*J Sust Dryland Agric Syst, 1(2), 78-89 (Des 2021) – e-ISSN: 2807-1727*
*Journal website:* https://jurnalpasca.unram.ac.id/index.php/josdas
*Article DOI:* https://dx.doi.org/10.29303/josdas.v1i2.441

# The Presence of predators of whitefly (*Bemisia tabaci*) on curly red chili (*Capsicum annum* L.) plantation with refugia

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**Article Info:**
First submitted:
April 17, 2023
Revised:
April 24, 2023
Accepted:
April 25, 2023
Published online:
April 25, 2023

Keywords:
Curly red chili
*Bemisia tabaci*
Refugia
Predator

**Abstract.** Curly red chili is one of the leading and strategic horticultural commodities, but it cannot be separated from attacks by various pests, one of which is the whitefly *Bemisia tabaci* Genn (Homoptera: Aleyrodidae). Utilization of refugia plants is a compatible control alternative, because it can encourage the conservation of natural enemies such as predators. This study aims to determine the effect of several types of refugia plants on the presence of Arthropod predators of whitefly pests on curly chili (*Capsicum annum* L.). The treatments in this study were sunflower plants (Helianthus annuus L), marigold flower plants (*Tagetes erecta*), paper flower plants (*Zinnia elegans* Jacq) and controls (without refugia). The design used was a randomized block design. Sampling of predatory arthropods was carried out using yellow pan traps which were set in the morning and left for 24 hours. The caught predators were identified at the Laboratory of Plant Protection, Faculty of Agriculture, University of Mataram. The observed variables included the type and characteristics of the predatory whitefly arthropods found, and the population of predators. Data were analyzed using analysis of variance (ANOVA). The results showed that the number of predator species on curly chili plants with refugia was higher (8 species) than on control plants (7 species). Planting refugia in curly chili plantation significantly increased the population of predatory arthropods but the refugia species between sunflower, marigold and zinnia plants did not show any differences in predatory arthropod populations on red chili plants.

**Cite as:** Thei, R.S. (2021). The Presence of predators of whitefly (*Bemisia tabaci*) on curly red chili (*Capsicum annum* L.) plantation with refugia. *Journal of Sustainable Dryland Agricultural Systems*, 1(2): 78-89. DOI: https://dx.doi.org/10.29303/josdas.v1i2.441

## 1. INTRODUCTION

Curly red chilies are one of the leading horticultural commodities, are strategic and important in food consumption patterns, namely as vegetables or cooking spices, and have broad market opportunities to meet the very large demand for household consumption and domestic industry, with a volume of up to 900 tons/year. The demand for this chili has not been fulfilled from domestic production, which only reaches 76% so that Indonesia still imports chili from Malaysia and Australia (Subagyono, 2010; Andayani, 2018).

Chili plants are related to the organisms around them either directly or indirectly. One group of organisms that interact with chili plants is a group of arthropods which can act as plant-damaging pests, predators, parasitoids, pollinators and as decomposers of organic matter. Obstacles that are often faced in increasing the production of chili plants are pests and diseases. Pests are plant-disturbing organisms that cause losses to farmers (Septariani *et al*., 2019). According to Setiawati *et al*. (2005), the main pests of chili plants include: Spodoptera sp, aphids, and thrips. In addition, many diseases caused by viruses have been reported, one of which is the Gemini virus which is mediated by whitefly pests (Nooraidawati et al., 2001).

The whitefly Bemisia tabaci (Hemiptera: Aleyrodidae) is an important pest of red chili because it attacks it by sucking the liquid from leaves, shoots, flower stalks or other plant parts. Heavy attacks cause the leaves to curl, curl, have yellowish mottles (chlorosis) and eventually fall off resulting in decreased chili production. Bemisia tabaci is the only carrier of the Gemini virus (yellow virus). Symptoms of the curly yellow virus caused by the Gemini virus are now epidemic in various regions in Indonesia, such as West Java, Central Java, DI Yogyakarta, North Sumatra and Lampung, with an attack intensity of between 20 and 100% (Udiarto, 2012).

