JURNAL ILMIAH AGRINECA
ISSN : 2721-074X (Online) - 2301-6698 (Print)
Homepage : http://ejournal.utp.ac.id/index.php/AFP/index

Research Article
DOI : 10.36728/afp.v22i2.2029

Impact of carbofurans on sweet corn pest predators: A study of good agroecosystem practices

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ABSTRACT

Sweet corn (*Zea mays var. Saccharata, Sturt*) is a horticultural crop with high economic value. Sweet corn plants are susceptible to attack by plant pest organisms, reducing production yields. Using synthetic chemical pesticides of the carbamate group can reduce the diversity of predatory insects as biological controllers. Many farmers do not know about the role of predatory insects in agriculture, so there is often a mistarget in control. This study aimed to determine the diversity of predatory insects on sweet corn. The research was conducted in Cabeyan, Sukoharjo district, using the descriptive observation method. Data collection is done directly. In this study, several types of predatory insects were found, including three species from the Araneae order, two from the Odonata, one from the Hymenoptera, one from the Diptera, and one species from the Coleoptera.

KEYWORD

agrotourism, strategy, development, marketing

INFORMATION

Received : 5 May
Revised : 17 June
Accepted : 20 July 2022

Volume : 22
Number : 2
Year : 2022

1. INTRODUCTION

In agriculture, it is impossible to avoid synthetic chemical pesticides, which have consequences for the agroecosystem and the clinic. The use of synthetic chemical pesticides in the long term disrupts the balance of the ecosystem due to the killing of natural enemies, pest resistance, resurgence, and clinical impact. Carbamate pesticides such as carbofuran have a broad spectrum and fast action, so they are widely used by farmers. In general, carbamate pesticides are toxic to animals, including humans.

Natural enemies (predators), as components of the agroecosystem, have sensitivity to pesticide exposure. According to Mishra *et al.*, 2020, carbofuran inhibits choline esterase in the insect nervous system. The increase in dose and exposure time of carbofuran was

positively correlated with the killing of Poecilia reticulata; EC50 occurred at a dose equivalent to 200 ppm with an exposure period of 2-4 hours (Bej *et al.*, 2021).

Corn is one of the essential food commodities, and this makes corn have enormous potential to support food security (Andini and Pribadi, 2019). In terms of food security, corn can be made into various preparations or directly consumed as a staple food other than rice (Wijaya, 2019). Corn is an essential food ingredient because it is the second source of carbohydrates after rice (Adinurani *et al.*, 2019). Corn is used as one of the ingredients for animal feed (Pazla and Sriagtula, 2021). At this time, the processing of corn plants is very diverse and innovative; this encourages market development not only on a household scale but has expanded to a large industrial scale using modern machines, so the quality of corn plants is essential (Palacios-Rojas *et al.*, 2020). The high demand for sweet corn has spurred farmers to increase sweet corn production (Sabur *et al.*, 2021).

Sweet corn kernels have a good taste, a higher carbohydrate content of vitamins A and C, and a lower fat content than regular corn kernels. The high consumption of sweet corn causes market demand to always exist throughout the year. Sweet corn has a harvest age ranging from 70-85 days. Sweet corn is an agricultural commodity that is very popular with the community because it contains many nutrients and has economic value (Nuryadin *et al.*, 2016).

Using pesticides in large quantities and those difficult to degrade by soil can cause various negative impacts on the environment, such as loss of biodiversity, decreased populations of beneficial organisms such as natural enemies, and environmental pollution. Trigger the decline in natural enemy populations (Muhibah and Leksono, 2015).

Pest control efforts on corn plants carried out by farmers in Cabeyan Village, Bendosari District, and Sukoharjo Regency still uses synthetic pesticides. Undoubtedly, this is the most effective and fastest way to deal with plant pest attacks. The continuous use of synthetic pesticides, as practiced by farmers, will cause residue accumulation in the soil and will cause long-term damage to agricultural land. Of course, researchers are looking for the right solution to overcome this problem. Using biological control agents is one way to control plant pests that are environmentally friendly and do not cause environmental pollution.

