Diversity of insect on cowpea cropping in rainfed land

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Abstract. Cowpea (Vigna unguiculata subsp. Unguiculata) is a plant that is widely cultivated in dryland or the dry season because it is relatively resistant to drought. Insect diversity in the cowpea ecosystem has different characteristics from other ecosystems. This study aimed to understand the diversity of insects on cowpea cropping in rainfed agricultural land. Insect collection used a survey method in which light trap, pitfall trap, and swing net as tools. Observation time using each tool was 3, 2, and 5 times a week, respectively. The experiment was carried out at rainfed land of Jakenan field station using an area of 2500 m2 with altitude 7 m above sea level (masl). The most dominant insect population on light trap observation was an order of Lepidoptera in the form of moths. In contrast, the observations using a pitfall trap were dominated by an insect from the Hymenoptera order in the form of ants and bees. Furthermore, observation using insect swing net was the Hemiptera order or the ladybug group as the most dominant. The diversity index value was categorized as a medium since the value in the range of 1<H<3, and the evenness index value showed very even.

1. Introduction
Cowpea (Vigna unguiculata subsp. Unguiculata) is a plant that is widely cultivated in dryland or dry season but it can also be planted in former rice fields. It is a most versatile pulse crop because of its smothering nature, drought-tolerant characters, soil restoring properties, and multi-purpose uses [1]. Cowpea also plays an important role in providing soil nitrogen to cereal crops (such as maize, millet, and sorghum) when grown in rotation [2]. Cowpea is cultivated mainly for its grains, which are rich in protein with most improved varieties containing between 20 and 25 per cent protein on dry weight basis [3].

Cowpea can well adapt to various soil types of marginal land with good drainage. The optimum altitude is about 0-500 m asl, although can grow until 1500 as l. Cowpea is tolerant of salinity and acid soil conditions, but optimum pH is 5.5−6.5. Cowpea is most cultivated in rainfed land with rainfall of about 600 mm/year [4]. This crop is very quick and responsive to absorb water with a value of 140 mm on a period of 66 days in a vegetative stadium [5]. Cowpea root system is dense and well-developed and has a beneficial effect on the structure and tilth of the topsoil layer. Most root growth occurs within the topsoil layer but, in drought conditions, a long taproot can grow for reaching the deeper moisture in the soil profile [6]. These characteristics furnish cowpea plants with a high resistance to drought in comparison with other legumes. Since cowpea is tolerant of drought and acid, it is the potential to increase crop productivity in a dry land.

Rainfed agricultural land is an agricultural ecosystem that has particular characteristic in which watering just only used rainfall without irrigation and ground water, thus the cropping pattern follow rainfall pattern. In Indonesia, the dry land potential for agriculture is 68.64 million ha, consisting of 25.09 million ha annual crops and 43.55 million ha for perennials [7]. In Indonesia, cropping pattern in rainfed land is started in the end of year in which rainfall season started to reveal and categorized as
first growing season, after that continued to second growing season that occur in the early of year in which water still available. In the third growing season, farmers are usually grow the plant that only need a few of water because of water is very limited in water reservoir.

Indonesia is known as a country that has a big diversity of flora and fauna since Indonesia is located in a tropical area that has a stable climate and geographically located among Asia and Australia continent [8]. One of the biggest Indonesian fauna diverse populations is an insect in which there are more than 250,000 species or 15 % of the main biota in Indonesia [9]. The study of insect diversity is the first step in crop pest control and management. Beneficial of this study is to know and detect disturbance of ecosystem component in nature so that can reach balancing in nature (homeostatic) without using pesticides [10]. The purpose of the research is to know about diversity of insect on cowpea cropping in rainfed agricultural land.

2. Material and Methods
This study was conducted on 1-20 October 2019 when the crop on 78 to 96 days after planting. At that time was drying season while water availability is limited thus temperature, evaporation, and sunlight intensity were very high. The experiment was located at Jakenan field station, Pati, Central Java. The experiment was carried out in the area 2500 m² that used a survey method to collect data in which tools to collect insects were light trap, pitfall, and swing net.

