The in-situ inventory of natural enemies at the corn plantation experimental garden of Balitsereal (Indonesian Cereal Research Institute)

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Abstract. The use of natural enemies can reduce the application of insecticides which have a negative influence on ecosystems and human health. The objective of this study is to inventory the insitu of the natural enemies in corn crops that found in the experimental station of Indonesian Cereals Research Institute (Balitsereal) in Maros, South Sulawesi. The observation plot used three replications by taking a sample of 30 plants for each replication, with a total plant observation of 90 units per block. The number of natural enemy populations obtained was recorded by counting the number of natural enemies to find out the total average number of natural enemy populations contained in the observation plot. The results showed that there were 11 types of natural enemies in corn crops namely Harmonia octomaculata (lady beetle), Menochilus sexmaculatus (lady beetle), Ophionea nigrofasciata (Schmidt-Goebel) (ground beetle), Cyrtorhinus lividipennis Reuter (plant bug), Panstemon nr. Collaris Boucek (wasp), Araneus inustus (orb spider), Cardiochiles philippinensis (wasp), Phanerotoma sp. (wasp), Pipunculus mutilatus (big-headed fly), Harpalus pensylvanicus and Chrysoperla carnea (Stephens). The existance of the above natural enemies will be very usefull in decreasing the pesticide application in the fields.

1. Introduction
Corn has good nutritional value and has various uses. The nutritional value of corn is 10.3% protein, 4.8% fat, 1.4% ash, 71.5% starch, and 2% sugar [1]. The use of corn varies greatly depending on the level of maturity at harvest. Soft-ripe harvested corn is useful for vegetables, boiled corn, or roasted corn. Old harvested corn is used for various consumption needs such as staple food, corn flour, animal feed, and others [2]. The demand of corn continues increasing year by year as a result of the high rate of world population growth which reaches 1.4% per year. The progress in the food processing industry and the increasing need for animal feed raw materials from corn, especially poultries, also contribute to the increase in national and world consumption of corn. Today, the national corn production has not yet been sufficient, so that Indonesia still needs to import it with a volume up to 1 million tonnes per year [3]. The data from BPS (the Indonesian Central Statistics Agency) in 2012, the corn production was 19,387,022 tonnes of dry shelled (PK), however, there was a decrease in 2013 by 18,511,853 tonnes of dry shelled (PK). In 2014, the corn production increased again as much as 19,008,426 tonnes ha⁻¹ [4].
Sorghum is a food ingredient whose nutritional content is equivalent to rice’s, yet with a higher protein, fat, and P content. Sorghum has a fairly large genetic diversity, and has a wide variety which makes it very different in terms of its quality, taste, color, and the uses. The chemical composition of sorghum seeds is very diverse, however, generally it consists of 9.5% protein, 2.3% crude fiber, 2.3% ash, 68% carbohydrate, 0.11% calcium, 0.35% methionine, and 0.22% lysine [15-19]. In some areas with dry climate where other crops are difficult to grow, sorghum is an important staple food as a substitute for rice [19].

The expected production targets sometimes cannot be achieved due to various obstacles. Swastika et al. [5], reported that the obstacles often faced in increasing corn production are: (1) socioeconomic, which includes high input costs (seeds and fertilizers), low output prices (yield), little infrastructure, and low purchasing power; (2) low technology adoption, and weak marketing system, as indicated by the difficulty in obtaining credit and the market; (3) low soil fertility, around 89% of corn plants in Indonesia are cultivated on dry land with low fertility levels; and (4) abiotic and biotic constraints. Abiotic constraints are caused by the low availability of nutrients in the soil, while biotic constraints include disturbances caused by plant pest organisms (OPT) consisting of weeds, pests, and diseases [6,8]. The obstacles in corn cultivation that cause low corn productivity include pests and diseases.

In the cultivation of maize and sorghum, plant pest organisms (abbreviated as OPT in Indonesian) become one of the obstacles in increasing the crop production and productivity, which need serious attention as well. The uncontrolled growth of OPT will emerge other problems, both; social, economic, and even ecological. Several types of OPT in maize and sorghum can be limiting factors that have a major effect on the quantity and quality of yields. OPT can attack all growth stages of plants, from the early growth to the storage of yield. Therefore, one of the safest ways in handlings for OPT is the use of natural enemies, especially predators and parasites, which are already existed in-situ, in the nature. Monitoring their existence will be useful in delivering information to researchers, academics, and also for policy makers in order to formulate appropriate and correct control strategies [20-21].