Biological control agents or natural enemies of plant pests exist in every agricultural land with different groups and types. The classification is divided into three: predators, parasitoids, and parasites. Therefore analysis and identification of each biological control agency in the land are needed. Agriculture so that the biological enemies of each pest attacking corn can be identified. Insect responses to this physical environment are different so that their active times are different, namely morning, afternoon, evening, or night (Kurniawati and Martono 2015)

2. METHODOLOGY

The research method used is observation, with data collection done directly, with the method used is random sampling. The research object is sweet corn (*Zea mays var. Saccharata, Sturt*) agricultural land in Cabeyan Village, Bendosari District, Sukoharjo Regency, with a land area of 1000 m2. The tools used in this study were a hoe, a hole tool, a ruler, a predator identification book, and a camera. The materials used in this study included sweet corn seeds (Talenta), cow dung, and herbicides with the active ingredient mesotrione. The Latosol soil type is characterized by a reddish brown color, slab texture, and slightly sandy, with a research period of three months starting on December 5, 2020, and ending on February 25, 2021.

3. RESULTS AND DISCUSSION

In research activities with the observation method carried out on sweet corn farmland (*Zea mays var. Saccharata, Sturt*) Cabeyan, Bendosari, Sukoharjo, there are eight types of predators and are presented in Table 1. In contrast, predators are found when the observer and their host are presented in table 2.

Table 1. Observation and inventory of main pest predators on sweet corn

No.	Date	Time	Plant age (dap)	Predatory species	Growth stage
1	January 20	7-10 am	11	*Agriocnemis femina*	Imago
2	January 27	7-10 am	18	*Orthetrum Sabina*	Imago
3	February 03	7-11 am	25	*Solenopsis invicta*	Imago
4	February 10	7-9 am	32	*Marpissa sp*	Imago
5	February 16	7-10 am	38	*Xysticus sp*	Imago
6	March 02	7-10 am	53	*Promachus rufipes*	Imago
7	March 09	7-10 am	59	*Coccinella tranversalis*	Imago
8	March 16	7-11 am	66	*Oxyopes liniatipes*	Imago

Source: Primary data, 2021

Table 2. Observed predators and hosts

No.	Predatory species	Found in	Host pests
1	*Agriocnemis femina*	Flying around the plants	Moths and seed flies
2	*Orthetrum Sabina*	Flying around the plants	Moths and seed flies
3	*Solenopsis invicta*	Soil surface, leaves and stems	Seed flies
4	*Marpissa sp*	Leaves and stems	Moths and seed flies
5	*Xysticus sp*	Leaves and stems	Moth
6	*Promachus rufipes*	Flying around the plants	Seed flies and grasshopper
7	*Coccinella tranversalis*	Leaves and stems	Moth
8	*Oxyopes liniatipes*	Leaves and stems	Moth

Source: Primary data, 2021

3.1. *Agriocnemis femina*

Agriocnemis femina is a predator that lives on land. The body of the *Agriocnemis femina* is divided into three parts: the head, chest, and abdomen, with six limbs and compound eyes composed of thousands of lenses. It also has 9 to 10 segments of the abdomen and appendages. The wings consist of 2 pairs with specific venation for each species (Rahadi *et al.*, 2013).

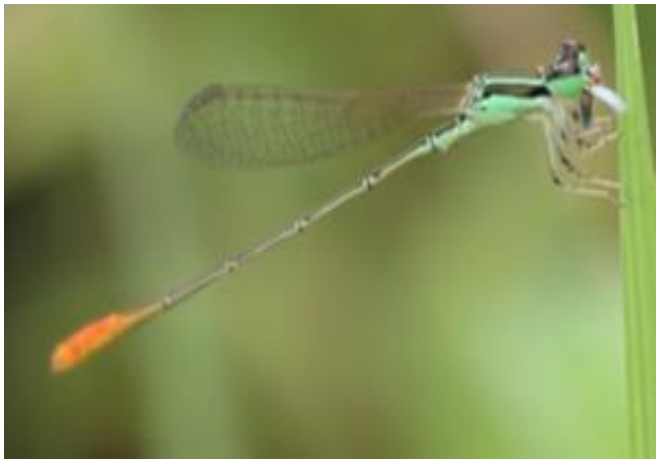

Figure 1. Orange-tailed needle dragonfly (*Agriocnemis femina*)