2.1. Insect collection using light trap
Light trap was used to attract nocturnal insect. Four light trap was installed in the middle of cowpea cropping at bund side (Pematang). Light trap was using LED lamp which is installed above 70 cm logs with a roof on the top to protect from rain and the 5 liters water container was installed under the lamp that filled in with 1 liter water and 1 g detergent to catch the insect that attracted to the light. Detergent has a function to reveal water surface tension thus insects could be trapped in water and disable to move out. The observation was executed three times a week that is on Monday, Wednesday, and Friday then collected insects were identified and documented.

2.2. Insect collection using pitfall
Pitfall was made from a 1-liter plastic container in which the mouth hole of the container was equipped with a plastic funnel. The container was filled in 100 ml of water in which has a function to trap the insect. Pit wall was installed in the center of cropping by dipping to the soil in which the surface of the pitfall should be in line with the soil surface so that the insect would fall into pit fall that contains water. Furthermore, pitfall was covered by a roof to protect from rain and hot weather. The experiment area was installed 4 pitfalls in which observation was conducted two times a week that is every Tuesday and Thursday.

2.3. Insect collection using swing net
The swing net was made from the net that was installed on the circular iron with a diameter of about 50 cm and a hilt length of about 100 cm. The application of the swing net was conducted by a single swing in the center of cropping then the insect put in the plastic bag. The application of swing net was carried out at 4 different block areas in which each area was 30 single swings. The observation was conducted two times a week that is Monday and Friday. The next, insect was identified and count the population.

Data analysis was to identified diversity value that is using Shannon-Winer[11] and Evenness index [12]. The formula of Shannon-Weiner index is

$$H' = -\sum P_i \ln P_i$$, in which $$P_i = \frac{n_i}{N}$$

Remarks :
H' : Diversity index of shannon-weiner
P : Relative number of each species
n : Species number-i
N : Total of species number
If \( H' < 1 \) means low diversity, If \( 1 < H' < 3 \) means middle diversity, If \( H' > 3 \) means high diversity.

While evenness index as follow:

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

Remarks:

- \( H' \): Diversity index of Shannon Wiener
- \( S \): Total of species number
- \( E \): Evenness Index.

Evenness index value is in range of 0-1, If 0 means population is unevenly distributed, while 1 means population is total distributed.

3. Result and Discussion

Weather conditions can affect insect populations. Climatology data in October 2019 showed that the minimum temperature at night was 21.39 °C on average, while the maximum temperature at noon was 41.6 °C on average, and the mean of daily temperature was 38.18 °C. Air humidity ranged from 38.68-96.19 % with rainfall 0 mm and wind speed about 1.65 m/second. The average temperature in the first week was around 37 °C then increased in the second week around 38 °C. Each insect has a different suitable temperature for its life. According [13], the effective temperature for insect survival is minimum temperature of 15°C, an optimum temperature of 25°C, and a maximum temperature of 45°C. Generally, the hibernation condition is usually started at 15 °C and aestivation at a temperature of 38 °C-45 °C. Poor rainfall has a negative impact on insect reproduction and its growth. The wind affects the reproduction of insects, particularly to its distribution [14,15]. The fluctuation of the environment condition can bring to the diversity of insects in the ecosystem [16,17]).

Climate and cropping patterns also affect the diversity and dynamics of the insect population. Each different condition has different pest management where this knowledge will bring effectiveness and efficiency in pest control [18]. Pests and diseases would be making big disturbances if living in a suitable condition. An outbreak of pest and disease are also affected by the land condition, bad agricultural practice such as continuous monoculture cultivation, and misleading of using pesticides and fertilizer.