In plant cultivation, one attempt to overcome pests is biological control using natural enemies. The use of natural enemies can reduce the application of insecticides which has a negative influence on ecosystems and human health. Natural enemies are divided into three groups including predators, parasites, and pathogens. Predators are a group of living things that act as life controllers in agricultural plants that attack other insect species. Parasitoids can be classified based on the phase of the host’s body being attacked: egg parasitoids, egg – larvae parasitoids, larval parasitoid, pupa larvae parasitoid, pupa parasitoid, and imago parasitoid; while pathogens are microorganisms that cause insects to get sick and eventually die. Microorganisms that can become pathogens are viruses, bacteria, protozoa, fungi, rickets, and nematodes [7,8].

This paper examines the diversity of natural enemies found in corn at several stages of plant life. The stability of the population of pests and their natural enemies generally occurs in natural ecosystems, so that the presence of insect pests in corn is no longer detrimental. Several types of natural enemies found in corn plantations include dome beetles (Harmonia octomaculata), lady beetles (Ophionea nigrofasciata), black ants (Delishoderus Thoracius), green grasshoppers (Conecephalus longipennis), and spiders (Lycosa sp.) [9,11,12,13,14].

2. Materials and methods
This research was conducted at the Corn Plant Experimental Garden of Maros Research Institute for Cereal Crops, Maros, South Sulawesi, Indonesia 2018. The identification of predatory insects was carried out at the Laboratory of Pest and Plant Diseases.

The research was conducted using a survey method. A direct observation was applied to see the presence of natural enemies at the corn plant and sorghum. The observations obtained would be identified based on the guidelines by Shepard and Litsinger [9,11,12,13,14], regarding natural enemies of food crops. The observation plot used three replications by taking a sample of 30 plants for each replication, with a total plant observation of 90 units of plants per block.
The number of natural enemy populations obtained was recorded by counting the number of natural enemies to find out the total average number of natural enemy populations found in the observation plot.

3. Results and discussion
Based on the identification results of natural enemies obtained from the corn and sorghum of the observed area, several types of natural enemies that acted as predators were found including *Harmonia octomaculata* (lady beetle), *Menochilus sexmaculatus* (lady beetle), *Ophionea nigrofasciata* (Schmidt-Goebel) (ground beetle), *Cyrtorhinus lividipennis Reuter* (plant bugs), *Panstenon nr. Collaris Boucek* (wasp predator), *Araneus inustus* (orb spider), *Cardiochiles philippinensis* (wasp), *Phanerotoma* sp. (wasp), *Pipunculus mutilatus* (big-headed fly), *Harpalus pensylvanicus* and *Chrysoperla carnea* (Stephens).

| Table 1. Classification of *Harmonia octomaculata* (Fabricius). |
|-------------------|------------------|
| **Kingdom**       | Animalia         |
| **Filum**         | Arthropoda       |
| **Class**         | Insect           |
| **Ordo**          | Coleoptera       |
| **Family**        | Coccinellidae    |
| **Genus**         | Harmonia         |
| **Species**       | *Harmonia octomaculata* |

*Harmonia octomaculata* (dome beetle) is a type of beetle that is reddish brown in color. Each of the forewings or elytrons has five black spots, and on the pronotum there are one to two pairs of black spots. This predator has black feet with a yellow tibia and tarsi [9,11].

*Harmonia octomaculata* can lay eggs as many as 150 to 200. The growth from eggs to adults takes about 1 to 2 weeks, and the fertilization process takes place in the leaves. The larvae of these beetles are more voracious than the adults. The larvae can attack 5 to 10 preys a day, and eat all stages of insect growth. In addition, *H. octomaculata* also captures slow moving preys. These beetles attack leafhoppers, stem leafhoppers, and aphids [9,11].

Based on the observations (figure 1), it shows that *Harmonia octomaculata* are not found in sorghum but are found in the JH 37 and HJ 21 corn plants, respectively as many as 9 and 3 per 90 clumps, with an average of 3 and 1 beetles. This happen due to insect prey that is found in corn plant is generally more than the prey that is found in sorghum, that is why the predator is also higher.