Whitefly attacks cause direct and indirect damage. Direct damage as a result of feeding activity, namely (1) closing of stomata by honeydew released by nymphs, and sooty dew that grows on the honeydew layer, such as *Cladosporium spp* and *Alternaria spp*, (2) formation of chlorotic spots on leaves as a result of damage some tissues due to stylet puncture, (3) formation of anthocyanin pigments, and (4) leaves fall and can inhibit plant growth (Setiawati *et al*., 2008). Hoddle (2003) (in Setiawati *et al*., 2007) states that indirectly, Bemisia tabaci is a yellow virus vector. The damage due to the yellow virus attack was heavy with high economic losses.

Whitefly Pest (*Bemisia tabaci* Genn.) from the Order Hemiptera, Family Aleyrodidae, Bemisia genus, Tabaci species, is a highly polyphagous leaf-sucking pest that attacks various types of plants, including ornamental plants, vegetables, fruits and wild plants. Plants that are the main hosts for whitefly are recorded around 67 families consisting of 600 plant species (Supiana, Murtini, 2015). There are 49 types of plants that become new hosts for whitefly pests, including oats (Avena sativa), wheat (*Triticum aesticum*) and millet (*Panicum miliaceum*) (Simmons et al., 2008).

Efforts to control *Bemisia tabaci* that are commonly carried out by farmers so far are the intensive use of synthetic chemical insecticides. Excessive use of pesticides has an impact on changes in the agricultural ecosystem and has a direct impact on arthropods which consist of natural enemies and neutral arthropods which are important as ecosystem balancers. The excessive use of insecticides has a very direct detrimental impact on the biodiversity of predatory and parasitic arthropods, causing resistance and resurgence of pests, and even harming other arthropods that have important ecological functions such as pollinators and detriphores that also become extinct. The same thing was stated by Asih (2019), that the use of very strong and broad-spectrum pesticides which was carried out extensively and excessively had a detrimental effect.

The excessive use of synthetic chemical insecticides, apart from being a waste, can also harm humans and cause various losses to the environment, including the killing of non-target organisms such as predators and parasitoids, and the occurrence of pest resistance to insecticides. Sugiyama and Setiawati et al. (2007) in Hendrival (2011), reported that *Bemisia tabaci* has started to show symptoms of resistance to several types of synthetic chemical insecticides such as organophosphate, carbamate and synthetic pyrethroid groups. For this reason, control efforts are needed that are more based on ecological and economic approaches, namely not polluting the environment, safe for red chili users and consumers, relatively inexpensive, but also effective in controlling *Bemisia tabaci* pests.

One control concept that is more based on an economic and ecological approach is integrated pest management (IPM), which aims at assembling bio-intensive technologies, seeking to utilize existing biological resources in nature, such as natural enemies, resistant varieties, and plant pesticides. Utilization of refugia plants is a compatible control alternative, because it can encourage the conservation of natural enemies such as predators. Refugia is a microhabitat that provides space and time protection for natural enemies and supports components of biotic interactions in ecosystems, such as pollinators or pollinating insects (Purba, 2019). It was further reported that planting Axonopus compressus refugia around upland rice plants can attract natural enemies such as Coccinellidae beetles and spiders and reduce insect pest populations.

The benefits of refugia as a conservation area for natural enemies around plantations are as pest trapping plants, pest repellent plants, shelter, attracting natural enemies to live and breed in the area because they provide a source of nutrients and energy such as nectar, powdered honey and honey dew needed by the natural enemies so that the presence of natural enemies can balance the pest population at a non-detrimental limit (Landis et al., 2000). Types of plants that can be used as refugia include flowering plants, broadleaf weeds, wild plants that are planted or grow alone in the planting area, and vegetables (Ehlmann et al., 2016), usually from the families Umbelliferae, Leguminosae, and Compositae or Asteraceae. The mechanism of insect attraction by flowering plants is determined by the morphological and physiological characters of flowers in the form of color, shape, size, fragrance, flowering period and nectar content. Most insects are attracted to flowers that are small, tend to open and have a long flowering period (Nicholls & Altieri, 2007).