3.1. Light Trap Observation

Observations with light traps showed that there were 7 orders found in cowpea cropping (Figure 1). The population of the order Lepidoptera, Coleoptera, and Hemiptera were high, while the the orders population of Hymenoptera, dipter, Dermaptera, and Neuroptera were low. Coleoptera and Lepidoptera are some of the largest and most common orders of the four insect orders [19]. Generally, Order of Lepidoptera and Hemiptera have a function as harmful insects (pests) while Coleoptera, Hymenoptera, Dermaptera, and Neuroptera as useful insects (natural enemy). Coleoptera has important economic value because many of its types become biological control agents for agricultural plant pests as predators [20] [21].
Biodiversity in the agriculture ecosystem has affected plant growth and production particularly in nutrition circle, microclimate, chemical compound detoxification [22]. Insect as one of the biodiversity components has an important role in the food chain as an herbivore, carnivore, and detritivore [23]. Herbivore insect is the main factor in the loss of harvest both directly feeding to the crop and as a vector of crop pathogen [24].

Further analysis showed that there was a balancing population between harmful and useful insects, so that pest attack was low and under control. It has happened because the experiment site only uses synthetic pesticides selectively and much more using botanical pesticides to control pests. The insect that was observed such as from order lepidoptera mainly: Scirpophaga incertulas, Helicoperva armigera, Ostrinia Purnacalis, from order coleoptera mainly Dystiscus sp, Paederus fuscipes, Coccinella, Ophionea nigrofasciata, from order hemiptera mainly: Nevotetix virescens, Nezara viridula, Leptocorisa acuta.

3.2. Pitfall Observation
On the pitfall observation, insect and arachnid were the dominant creatures that were trapped (Figure 2). The insects that were trapped were the order of Hymenoptera, Coleoptera, and Orthoptera. This order and arachnid have a function as a natural enemy in the agricultural ecosystem. The population of an insect in pitfall was low, but there were a few increases in Hymenoptera and Orthoptera in 99-103 DAP. Dominant species on pitfall was Gryllus mitratus, Agelelopsis, C. consobrinus, M. domestica, D. melanogaster, Cerceris arenaria. According to Riyanto (2007) ecologically Hymenoptera insects can be useful for other animals and plants because they have has an important role in the food chain, which is utilized as predators and pollinators to reduce pests and support the development of plants on plantations. Another function of an insect in the ecosystem is as bioindicator one of them is ant (Peck et al.1998).
3.3. Swing Net Observation
Observations with swing net showed that there were 7 orders found in cowpea cropping, namely Orthoptera, Hemiptera, Homoptera, Coleoptera, Lepidoptera, Diptera, and Hymenoptera. The dominant insect populations found were the order Hemiptera and Coleoptera (Figure 3). In the first week of October, the population of insects from every order had the same tendency that is low. In two next weeks, the population of order Hemiptera were significantly increasing but later sharply decrease. The weather condition at that time was high temperature in which Hemiptera was able to adapt to that condition. Hemiptera is a pest with a type of mouth like a sucker that able to suck water in the crop. The dominant species in swing net observation was *Leptocorisa acuta*, *Paederus fuscipes*, *Nevotetix virescens*, *Oxyopes lineatipes*, *Nezara viridula*

![Figure 2](image1.png)

**Figure 2.** Diversity and population rate of insect according to pitfall catchment

![Figure 3](image2.png)

**Figure 3.** Diversity and population rate of insect according to swing net catchment

3.4. Diversity and Evenness Index Value of Insects
The results of the calculation of the diversity (H’) and evenness index values (E) (table 1) for each observation period indicate that the diversity of insects in cowpea cultivation was in the middle diversity category and the community distribution was even. The diversity index value of insect species ranged from 1.44 to 1.98. This value indicates that diversity is moderate, productivity is sufficient, ecosystem conditions are fairly balanced, and ecological pressure is moderate. The highest diversity index value was obtained during the fifth week of observation, namely 1.98. at the fifth week
of observation, there were no very dominant insects. Meanwhile, in the third week of observation, the diversity index value was 1.44 lower than the others. In this third week, the insects of the Hemiptera order are more common than other orders.

