at the beginning and end of white oyster mushroom cultivation. The pest activity associated and influenced by growth stages of the mushroom. Mushrooms are attacked by abundance of pests from spawning to Phase III (Rijal et al., 2021). Sciarids are initially attracted to the fermentation odors being emitted during cool down of peak heated compost (Sharma et al., 2019). In spawning Phase mushroom often an exposed process and vurnerable to the entry of pest, pathogen, and competitors. Phase III: Vulnerable to flies in order system, Emptying phase III and old crops generates mushroom mycelial fragments. The population dynamics of insect pests fluctuate along with the varying conditions of the environmental factors: abiotic and biotic such as host plant (growth stages of the mushroom), competition (inter and/or intra competition), and natural enemies, especially predator, such as *Euborellia spp*., the only one predator which found in this research (Gambar 5). This condition is understandable, because Euborellia spp. is an oliphagous predator, so it has the same potential to prey on the three pest species. However, the potential of Euborellia spp as a predator cannot function properly, because the population is very low compared to the total population density of the pest which also has a relatively low population density (Figure 5).

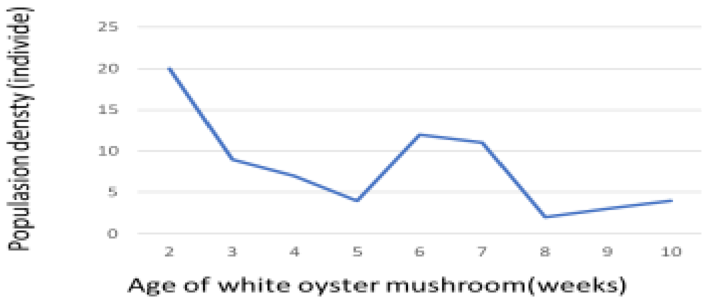

Figure 4. Population fluctuation of insect predator *Euborellia spp.*

Figure 4 showed that the population fluctuation pattern of Euborellia spp. appears to be the resultante of the three pest species, but with a very low population density. The total population density of predators obtained reached 72, much lower than the total population density of insect pests which reached 1,036. The highest population density was obtained in the initial observation (2 WAP), which was 20 imago, and the least in 8 WAP, which was 3. Based on the comparative data of the population density of insect pests and predators, it can be assumed that the predators found in the white oyster mushroom cultivation agroecosystem were unable to show their potential as predators (Figure 5).

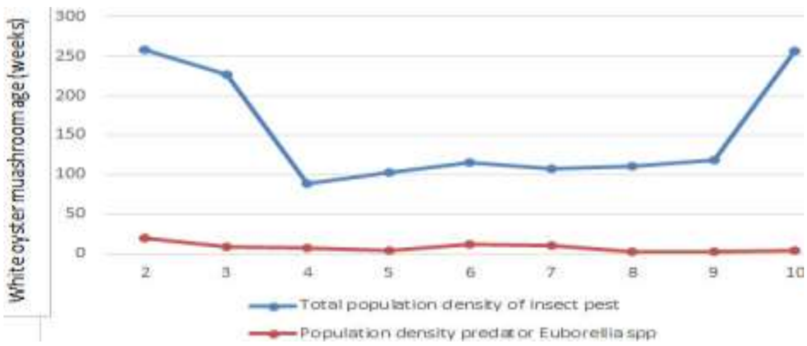

Figure 5. Population fluctuation of insect pest and predator *Euborellia spp.*

Insect community structure

Information about community structure consisting of abundance, diversity, evenness, and dominance of species, as well as their bioindicator potential is very important in providing an overview of the ecological conditions of various types of ecosystems, as a reference in management for sustainable ecosystem development (Rohyani, 2020). The insect community structure of insect pests and predator Cisarua Village Cisarua District West Bandung Regency was recorded in Tabel 1.

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Table 1. Structure of insects community in white oyster mushroom cultivation

Criteria	Index value	Category
Diversity index	0,64	Low
Eveness indexs	0,16	Very low*
Dominance Indexs	0,67	Moderat
Rischness species	0,003	Low

Information : * An other category by Kreb (1989): Deppress community

The result of research showthat Insect community structure, including diversity index with low criteria, eveness index with very low criteria, dominance index with moderat criteria, and rischness species index whit low criteria. Based data at Cisarua Village Cisarua District West Bandung Regency is low. Referring to Krebs (1988), specifically for the evenness index point, the insect community structure in Cisarua Village, Cisarua District, West Bandung Regency, is also referred to a depress community. This condition is understandable, because during the research, white oyster mushrooms cultivation were sprayed with insecticide, which active ingredient of acephate 75%. Insecticide spraying was conducted 3 time whit spraying interval once a month. The of water yellow pan trap, also is importani factor which cause the community structure is low. Water yellow pan trap is one of effective tool of pest control.

Distribution pattern

To determine the distribution pattern of insect pest populations, it is determined using the morisita index. Data analysis result results showed that the distribution pattern of insect pests was random (Table 2).

Tabel. 2. Distribution pattern of four insect found

Rack	*B.ocellaRandonis*		*L.MImaculipennis*		*C.bifacies*		*Euborellia spp.*	
	MI	DP	MI	DP	MI	DP	MI	DP
1	0,0006	R	-0,0003	R	-0,0003	R	-0,0003	R
2	0,0007	R	-0,0002	R	-0,0003	R	-0,0003	R
3	0,0006	R	-0,0002	R	-0,0003	R	-0,0003	R
4	0,0007	R	0,0007	R	-0,0003	R	-0,0003	R
5	0,0003	R	0,0003	R	-0,0003	R	-0,0003	R

KeteRandomangan : MI = Morisita Indexs
DP = Distribution Pattern
R = Random

According to O'Connor & Keil (2001), food factors are other factors that greatly determine the development of insect pest populations. The quality (as the insecticide used impact) and quantity of food factors will affect the high and low development of the population. Phorid flies are also very active flies and can jump uncertainly and are also stronger than sciarid flies. While sciarid flies are also active flies and can lay their eggs anywhere (Keil et al. 2002), so they can form a random distribution pattern. An other important factor of the random distribution of insect pest and predator in white oyster mushroom here, is the used of water yellow pan trap.

Conclussion

Population dynamics and community structure, including diversiy, dominance species, eveness, and species richness of insects pest and predator in white oyster mushroom is low. Only three insect pest spcies and one insect predator found, with total population density of 1,290 imago with random distribution pattern. The highest population density found at white oyster mushroom age of 2, 3, and 10 weeks, with total population densities of 249, 210, and 235 adult insects respectively, while the lowest population density found at 4 weeks with a total population density of 83. The pest population in white oyster mushroom is dominated by *B. ocellaris*, with total population of 1,036.

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