![Figure 1](image_url)

**Figure 1.** The average population diagram of *Harmonia octomaculata*. 
Table 2. Classification of *Menochilus sexmaculatus*.

| Kingdom   | Animalia          |
|-----------|-------------------|
| Filum     | Arthropoda        |
| Class     | Insect            |
| Ordo      | Coleoptera        |
| Family    | Coccinellidae     |
| Genus     | Menochilus        |
| Species   | *Menochilus sexmaculatus* |

*Menochilus sexmaculatus* (dome beetle) is a type of black spotted beetle. There is a long black line at the base of the pronotum, flanked by the anterior sides of the elytron. Each elytron has two black, wavy, and rounded stripes. This beetle catches slow moving prey. When disturbed, this predator will fly. The adults and larvae can prey on adult leafhoppers, nymphs, as well as the eggs as many as 5 to 10 preys every day. A single beetle can lay 150 to 200 eggs. The growth from eggs to adults takes about 6 to 10 weeks [9,10,11,12]. Based on the observation (figure 2), it shows that 3, 3, 2, and 3 *Menochilus sexmaculatus* are found in corn and sorghum plants per 90 families with an average of 1, 1, 0.67 and 1 beetles.

![Average population of *Menochilus sexmaculatus*](image)

*Figure 2.* The average population diagram of *Menochilus sexmaculatus*.

Table 3. Classification of *Ophionea nigrofasciata* (Schmidt-Goebel).

| Kingdom   | Animalia          |
|-----------|-------------------|
| Filum     | Arthropoda        |
| Class     | Insect            |
| Ordo      | Coleoptera        |
| Family    | Carabidae         |
| Genus     | Ophionea          |
| Species   | *Ophionea nigrofasciata* |

*Ophionea nigrofasciata* (ground beetle) is a reddish-brown insect with a bluish-black elytra. There are two white spots located at either end of the elytra. In addition, the head of this insect has a shiny black color. These insects are often found in leaf folds or leaf surfaces.
O. nigrofasciata can prey on 3-5 stem leafhoppers larvae per day. These insects are generally found in wet and dry land embankments [9,11,12].

Based on the observations (figure 3), it shows that three Ophionea nigrofasciata are found in the KAWALI corn and sorghum plants, each of which is 3 per 90 clumps, with an average of 1 beetle.

![Average population of Ophionea nigrofasciata](image)

**Figure 3.** The average population diagram of Ophionea nigrofasciata.

**Table 4.** Classification of Cytorhinus lividipennis Reuter.

| Kingdom | Animalia        |
|---------|-----------------|
| Filum   | Arthropoda      |
| Class   | Insect          |
| Ordo    | Hemiptera       |
| Family  | Miridae         |
| Genus   | Cytorhinus      |
| Species | Cytorhinus lividipennis |

Cytorhinus lividipennis (plant bedbugs) are insects that are oval elongated light green. This insect has a wing membrane that is green and a black thorax. The second segment of the antenna is slightly longer than the base width of the pronotal, and is greenish yellow in color. This insect has green feet on the tibia which is yellowish in color [9,11,12].

These predators are plant-eating insects. In addition, they are also predators of leafhoppers, stem leafhopper’s eggs, and stem leafhopper’s nymphs. These insects lay their eggs in plant tissue. This predator can give birth to 10 to 20 individuals. The growth from eggs to adult takes about 2 to 3 weeks. Each predator can prey on 7 to 10 leafhopper eggs or 1 to 5 leafhoppers every day. The adults and nymph insects can attack leafhopper eggs by sucking the liquid [9,11,12].

Based on the observations (figure 4), it is shown that 3, 3, 2 and 3 Cytorhinus lividipennis are found in corn and sorghum plants per 90 families, with an average of 1, 1, 0.67 and 1 bugs.
Figure 4. The average population diagram of *Cyrtorhinus lividipennis*.

Table 5. Classification of *Panstenon nr. Collaris*.

| Kingdom     | Animalia |
|-------------|----------|
| Filum       | Arthropoda |
| Class       | Insect |
| Ordo        | Hymenoptera |
| Family      | Pteromalidae |
| Genus       | Panstenon |
| Species     | *Panstenon nr. Collaris* |

*Panstenon nr. Collaris Boucek* (wasp) is a type of small wasp. This insect has a shiny bluish green color and has 13 antenna segments. The middle section of the thorax is very rough. The front of the insect's wings is relatively longer than the rear wings. The wasp has a slender belly that tapers at the end. This predator also has 5 tarsi segments on the legs. A female wasp can lay 1 or 2 eggs in the plant. After the eggs hatch, the C-shaped parasite larvae prey on 4 to 8 leafhoppers and stem leafhoppers every day. The growth from eggs to adults takes 4 to 6 days [9].