Table 1. Diversity and Evenness Index Value of Insects

| Observation Period | Diversity index value (H') | Evenness index (E) |
|--------------------|---------------------------|--------------------|
| First week         | 1.67                      | 0.8                |
| Second week        | 1.73                      | 0.78               |
| Third week         | 1.44                      | 0.69               |
| Fourth week        | 1.87                      | 0.85               |
| Fifth week         | 1.98                      | 0.86               |

On agricultural land, the existence of agricultural practices has a strong influence on insect diversity. Intensive use of insecticides can reduce diversity due to the toxic effects of pesticides. According to several classes of insecticides that are widely used, such as organophosphates and pyrethroid, harm various non-target species, including species of economic importance [25]. These insecticides have been shown to eliminate important predators and parasitoid species from agricultural systems. Besides that, environmental components (biotic and abiotic) will affect the abundance and diversity of biota in a place so that the high abundance and diversity of individuals of each type can be used to assess the quality of a habitat [26].

The level of diversity of insect species has an important role for stability in the ecosystem. Species diversity is a community characteristic that shows the level of diversity in the types of organisms present in it. To obtain this diversity of species requires the ability to recognize and distinguish types of pests. Insect biodiversity affects the quantity and quality of agricultural products produced. In natural ecosystems, there is generally population stability between pests and natural enemies so that the presence of insect pests is no longer detrimental [27].

The level of crop diversity affects the emergence of pest problems, and a diverse cropping system affects the population of pest species. The presence of insect pests in a cropping ecosystem will affect cultivation activities because it will directly reduce the quality and quantity of products produced. If pest control activities are not carried out properly, cultivation activities will suffer losses. Several studies reported that there was a positive relationship between biodiversity and plant productivity. Pest control is important because the level of pest attack is one of the factors that affect plant growth [28]. The Ecosystem structures that include the composition of plant species, pests, natural enemies, and other biotic groups, as well as dynamic interactions between biotic components are important to study. With this information, management strategies can be established that can maintain pest populations at a level that is not detrimental.

The strategy that can use to detect changes in habitat and environmental pollution is to use living organisms as bioindicators. One of the bioindicators commonly used is insects. The existence of various types of disturbance in the environment that interact with insect habitat supports the notion that the insect community will be negatively affected by this disturbance. Information on environmental factors that affect insects can use as a step in overcoming environmental disturbances that occur. The study of the relationship between insect communities and environmental disturbances and habitat characteristics is important to do to find a potential insect that can use as an environmental bioindicator.

Insects are the dominant group of organisms. The presence of insects in a place can be an indicator of biodiversity, ecosystem health, and landscape degradation. The roles of insects in the ecosystem include pollinators, decomposers, predators, and parasitoids. Insects are the dominant group of organisms. The ecosystem is the unity of a community and its environment. In this ecosystem, there are relationships between vegetation, animals, and various forms of matter that cycle in the system. Ecosystems provide a lot of useful information for humans and need to be studied to apply it in environmental management. The ecosystem offers a lot of information, which is very useful for humans and needs to learn to apply it in environmental management. Urban ecosystems can experience disturbances along with disturbances to the environment [29]. Farmers use the amount of
agricultural input intensively in the hope of providing maximum yields. This cultivation method creates various problems that can reduce the quality and quantity of crop yields. Pests and diseases are one of the important problems for crop productivity, especially if cultivated in wetlands (rice fields). According to [30] grasshoppers are plant pests that often damage crops. The presence of grasshoppers is caused by the environment around the land which is overgrown with wild grass. Various types of grass are the main host of grasshoppers.

4. Conclusion
Observation of macrofauna populations in cowpea cultivation using light traps showed that at the beginning of the observation, the dominant insects were Lepidoptera and Coleoptera's order. However, the population decreased drastically in the third week until the end of October or early November. While in the observation using a pitfall trap, the dominant macrofauna was Hymenoptera and Orthoptera's order. Meanwhile, in the observation using swing nets, the dominant insect was from the order Hemiptera or group of ladybugs, which experienced a drastic decline in the fourth week. The diversity and evenness index value indicate middle diversity and very even categories, respectively.

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