Insect diversity on toxic candlenut (*Reutealis trisperma*) plantation in Bajawa, East Nusa Tenggara

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Abstract. Toxic candlenut (*Reutealis trisperma*) is an important plantation commodity that serves as barrier to prevent erosion, as main material for bio-pesticides and as renewable source of biofuel production. It has been studied that toxic candlenut development in post-mining field can restore soil structure while also influencing environment surrounding, including insects. The study examined insect diversity in the *R. trisperma* plantation aged ±7 years in Bajawa field, East Nusa Tenggara from July 2018 until February 2019. Insect were collected by installed malaise traps, yellow traps, and pitfall traps in 5 different plots A, B, C, D, and E for 24 hours. Collected insects were then identified in the laboratory using identification book. The results showed there were 13 orders of insects were collected by traps. The diversity index (H') of insect in the area were 4.053; 3.305; 3.521; 2.973 and 2.611 while the Evenness index (E) of insect were 0.872; 0.836; 0.780; 0.665 and 0.614 respectively. Insect diversity in the Bajawa plantation was high and the dominant individual was Hymenopteran and Dipteran. Several insects were in *R. trisperma* plant, as herbivores, predators, parasitoids, and pollinators. Further research is needed to determine each family of insect's role in the *R. trisperma* plantation.

1. Introduction
Toxic candlenut (*Reutealis trisperma*) is also known as Philippine Tung is a native plant of Philippine includes in the family Euphorbiaceae that distributed in countries Filipina, Malaysia, Indonesia, China, India, Cuba, and Dominica (Figure 1). The plant serves as an erosion barrier, oxygen supply, biofuel, and bio-insecticides. Certain studies stated that toxic candlenut has the potential as the main material to manufacture renewable biofuel to substitute fossil fuel. This potential has become a factor in developing this plant to reduce fossil fuel consumption. Toxic candlenut was developed in several region in Indonesia such as Garut and Majalengka (West Java), Central Java, East Java, Bajawa (Nusa Tenggara Timur), Nusa Tenggara Barat, Riau, Jambi, Bangka and East Kalimantan [1].

Toxic candlenut plantation has been grown in some areas in Indonesia. One of its locations is in Bajawa Subdistrict, Ngada District, East Nusa Tenggara Province. Insect activity as pollinators, parasitoids, predators (natural enemies), decomposers, and bio-indicators in the field has influenced the growth of toxic candlenut. The environment and vegetation developed in the area will influence insect diversity in one habitat. Plants provide flower nectar that improves insect vitality and fecundity. Insects in toxic candlenut plantations have an important role as pollinators, parasitoids, predators (natural enemies), decomposers, and bioindicators [2,3]. The presence of insects in an agricultural habitat is influenced by various factors, one of which is the influence of the environment and plant vegetation.
He further explained that the more diverse the plant vegetation in a habitat, the more diverse the diversity of insects. The insect has a segmented body that consisted of 3 segments were head (caput), shoulders (thorax), and stomach (abdomen) and also has three pairs of the leg. Insecta is one class of phylum arthropods that is important because of its benefits as a bio-indicator of ecological balance and health. The insect activity in nature has an impact on the surrounding environment. Insects in plantation areas are known to have roles as predators, parasitoids, decomposers, and pollinators. Meanwhile, insects are known to have many roles as parasitoids, pollinators, and decomposers. Insects are known to have a close association with the success of the pollination process of toxic candlenut plant. Therefore, it is important to study the insects' diversity on the toxic candlenut plant.

Some studies reported insect pests have an association with toxic candlenut. Bagworms and fire caterpillars [1] infest leaves. Mealy bugs infest stems, branches, stalks, shoots, flowers and fruit, while grasshoppers and mites infest leaves and shoots, mites also reported suck the sap of flowers and fruit and termites attack the stems and roots [2]. Insect diversity is one of the bio-indicators for ecosystem conditions and has also become a factor success of the toxic candlenut plant production. Therefore, the objective of this study was to assess the insect's diversity in plants toxic candlenut (R. trisprema).