According to Altieri et al. (2007) in Kurniawati (2015) flowering plants attract insects using morphological and physiological characters. Thus the planting of these flowering plant species can attract the arrival of natural enemies such as predators and parasitoids (Alfilah et al., 2013). Utilization of refugia plants through ecological engineering is part of integrated pest control (IPM) technology which aims to achieve a biological balance of pests and natural enemies so that they are located at the bottom of the economic threshold and also increase the diversity of natural enemies so as to reduce pest attacks on red chili plants. Planting these types of flowering plants can attract the arrival of natural enemies such as predators and parasitoids. The predator group for *Bemisia tabac*i includes the families Coccinelidae, Staphylinidae, Chrysopidae, Cecidomyiidae, Dolichpodidae, Syrphidae, Anthocoridae, Miridae, Nabidae, Phytoseiidae, and Araneae (Gerling et al., 2001 in Hendrival et al., 2011). Based on the description above, a study has been carried out which aims to determine the effect of several types of refugia plants on the presence of Arthropod predators of whitefly pests on curly chili (*Capsicum annum* L.).

## 2. MATERIALS AND METHOD

This research was conducted from November 2018 to March 2019 in Rembiga Village, Mataram City, West Nusa Tenggara, using a Randomized Block Design (RBD) consisting of 4 treatments, each of which was repeated 3 times to obtain 12 experimental units. The treatments tested were:

Control (without refugia), Sunflower plants, Marigold Flower plants and Zinnia Flower plants. The experimental land was cleared of weeds and dirt using a sickle and then the soil was loosened and leveled using a hoe. After leveling, 20 beds were made, each measuring 1 x 3 m with a distance of 30 cm between the beds. After the soil was processed and the beds were made, then the mulch was installed.

Seeds of sunflower, zennia, and merigold were first sown in a planting medium made from roasted husks and compost filled into a 4.5 ml ice plastic bag. Before the chili seeds were sown, soaking was done first with the aim of cutting the seed dormancy period. Chili seeds that have been selected and considered good are first sown into small plastic bags. Each plastic was filled with one seed with a planting hole depth of ± 0.5-1 cm, then the hole is covered with thin soil. Seedlings can be transferred to the field after 5-6 leaves and 18-25 days old.

Refugia plants that have been sown and seedlings aged of 18-21 days after sowing (DAS) were then transplanted with a spacing of 50x50 cm. For chili plants, transplanting seedlings in the field was done after the seedlings are 18-25 days old (having 5-6 leaves). The chili seedlings that were planted were only good seedlings, namely the growth was upright, the color of the leaves was green, not disabled or affected by pests or diseases. Transplanting was done in the afternoon so that the sun's heat does not wilt and to reduce plant stress. Chili seedlings were transplanted into the planting hole with a depth of about 3 cm, with a spacing of 35x35 cm.

Plant maintenance includes fertilizing, replanting, weeding, stake installation and irrigation. Basic fertilizer wasgiven in the nursery before the curly chili seedlings are planted in the beds, using NPK fertilizer at a dose of 3 kg/are. Stitching is done on plants that do not grow well or plants that die, which is done after the plants are 14 HST. The seeds used for replanting are reserve seeds that have been prepared together with production seeds. Stitching is done by removing plants that don't grow and replacing them with new plants in the same planting hole. Weeding is done twice manually, namely removing weeds directly by hand. Giving stakes to chili plants was done when the plants are 14-21 HST. Watering the chili plants at the beginning of transplanting is done by watering the plants 2 times a day, namely in the morning and in the evening, until the chili plants show normal growth in the field. Chili fruit harvest is done after 80% fruit is red. Harvest time varies depending on the altitude. For the lowlands, harvesting begins after the plants are 70 HST. For the highlands, the harvest can start at 100-200 HST. Harvesting is done at intervals of 5 days depending on market conditions and planting.

The yellow pan trap is used to trap insects that have wings and actively fly in the air and insects that are attracted to the color yellow. The yellow pan trap is a quick and easy way to catch insects. The yellow pan trap used is a yellow round tray. Placement of the yellow pan trap is placed 3 yellow pans in one bed. Observation of trapped insects was carried out by observing which predators were caught in the yellow pot traps. These traps were set in the morning and left for 24 hours. The caught predators will be collected and put into bottles filled with 70% alcohol for later identification. Identification of predators of whitefly pests was carried out using a binocular microscope with reference to the insect determination key and other literature references, to determine the family and genus because in this study the species diversity referred to was only up to the genus level. Identification of predators of whitefly pests is carried out by observing adult sample insects. Identification of specimens was done using morphological characteristics of wings, antennae and thorax.