Agriocnemis femina has a chewing-type mouth apparatus; this dragonfly hunts by catching its prey directly while it is flying and tearing the body of its prey to death. As the plant entered the generative phase, *Agriocnemis femina* was detected. Dragonflies have an essential role in maintaining the food chain balance in the ecosystem. Dragonflies act as predators of small insects, even eating smaller dragonflies (Rahadi *et al.*, 2013). In the research area, *Agriocnemis femina* became a predator for moths (*Spodoptera sp.*), which caused 87% damage, and became a predator for seed flies (*Atherigonas sp.*), which caused 27% damage to the total sweet corn crop.

3.2. Army Dragonfly (*Orthetrum sabina*)

This type of dragonfly belongs to the Odonata order and is characterized by a dark green thorax with black stripes on its black legs. The abdomen is small or slender and long with black and white, the first to third segments being the same color as the thorax. Then the synthorax is yellow. Orthetrum sabina has a length of 5.5 cm measured from the head to the tip of the tail, and its wingspan reaches 4 cm (Kalliyil et al., 2020).

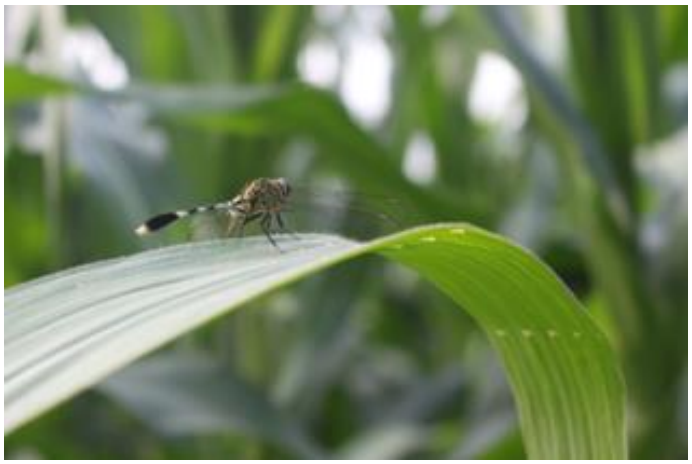

Figure 2. Army dragonfly (*Orthetrum sabina*)

The mouth of Orthetrum sabina is a chewing type, and the front part has a labrum (front lip); behind the labrum is a pair of mandibles (jaws) that are used to immobilize their prey. Orthetrum sabina undergoes incomplete metamorphosis, namely eggs, nymphs, and imago; usually, eggs are laid in waters free from pollutants. This army dragonfly was found in the research area in the vegetative to generative phase. In the research area, the sweet corn plant dragonfly (*Orthetrum sabina*) preys on moth pests (*Spodoptera sp.*), which cause 87% of the damage, and they also become predators of seed fly pests (*Atherigonas sp.*), which cause damage to 27% of the total sweet corn crop.

3.3. Fire Ant (*Solenopsis invicta*)

Ants are insects that live on the land, and they are abundant and easy to find anywhere, both in the houses around us and in the plantation area, where they can also be found in rice fields. The fire ant (*Solenopsis invicta*) has three body parts: a head, thorax, and abdomen. In addition, ants have six (three pairs) jointed legs, a pair of antennae, and an exoskeleton. According to Rosnadi (2019), ants have a strong exoskeleton for protection but are flexible for movement, and this is because of their integument. The head of Solenopsis invicta is identified as consisting of an antennal scribe, eyes, clypeus, frontal carina, mandible, palp formula, and antennae. Ants' segmented sensory organs are located between their compound eyes. In contrast, the compound eyes of *Solenopsis invicta* consist of a collection of larger eye lenses, which are small and incorporate excellent motion detection.

Solenopsis invicta has a cutting mouth type, using mandibles or jaws for cutting or holding in search of prey. *Solenopsis invicta* constantly forms colonies is found in the vegetative and generative phases; this species becomes a predator for seed fly larvae pests (*Atarigona sp.*), which causes damage to the whole corn crop by 27%.