2. Methodology

The research was conducted in the toxic candlenut plantation of Bajawa, Ngada, East Nusa Tenggara with the coordinate location at 8°35’26.6”S 121°06’56.7”E and altitude of 400-600 m above sea level. The dominant soil type was mollisol, which is dark soil, good structure, high base saturation. Toxic candlenut plants were ±7 years old and planted with a spacing of 5x5 m². The location of the field was bounded by the Flores Sea on the north, the Sawu Sea on the south, Nagekeo Regency on the east, and East Manggarai Regency on the west. Rainfall patterns in the observation area were influenced by monsoon La Nina and El Nino phenomena that are characterized by distinctive between the dry season and the rainy season. The identification of collected insect was carried out at the Integrated Laboratory of Indonesian Industrial and Beverage Crop Research Institute (IIBCRI). Insect collection from July 2018 to February 2019 consisted of 3 observation periods. Samples plots were 5 measurings 15x15 m² of each, namely plots A, B, C, D, and E. Each plot installed with 1 set of malaise traps, 1 set of yellow pan traps, and 2 sets of pitfall traps for 24 hours. The first and second periods of observations were a preliminary study of the research. The sample plots were determined by the purposive sampling method. Pitfall traps were used for trapping insects above the ground and malaise traps for trapping flying insects. Pitfall traps are glass-shaped traps with a diameter of 13 cm were immersed 10 cm deep in the soil until the surface of the glass is parallel to the ground [3], and filled with a soap solution (ratio of water and liquid soap 7:3). Insects that fall into the glass are filtered and put into a specimen bottle containing 70% alcohol and then labeled. Yellow Pan Trap (YPT) method was performed by using yellow container
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3. Result and discussion
3.1. Number and type of insect on toxic candlenut in Bajawa

The results showed that the number and types of insects caught in the toxic candlenut plantation area consisted of 13 orders with the number of insects found were 1609 individuals (Table 1, 2, 3). The insect collection was carried out for 2 times during 2018 and once in 2019. The first collection was an initial survey to find out the insects observed in the toxic candlenut plantation. The traps used in this period were insect nets and malaise trap. There were 7 insect orders collected and the dominant order was Lepidoptera, 15 individuals (Table 1). Order Lepidoptera is an insect whose consists of 4 stages, development process: egg, larva, pupa, and imago. The destructive stage of this order is the larval stage which can cause losses to most agricultural and plantation crops. However, at the imago stage, these

![Figure 2. Map of traps installation points for malaise trap, yellow trap and pitfall trap on the toxic candlenut plantation in Bajawa, East Nusa Tenggara](image)

Collected insects were then put into a specimen bottle and labelled. The specimen bottles are brought to the laboratory for identification based on their morphology to the morphospecies level.

The parameter for observation was
(1) Number of individual (N) and number of collected morphospecies (S);
(2) Evenness richness of insect index (E); Evenness indices were calculated using Ms. Excel with the formula of evenness richness index [4]. This index was calculated to study the evenness of each type in all observed community.

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

Notes: E = evenness richness index
$H'$ = diversity of insect
$\ln$ = logarithma natural
$S$ = number of morphospecies
Eveness richness has criteria $E > 1$: High level evenness, $E < 1$: low level evenness [4].
(3) Diversity index (H); The value of diversity index was calculated used Ms. Excel with formula according to [5] as follows:

$$H' = -\sum (Pi \cdot \ln Pi)$$

Notes: $H'$ = diversity index
$Pi = \frac{ni}{N}$
$ni$ = number of type at i
$N$ = Total number individual of all types
$\ln$ = Logarithm nature $S =$Number of taxa / species

Criteria: $H'< 1 = low diversity$
$1 < H' < 3 =$medium diversity
$H' > 3 = high diversity.$
insects suck the nectar of plant flowers so that they can act as plant pollinators. Several types of order Lepidoptera that act as pollinators are Erebidae, Hesperiidae, Lycaenidae, Pieridae, and Nymphalidae [7].

Pollinators are insects that transfer pollens because of their activity around the flower. They are important for agricultural cultivation because almost 90% of crops require insect pollinators in the pollination process. The orders of insects that play a role in the pollination process are Hymenoptera, Diptera, Lepidoptera, and Coleoptera [8, 9].

**Table 1.** Number and type of collected insect in Bajawa toxic candlenut on the first periods of observation at July-August 2018.

| Order      | Malaise Trap | Sweep net | Number of insect |
|------------|--------------|-----------|------------------|
| Coleoptera | 2            | 0         | 2                |
| Diptera    | 1            | 3         | 4                |
| Hemiptera  | 1            | 3         | 4                |
| Hymenoptera| 1            | 0         | 1                |
| Lepidoptera| 0            | 15        | 15               |
| Neuroptera | 1            | 0         | 1                |
| Orthoptera | 2            | 4         | 6                |
| Number of individual | 8 | 25 | 33 |

The observations on the second sample collections in toxic candlenut plantation in December 2018 showed that the least number of insects trapped was order Dermaptera and Neuroptera 1 individual, while the highest number was the order Diptera, 182 individuals (Table 2). Dermaptera and Neuroptera reported as a predator of the insect pest [10, 11]. *Labidura riparia* (Dermaptera: Labiduridae) is a generalist predator that suppresses the pest population in agricultural habitats. The further report mentioned that *Chrysoperla* spp (Neuroptera: Chrysopidae) is a predator of the Lepidopteran pest.