The parameters observed in this study were the characteristics of whitefly predators, and the population of whitefly predators. Observational data were analyzed by analysis of variance

(ANOVA) at the 5% level of significance and the results of the analysis which were significantly different (significant) were tested by Honest Significant Difference (Tukey's HSD) at the 5% level.

## 3. RESULTS AND DISCUSSION

### *3.1. Types of whitefly pest predators*

Whitefly pest predators (*Bemisia tabaci*) obtained during the study there were 2 classes, namely the insect class (Insecta) and the spider class (Arachnida). The predators from the class of insects obtained are from the order Coleoptera; the Coccinilidae family consists of 5 species, namely *Cheilomenes sexmaculatus*, *Coleophora reniplagiata, Verania lineata, Coccinella transversalis*, and *Coelophora inaequalis*, while the predators of the Arachinida class found in the experimental field came from the order Araneae as many as 3 species from 2 families, namely the family Oxyodidae (*Oxyopes macilentus* and *Oxyopes javanus* ) and from the family Lycosidae (*Pardosa sp*.). Research conducted by Lisdayani *et al*. (2022) found 4 species of predatory insects on red chili plants.

Overall, 8 species of predatory arthropods were collected, all of which were *Bemisia tabaci* predators. The Coccinilidae family is known to be a predator of various types of insect pests including the *Bemisia tabaci* pest. Gerling *et al*. (2001) stated that (Coccinelidae) predators are oligophagous predators, which prey on the nymphs of *Bemisia tabaci* on cotton and citrus trees. According to Cock (1993) in Gerling *et al*. (2001), the beetle *Chilomenes sexmaculatus* (Coccinelidae) is a whitefly predator. This insect is capable of preying on 200-400 whitefly nymphs. The majority of coccinellid species (about 90%) are beneficial predators (others are phytophagous or mycophagous); accordingly coccinellids have played a significant role in the development of biological control strategies (Brown and Miller, 1998; Berthiaume *et al*., 2007).

The predators *Chilomenes sexmaculatus* and *Verania lineata* were more effective to control *M. persicae* than *B. tabaci*. *M. sexmaculatus* was the effective predator to control adult M. persicae (Hidayat & Putirama, 2021). In contrast, Spider predators are generalist predators, preying on many types of pests. Oxyopes and Pardosa spiders are hunter spiders that actively search for prey both on the ground and in the plant canopy. Sharp-eyed spiders (Oxyopes) are active spiders that hunt their prey. Every day this spider can eat 8 whiteflies (Puslittan, 2007). Other types of prey are rice leafhoppers, rice flies, and false white bugs.

### *3.2. Characteristics of Coccinelidae at the study site*

Koksi beetles are identified by imago which are very brightly colored (almost all have spots with a certain shape and number of eel), convex bodies, and short clubbed antennae. Identification results in the laboratory show that the distinctive features of the species *Cheilomenes sexmaculatus* (Figure 1), namely body color varies from red to yellow (d), but is usually yellow, body length 3-3.5 mm. The head is hidden under the pronotum. The pronotum is dark yellow with two black bands transverse laterally (c). Elytra are yellow (d), median band is black (b). The posterior border of the pronotum is convex, the small scutellum is black (Amir, 2002).

Characteristics of the species Coleophora reniplagiata (Figure 2), which has an almost round body, medium size with a length ranging from 3.5 to 4.5 mm. The head and pronotum are black. The surface of the pronotum is smooth, the left and right sides of the pronotum are yellow. Posterior pronotum convex (b), elytra surface smooth.

Characteristics of *Verania lineata* (Figure 3), namely the body is dark brown, the body is oval in shape, the body length is 4-5 mm. The pronotum is rather large, yellow-brown (a), has one pair of broad bands that extend laterally (c). The two black dots and widened bands touch each other. The posterior border of the pronotum is convex (b). The scutellum is black, the elytra are smooth, convex, yellow-brown (d), and there are very fine small holes. The elytra are brownish yellow (d). On the front of the elytra there are four spots, two large curved rectangular spots in the middle.