Based on the observations (figure 5), it shows that *Panstenon nr. Collaris Boucek* on the corn and sorghum plants as many as 3, 3, 2, and 3 respectively per 90 clumps, with an average of 1, 1, 0.67 and 1 wasps.
Figure 5. The average population diagram of *Panstenon nr. Collaris* Boucek.

Table 6. Classification of *Araneus inustus* (L. Koch).

| Kingdom       | Animalia          |
|---------------|-------------------|
| Filum         | Arthropoda        |
| Class         | Arachnida         |
| Ordo          | Araneidae         |
| Family        | Araneus           |
| Genus         | Araneus           |
| Species       | *Araneus inustus* |

*Araneus inustus* (L. Koch) known as the round spider. This predator has a grayish yellow and white appearance on its abdomen with thin hair covering the abdomen. The males are 4 to 5 mm in length, while the females are longer, 5 to 8 mm. This predator's legs are yellow. In hot weather, these predators seek shelter under the leaves; while in cloudy weather, these insects will wait for their prey in the nets because these predators make nets in an irregular pattern to catch their prey, located among the leaves. The preys caught in the net will try to break free, but the more they move, the stronger the preys are bound. *Araneus inustus* (L. Koch) lays eggs in leaf folds and covers them by removing white silk threads. These predators attack leafhoppers, flies, and stem leafhoppers [9].

Based on the observation (figure 6), it shows that *Araneus inustus* (L. Koch) are found in the corn and sorghum plants as many as 3, 2, 3, and 3 spiders per 90 clumps, respectively with an average of 1, 0.67, 1 and 1 spiders.
Figure 6. The diagram of *Araneus inustus* (L. Koch) average population.

Table 7. Classification of *Cardiochiles philippinensis* Ashmead.

| Kingdom       | Animalia       |
|---------------|----------------|
| Filum         | Arthropoda     |
| Class         | Insecta        |
| Family        | Braconidae     |
| Genus         | Cardiochiles   |
| Species       | *Araneus inustus* |

*Cardiochiles philippinensis* (wasp) is a medium-sized black parasitoid. It has hairy eyes and black feet with white hair. The brown forewings have an after-stigmal vein infusion. The back is also brown. The tips of the two wings are dark. The larvae of *Cardiochiles philippinensis* are creamy white. Parasitoid parasites are commonly found in dry land and rice fields. The females deposit one egg in their host by inserting folded leaves. The growing parasitoid larvae also feed on the external host. Laboratory studies show that *C. philippinensis* can attack as many as 17 leaf-rolling larvae, and live as long as 22.7 days [9].

Based on the observations (figure 7), it shows that *Cardiochiles philippinensis* are found in the corn JH37, HJ21, and KAWALI sorghum plants as many as 2 each per 90 clumps, and in the NUMBU as many as 3, with an average of 0.67 and 1 wasps.
Figure 7. The Average Population Diagram of *Cardiochiles philippinensis*.

Table 8. Classification of *Phanerotoma* sp.

| Kingdom      | Animalia          |
|--------------|-------------------|
| Filum        | Arthropoda        |
| Class        | Insecta           |
| Family       | Phanerotoma       |
| Genus        | Phanerotoma       |
| Species      | *Phanerotoma* sp. |

*Phanerotoma* sp. (wasp) is a small braconid wasp. The color is light brown. Its short belly is wide and slightly compressed. It has three visible stomach segments. Another distinguishing characteristic of wasps is the small terminal antenna segment [9].

*Phanerotoma* sp. attacks stem borer larvae by laying one egg in each larval host. It grows inside the host up to the larvae of the mother larva. The growth from eggs to adults takes 2 to 6 days. The parasites live as long as 3 to 6 days [9].

Based on the observation (figure 8), it shows that *Phanerotoma* sp. in the corn and sorghum plants, each as many as 3 per 90 clumps, with an average of 0.67 wasps.
Figure 8. The Average Population Diagram of *Phanerotoma* sp.