**Table 2.** Number and type of collected insect in toxic candlenut plantation at the second periods of observation.

| Order      | Plot 1 | Plot 2 | Plot 3 | Plot 4 | Plot 5 | Number of individual |
|------------|--------|--------|--------|--------|--------|---------------------|
| Blattodea  | 1      | 0      | 3      | 0      | 1      | 5                   |
| Coleoptera | 2      | 0      | 0      | 4      | 6      | 12                  |
| Dermaptera | 0      | 0      | 0      | 0      | 1      | 1                   |
| Diptera    | 39     | 78     | 14     | 21     | 30     | 182                 |
| Hemiptera  | 1      | 0      | 3      | 1      | 2      | 7                   |
| Hymenoptera| 8      | 26     | 4      | 10     | 2      | 50                  |
| Lepidoptera| 13     | 15     | 17     | 16     | 20     | 81                  |
| Neuroptera | 0      | 0      | 0      | 1      | 0      | 1                   |
| Orthoptera | 2      | 3      | 1      | 1      | 1      | 8                   |
| Number of individual | 66 | 123 | 42 | 55 | 63 | 349 |

Note: periods of observation is on December 2018.

The observation on February 2019 has collected 12 orders of insects and the highest individual number was from Hymenopteran 713 individuals (Table 3). Pollinators from order Hymenoptera and Lepidoptera were also collected in observation in toxic candlenut plantation.
Table 3. Number and type of collected insects in toxic candlenut on 3rd period of observation at February 2019 in Bajawa toxic candlenut plantation.

| Order          | Plot observation | Number of individual |
|----------------|------------------|----------------------|
|                | A    | B    | C    | D    |                   |
| Blattodea      | 0    | 0    | 1    | 0    | 0                 | 1 |
| Coleoptera     | 4    | 2    | 5    | 0    | 2                 | 8 |
| Collembola     | 29   | 19   | 13   | 5    | 27                | 172 |
| Dermaptera     | 3    | 0    | 2    | 2    | 0                 | 8 |
| Diptera        | 53   | 40   | 31   | 19   | 24                | 210 |
| Hemiptera      | 11   | 9    | 14   | 11   | 8                 | 69 |
| Hymenoptera    | 38   | 49   | 94   | 29   | 18                | 713 |
| Isoptera       | 1    | 0    | 0    | 0    | 0                 | 1 |
| Lepidoptera    | 3    | 4    | 8    | 2    | 1                 | 22 |
| Mantodea       | 0    | 0    | 0    | 0    | 1                 | 1 |
| Orthoptera     | 16   | 10   | 5    | 0    | 1                 | 42 |
| Psocoptera     | 0    | 2    | 0    | 0    | 0                 | 2 |
| **X**          | 3    | 0    | 2    | 1    | 0                 | 9 |

3.2. Insect diversity and evenness in toxic candlenut plantation

Based on number of morphospecies, result of insect diversity and evenness index in toxic candlenut plantation was calculated. Result of H’ and E index of plots A, B, C, D and E is presented in Table 4.

Table 4. Number of morphospecies, number of individual, diversity index, evenness indices of insect in toxic candlenut in Bajawa, East Nusa Tenggara in 5 different plots.

| Plots | Number of morphospecies (S) | Number of individual (N) | Diversity index (H) | Evenness Index (E) |
|-------|-----------------------------|--------------------------|---------------------|--------------------|
| A     | 104                         | 296                      | 4.053               | 0.872              |
| B     | 52                          | 135                      | 3.305               | 0.836              |
| C     | 91                          | 301                      | 3.521               | 0.780              |
| D     | 87                          | 509                      | 2.973               | 0.665              |
| E     | 70                          | 445                      | 2.611               | 0.614              |

The result presented in Table 4 showed that the insect diversity index of 5 plots in toxic candlenut in Bajawa, East Nusa Tenggara were ranged from 2.6-4. According to the criteria of the diversity index, this value showed that insect diversity in toxic candlenut was considered medium to high. Toxic candlenut's plantation in Bajawa was aged 7 years and planted on the post-mining field. The high insect diversity was in line with the study of Buchori et al [12] stated insect diversity tended to increase with increasing reclamation age. The toxic candlenut provides the food resources for an insect which caused the insect population to grow in the area. The insect evenness index of 5 plots in toxic candlenut in Bajawa was 0.872; 0.836; 0.780; 0.665 and 0.614. The less than 1 value showed that among the insect collected by the traps, there are one or two dominant species in the area, that was order Hymenoptera, and Diptera. The traps used in this research influenced the high abundance of Hymenoptera and Diptera in one agricultural habitat. Malaise trap and yellow pan trap is the trap for collecting flying insects specifically from order Hymenoptera and Diptera [13,14].
3.3. The insect role in toxic candlenut plantation