Based on observations, the characteristic feature of *Coccinella transversalis* (Figure 4) is a body length of about 5 mm. The body is reddish yellow (c). Black pronotum (a) with yellow front corners, posterior pronotum convex (b). The small scutellum is black. The posterior border of the pronotum is convex. The surface of the elytra is smooth and there are very fine small holes, the elytra are yellow brown (c), on the right and left elytra there are two pairs of large black bands (d) and a black median line, on the front and back of the median line there is one rather large black dots.

The characteristics of the species *Coelophora inaequalis* (Figure 5), based on observations, are 4 mm body length. The ventral body is brownish yellow. The small head is hidden under the pronotum (a). The surface of the pronotum is smooth, the color of the pronotum is brownish yellow but younger than the elytra, the posterior border of the pronotum is convex (b). The surface of the elytra is smooth and there are very fine small holes, the color of the elytra is brownish yellow (d), and there are four black spots on each elytra (c), near the posterior end of the elytra there is a black pattern which if the elytra closes the black pattern like black spot. Abdomen is under the elytra (e).

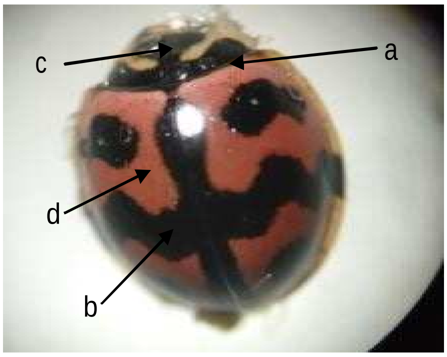


Figure 1. Species *Cheilomenes sexmaculatus* (a. posterior border of the pronotum; b. large band on the elytra; c. pronotum; d. posterior elitera) (Picture was taken from Personal collection)

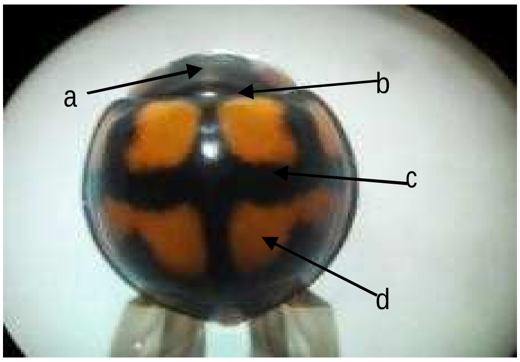


Figure 2. The species of *Coleophora reniplagiata* (a. Pronotum; b. Posterior border of the pronotum; c. Large band on the elytra; d. Posterior elytra) (Picture was taken from Personal collection)

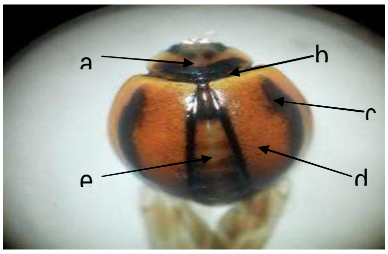


Figure 3. Species *Verania lineata* (a. Pronotum, b. posterior border of the pronotum, c. Large band on the elytra, d. Posterior e. abdomen) (Picture was taken from Personal collection)

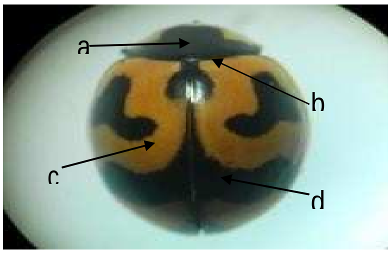


Figure 4. Species of Coccinella transversalis (a. Pronotum, b. Posterior border of the pronotum, c. Posterior elitra, d. Large bands on the elite) (Picture was taken from Personal collection)

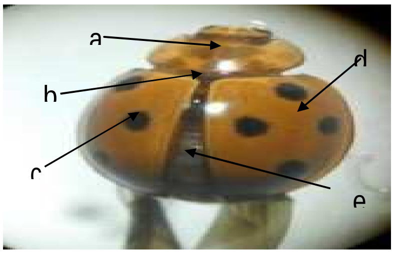


Figure 5. Species Coelophora inaequalis (a. Pronotum, b. Posterior border of the pronotum, c. Large band on the elitra, d. Posterior elitra, e. Abdomen) (Picture was taken from Personal collection)

*3.3. Characteristics of Spiders Collected at Experimental Sites*

The Arachnida class obtained at the experimental site was from the order Araneae, Family Oxyopidae with 2 species namely *Oxyopes macilentus* and *Oxyopes javanus* and family Lycosidae with 1 species namely *Pardosa sp*.