**Table 9. Classification of *Pipunculus mutillatus*.**

| Kingdom     | Animalia          |
|-------------|-------------------|
| Filum       | Arthropoda        |
| Class       | Insecta           |
| Ordo        | Diptera           |
| Family      | Pipunculidae      |
| Genus       | Pipunculus        |
| Species     | *Pipunculus mutillatus* |

*Pipunculus mutillatus* (Big-headed fly) is a parasite that has yellowish brown legs except for the femoris and distal tip of the tarsi. A distinct brown spot is on the marginal vein of the forewing. The ovipositor is curved toward the three stomach segments [9].

The parasitoids keep their eggs in the stomach of the host. The host insect grows normally, and then dies as soon as the parasite larvae appear. The larvae are in the soil or near the base of the plant. The adults live for about 4 days, and attack 2 to 3 leafhoppers a day [9].

Based on the observation (figure 9), it shows that 3, 2, 1 and 3 flies are found in the corn and sorghum plants per 90 clumps, with an average of 1, 0.67, 0.33 and 1 flies.
Figure 9. The diagram of *Pipunculus mutillatus* average population.

Table 10. Classification of *Harpalus pensylvanicus*.

| Kingdom  | Animalia   |
|----------|------------|
| Filum    | Arthropoda |
| Class    | Insecta    |
| Ordo     | Coleoptera |
| Family   | Carabidae  |
| Genus    | Harpalus   |
| Species  | *Harpalus pensylvanicus* |

*Harpalus pensylvanicus* has a body length of 13 to 16 mm. These insects are dark brown and have long legs that allow them to move quickly to catch prey, and avoid other predators. These insects produce one generation per year. After finding a suitable place, the females will keep 30 to 600 oval-shaped eggs in the soil or at ground surface. These predators attack armyworms, leafhoppers, and butterfly larvae [9].

Based on the observations (figure 10), it shows that *Harpalus pensylvanicus* are found only in the corn plants as many as 3 and 2 per 90 clumps, with an average of 1 and 0.67, respectively.
Chrysoperla carnea is ¾ inch long, has long netlike wings. Additionally, these insects are pale green in color and have golden eyes. The eggs laid by Chrysoperla carnea are green and oval in shape. Whereas the larvae are alligator-shaped with long tubular mandibles, curved and range in color from gray to brown. The adults generally live from 1 to 3 months depending on the temperature, humidity, and quality of the food source [9]. In the breeding, the females can lay hundreds of eggs and tend to lay their eggs near sources of prey. The incubation period for eggs depends on the species. In addition, the larvae grow through three instars. Each larva is capable of gobbling up 200 or more aphids or pest eggs per week during their growth period. After 2 to 3 weeks, the larvae will pupate in a round silk which are usually attached to vegetation. The pre-pupal stage lasts about 5 to 8 days. Next, the adulthood occurs after 1 to 2 weeks. The predators Chrysoperla carnea attack aphids, caterpillars, leafhoppers, and whiteflies [9].

Based on the observation (figure 11), it shows that the Chrysoperla carnea (Stephens) are found in the corn plants JH 37, HJ 21, and KAWALI sorghum plants, respectively 3, 2, and 1 per 90 clumps, with an average of 1, 0.67, and 0.3 insects.
The implication of this research is that by knowing the population density of each type of predator in the cultivation, it will be easy to know the distribution and presence of the main insect predators of plants as well which are commonly found in rice and are also found in maize. This means that the farmers who plant maize and sorghum in maize cultivation, as the second crop after rice, will be benefited due to the availability of the enemies’ presence in the field, therefore, it is no need to carry out chemical controls or other controls which can take a lot of time and money. In addition, by utilizing the role of natural enemies in-situ, the safety of the environment and non-pest organisms on the location will be safe and maintained.

4. Conclusions
Natural enemies of corn plants found at the Corn Plant Experimental Garden of Maros Research Institute for Cereal Crops, South Sulawesi, Indonesia are Harmonia octomaculata (dome beetle), Menochilus sexmaculatus (dome beetle), Ophionea nigrofasciata (Schmidt-Goebel) (beetle soil), Cyrtorhinus lividipennis Reuter (bedbugs), Panstenon nr. Collaris Boucek (wasp predator), Araneus inustus (round spider), Cardiochiles philippinensis (wasp), Phanerotoma sp. (wasp), Pipunculus mutillatus (big-headed fly), Harpalus pensylvanicus and Chrysoperla carnea (Stephens).

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