Toxic candlenut is an annual plant that is widely cultivated and used as body cell material. Morphologically, toxic candlenut is a dicotyledonous plant, class Magnoliopsida, order Euphorbiales, family Euphorbiaceae, genus Reutealis [15]. Apart from its benefits as main material of biofuel production, the toxic candlenut plant was used to control insect pest populations. Soesanthy's [16] research stated that the toxic candlenut oil was able to reduce the cocoa pod borer (CPB), Conopomorpha cramerella Snellen (Lepidoptera: Gracillariidae) population in cocoa plants. The toxic candlenut plant acts as an insect repellent because it has an odor that insects do not like (repellent).

As an annual plant, the toxic candlenut plant also interacts with insects in its life cycle. Each insect has a role in the growth and development of the toxic candlenut plant. Insects are known to have an important role in nature, namely as pollinators, natural enemies, and decomposers. Some of the insects found to have a specific role are as follows:

a. Herbivores. Herbivores insect is an insect that consumed part of the plant such as leaves and the flower of toxic candlenut seeds. According to the result of research in India, younger plants are more vulnerable to herbivores' attacks. Some of the herbivores in the young plant were fire caterpillar, thrips, mealybugs, leaf miner, stem and fruit borer, bagworm, and grasshopper [17].

b. Pollinators. Insect pollinators have an important role in the cultivation of agricultural crops because they can increase the yield quantity and quality. The assistance of pollinating insects on plants can increase yields and can increase the weight and size of the fruit circumference produced. Reports said that pollinating insects come from the orders Hymenoptera, Lepidoptera, Coleoptera, and Diptera. Pollinating insects or pollinators are insects that play an important role in the life cycle of toxic candlenut because the structure of the toxic candlenut flower is separate from male flowers and female flowers. Although there are also hermaphrodite flowers, the presence of wind and pollinator insects will determine the success of the fruit. Some of the pollinator insects found were from the orders Diptera and Hymenoptera.

Tropical trees are mostly pollinated by insects. Therefore, it is essential to know the phenology of the trees and their pollinators [18]. Pollinators and host trees might be very specific and synchronized, or there might be a variety of pollinators visiting a variety of plants over long periods of time. This is because pollinators may rely on other plant species as nesting sites and for food at other times of the year [19].

Flower-visitor insects are insects that come in the flower section because of the attractiveness of the flower, such as the shape of the flower, the color of the flower, pollen, nectar, and aroma[10]. The diversity of insects in flowers is influenced by several factors, namely primary factors (flower shape, flower color, pollen, and nectar), secondary pull factors (flavor), and environmental factors [10], such as environmental temperature and humidity, light intensity and speed wind is a number of environmental factors that influence the diversity of insect flower visitors [11].

Figure 3. A. Augochlora sp/Agapostemon sp. B. Ceratina sp. C. Ceratina binghami.

Augochlora sp. is an insect found in toxic candlenut plantation, A. pura was found in St. Catharines, Ontario, Canada [20]. Ceratina sp. was known as wild bees from order Hymenoptera family Apidae is
pollinators that found in agricultural land near the slope of Slamet Mountain, Central Java [21], in watermelon [13], strawberry [14], pomelo [10]. The research stated there were 3 species of Ceratina sp. in St. Catharines, Ontario Canada were Ceratina dupla, C. mikmaqi, and C. calcarata [22].

3.4. Natural enemy
Natural enemies of insects include predators and parasitic wasps are generally present in the ecosystem where preys exist. Some predators that known to be associated with toxic candlenut was from order Coleoptera (Coccinellidae), Hymenoptera (Formicidae), Mantodea (Mantidae), Neuroptera, and parasitoids were from order Hymenoptera (Scelionidae, Cinypidae, Diapriidae, Braconidae, Ichneumonidae, Evaniidae, Chalcidoidea, Buthrylidae dan Encyrtidae) and Diptera. Besides the prey, another factor that influences the population of the natural enemy is the suitable habitat. The results of research in East Kalimantan stated that the proportion of flowering herbs plays a role in affecting diversity of Hymenopteran parasitoid [23].

4. Conclusion
There are several types of insects that play a role in the toxic candlenut plantation, namely herbivores, predators, parasitoids, and pollinators. On land planted with toxic candlenut, 13 orders of insects were found. The orders with the most individuals found are Hymenoptera and Diptera. The diversity of insects in the toxic candlenut plantation is relatively high, this is indicated by the diversity index value (H') of blocks A, B, C, D, E respectively 4.053; 3.305; 3.521; 2.973 and 2.611 while the evenness indices of 5 plots were 0.872; 0.836; 0.780; 0.665 and 0.614.

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