Based on observations in the laboratory, the characteristics of the Oxyopes macilentus species (Figure 6), namely having a long and thin or slender body, brownish yellow body color (d) and a body length of about 10 mm, has 8 limbs and has a single eye (b) ) with a lens, has no antenna but has a support, there is a cephalothorax (c) which is a combination of the head and chest and has an abdomen.

Based on observations in the laboratory, the characteristics of the *Oxyopes javanus* species (Figure 7), namely having a long and thin or slender body, greenish-yellow body color (d) and a body length of about 7-10 mm, has 8 legs and has a single eye ( b) with a lens, has no antenna but has a support, there is a cephalothorax (c) which is a combination of the head and chest and has an abdomen.

Based on the observations of the characteristics of the *Pardosa sp*. (Figure 8), which has a cephalothorax (b) and has a white line or spot on the abdomen (c). It has a body length of 9.95 mm, the cephalothorax is gray-brown to dark gray except for the eye area, in the middle there is a fork and ribbon shape (b).

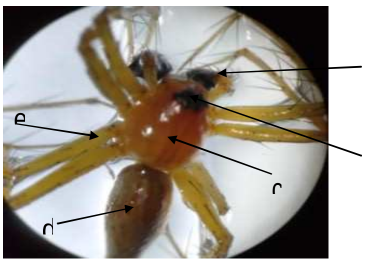

Figure 6. Species of Oxyopes macilentus (a. Ceilecerae b. eyes c. Chepalothorax d. Abdomen e. Limbs) (Picture was taken from Personal collection)

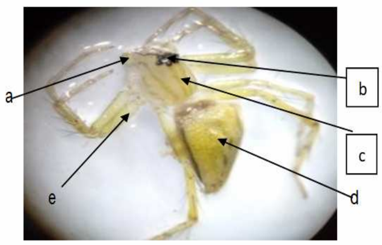


Figure 7. *Oxyopes javanus* species (a. Ceilecerae, b. eyes, c. Chepalothorax, d. Abdomen, e. Limbs) (Picture was taken from Personal collection)


Figure 8. Species *Pardosa sp*. (a. Ceilecerae b. Chepalothoraxc. Abdomen d. Limbs e. eyes) (Picture was taken from Personal collection)

*3.4. Characteristics of Spiders Collected at Experimental Sites*

In chili plants without refugia, *Verania lineata* was not found at all, only one individual was *Coleophora reniplagiata, while Coelophora inaequalis* and *Coccinella transversalis* were found 2 individuals respectively during the observation period. In the chili plants planted with refugia, eight species of predators were collected. The results of the analysis of variance showed that planting refugia had a significant effect (P=0.009) on predator populations in chili plants (Table 1).

The average population of Coccinilidae in chili fields surrounded by refugia plants, namely Zinnia, Marigold (*Tagetes erecta*) and Helianthus was much higher than chili fields that were not planted with refugia, but the type of refugia plant had no effect on the population of predatory insects in the Coccinilidae family on chili plants. Wardana *et al*. (2017) stated that marigold flowers are indeed suitable as refugia plants because the flower colors are very striking and have a pungent scent, so they can attract pests and natural enemies. In rice plants, marigolds have been shown to be able to reduce attack intensity and populations of brown planthopper pests. Another study (Lestari, 2018 in

Kurniati 2021), also showed the ability of marigold plants to suppress the intensity of onion caterpillar pest attacks (*Spodoptera exygua* Hubner). Treatment of refugia with flowering plants on each side of the chili land can attract beneficial insects to the field, and planting refugia on cultivated land can disturb insect pests in finding their hosts (Haryadi *et al.*, 2022). According to Retno (2014), the addition of flowering plants planted on the edge of chili plantations in the refugia treatment could affect *B. tabaci* pests in finding their hosts, which ultimately led to lower populations and intensity of B. tabaci attacks on plantations added to refugia plants when compared to with conventional treatment.

Tabel 1. The average population of Coccinelidae on chili plants with refugia treatment

| Treatment (refugia) | Predatory insect populations |
|---|---|
| *Zinnia elegans* Jacq | 13.00 a |
| *Tagetes erecta* | 12.66 a |
| *Helianthus annuus* L | 10.30 a |
| Control | 3.00 b |
| **HSD 5%** | 4.04 |

In relation to spiders, the results of the analysis of variance showed that the refugia treatment had a significant effect (P=0.016) on the spider population (Table 2). Refugia is a type of plant that can increase the presence of natural enemies such as Coccinilidae predators and spiders, because refugia can provide for the needs of natural enemies to grow and develop. This is in accordance with the statement of Wardani et al. (2013) that refugia is a way to increase the existence of natural enemies because it can provide habitat and food sources for their survival. Sunflower, merigold, and zenia are several types of refugia plants which are used as treatments whose effect is not significantly different on the population of Arthropod predators of whitefly pests, namely Coccinelidae and Spiders. These three types of flowers come from the Asteraceae family which are highly favored by natural enemies as their habitat. This is because these flowers have a bright color, smell good, the flowers tend to open, have a long flowering period, and have nectar and pollen which are favored by natural enemies. Altieri *et al*. (2007) stated that flowering plants can attract natural enemies because of the morphological and physiological characteristics of flowers, namely size, shape, color, fragrance, flowering period, and nectar and pollen content. Most of the natural enemies like flowers that are small, tend to open, with a long flowering period, which are generally found in flowers from the Compositae or Asteraceae families. The existence of flowering plants of the refugia type is very important for preserving natural enemy populations in an agroecosystem (Sakir and Desinta, 2018).

Table 2. Average population of Aranae on chili plants treated with refugia

| Treatment(refugia) | Population of Aranae |
|---|---|
| *Zinnia elegans* Jacq | 10.66 a |
| *Tagetes erecta* | 8.33 a |
| *Helianthus annuus* L | 8.00 a |
| Control | 4.00 b |
| **HSD 5%** | 2,60 |

The predatory insect that appears most often at every observation is *Cheilomenes sexmaculatus*, so it is suspected that *Cheilomenes sexmaculatus* is very active in searching for food compared to other species. *Cheilomenes sexmacultus* is also a predator that has a very wide range of prey. At the time this experiment was carried out, there were other food crops around the experimental area such as rice, corn, mustard greens, eggplant, tomatoes and others which were hosts for aphis aphids, mites and mealybugs. All of these pests are the prey of Cheilomenes sexmaculatus. Omkar et al. (2006) stated that *Cheilomenes sexmacultus* is a very potential predator, and has a very wide range of prey such as the families Aphididae, Diaspidae, Psillodidae, Aleyrodidae, and Coccidae.

There are 39 species of arthropods that can be preyed on by *Cheilomenes sexmaculatus* (Gautam, 1989). *Cheilomenes sexmacuulatus* has a unique preying behavior because the beetle attacks day and night (Saleem et al., 2014). Cheilomenes sexmaculatus also has a higher ability to search for prey, in sync with the presence of its prey and is able to survive with a limited number of prey. This is in accordance with the opinion of Rai et al. (2003) that Cheilomenes sexmaculatus has a high reproductive capacity and a long life cycle. The preying ability of predatory beetles (*Cheilomenes sexmaculatus*) can reach 200-400 *B. tabaci* nymphs with a predatory life cycle of 18-24 days, and one female can produce 3000 eggs (Nurtjahyani and Murtini, 2015).

In addition, there were other species that appeared at one observation site, including *Coleophora reniplagiata, Verania lineata, Coccinella transversalis*, and *Coleophora inaequalis* but the appearance of these 4 species was not like *Cheilomenes sexmaculatus. Coleophora reniplagiata* appeared only at the 8th to 11th week of observation after planting. There were also species that were present from the first observation, which was 6 weeks after planting until the observation was complete, but the population was small. This is presumably due to the lack of availability of various types of alternative prey and feed for these species, in accordance with Elisabeth's statement that the abundance of insects in a habitat is determined by the diversity and abundance of feed and other resources available in that habitat.

Spiders play an important role in maintaining agricultural ecosystems so that pest population explosions do not occur. Pardosa spider sp. the highest population compared to other species, presumably because *Pardosa sp* is very dominant in the soil and in dry areas and lots of light. The abundance of predatory arthropods such as spiders is due to the presence of phytophagous insects and pollinators in an ecosystem (Herlinda et al., 2004). The presence of spiders will be high if the availability of prey is also high (Linda and Fujisaki, 2007). Pardosa sp is a prey hunter spider that is very active in moving from one place to another and can survive on new land in a very short time. The population development of Pardosa sp was very clear from the observations made every week, but the population decreased when the plants were 9-12 weeks after planting. This is due to abiotic factors, namely rainfall that is too high, the average rainfall at the study site reaches 203.75 mm/month. This is in accordance with the statement of Tumbull (1973) in Kasibun et al. (2017) that rainfall that is too high can reduce the activity of spiders. As is the case with other living things, the life of spiders is influenced by abiotic factors such as temperature, humidity, wind and light intensity and biotic factors such as food supply.

Compared to *Pardosa sp*, spiders of the type *Oxyopes macilentus* and *Oxyopes javanus* have fewer populations, presumably because these two species live in the crowns of plants and plant leaves and tend to be few on the soil surface. O. javanus was able to prey on imago *Etiella zinckenella, Helicoverpa armigera, Spodoptera litura*, and 2nd instar nymphs sucking soybean pods (Riptortus annulicornis, *Nezara viridula*, and *Piezodorus hybneri*). Population abundance of O. javanus in nature is influenced by cultivation systems, including insecticide applications.

The Coccinilidae and Spider populations fluctuated during the observations in this experiment (Figure 9). The predatory arthropod population increased from the 6th week after planting and reached its maximum population on the 8th week of 27 Coccinilidae individuals and 20 spider individuals. This is because at 6-8 weeks the refugia flowers were still fresh and there were still many whitefly nymphs which were the prey of these predators in chili cultivation. In the 9th to 12th weeks the Coccinilidae and Spider populations continued to decrease. At this time there was very high rainfall at the study site, reaching an average of 203.75 mm/month. The use of herbicides and insecticides around chili fields is also a factor that affects the Coccinilidae and Spider populations. It is known that the use of chemical pesticides can kill non-target insects such as natural enemies of plant-damaging pests. This is in accordance with the statement of Sulistiyono (2002), that the use of insecticides that are not in accordance with the dosage can increase the level of pest resistance and on the other hand can destroy various animal and insect predators.

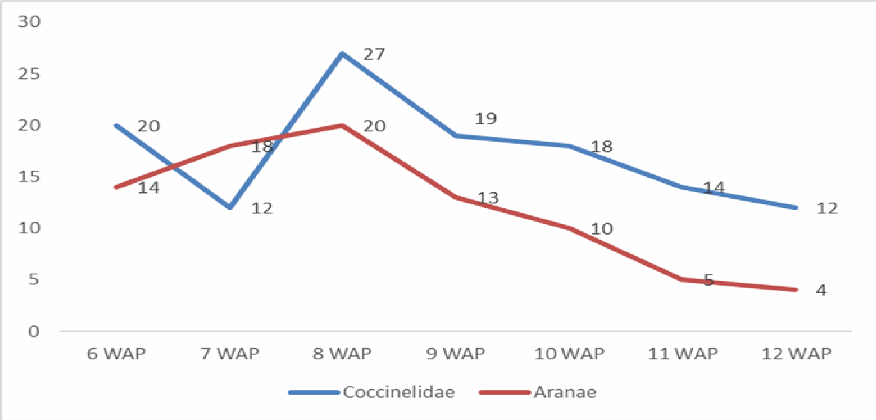


Figure 9. Population of Coccinellidae and Spiders based at different plant age (WAP= week after planting)

## 4. CONCLUSION

The results showed that planting curly chili with refugia significantly increased the population of predatory arthropods of *B. tabaci* (8 species) compared with the control (7 species). The eight predator species included the Insecta Class of the Coccinelidae family *(Cheilomenes sexmaculatus, Coleophora reniplagiata, Verania lineate, Coccinella transversalis, and Coelophora inaequalis*), and the Arachnida class of the Oxyopidae family (*Oxyopes macilentus*, and *Oxyopes javanus*) and the Pardosa family (*Padosa sp*). However, there were no differences in predatory arthropod populations on red chili plants between the refugia species.

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