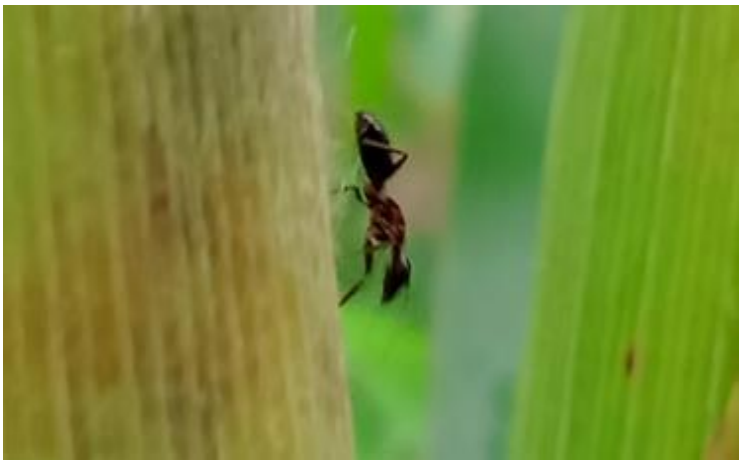

Figure 3. Fire Ant (*Solenopsis invicta*)

3.4. Robber Fly (*Promachus rufipes*)

Robber flies are effective predators of pests; these flies eat many types of insects and can catch prey more significantly than their body size. Robber flies have a perfect life cycle: eggs, larvae, pupae, and imago. Each robber fly has its own area of control. The robber fly has a short, strong proboscis and uses it to stab and inject its prey with its saliva, which contains neurotoxic and proteolytic enzymes to immobilize and digest the prey's interior, then suck it through the proboscis to kill the prey. His mouth against his prey, then he sucks the prey's body fluids to dry. Flies only eat in liquid form, and dry food will be moistened using their saliva; this is related to the type of fly's mouth, namely sucking. *Promachus rufipes* in the research area became a predator for seed flies (*Antharigonas sp.*), which caused 27% damage to corn plants. They became a predator for grasshoppers (*Oxya sp.*), which caused 80% damage to the whole corn crop.

Figure 4. Robber Fly (*Promachus rufipes*)

3.5. Dome Beetle (*Coccinella transversalis*)

The dome beetle is a tiny insect with a beautiful color, namely red with a black color combination that is oval, not in a perfectly round shape, which is, in this case, what distinguishes one species from another. Mitra (2013), states that dome beetles undergo holometabolous metamorphosis or complete metamorphosis (eggs-larva-pupa-imago).

The dome beetle has a round body shape, a body length of 8–10 mm, and rigid wings on its back called elitra. Elitra is orange in color, coupled with a black spot-like pattern that varies from individual to individual. Elitra on *E. admirabilis* looks dull and not shiny (Rivera *et al.*, 2021).

Found in maize entered the generative phase. The dome beetle has a biting and chewing mouth. The dome beetle is an oligophagous predator that can eat several types of prey. In the sweet corn research area, the dome beetle preyed on the moth (*Spodoptera sp.*), which caused 87% of the damage to the research area.

Figure 5. Dome Beetle (*Coccinella transversalis*)

3.6. Spiders (*Xysticus sp.*)

Spider is a hunting spider that hunts passively, waiting for its prey's arrival through camouflage. In its life cycle, the spider undergoes incomplete metamorphosis where the female will produce eggs, hatch, and become tiny spiders.

The morphology of the spider has a blackish brown body color, and the whole body is covered with white hair. The cephalothorax is black–brownish in color, and there are white hairs on the left and right sides of the cephalothorax. The mouth shape of the spider is a sucker-biter by using a pair of large jaws (Chelicera) that have fangs (fingers) that function as a means of transport. The prey will die from the poison that will destroy their internal organs. In the study area, spiders were found in the vegetative and generative phases as predators of pests.

Figure 6. Spider (*Xysticus sp.*)

3.7. Sharp-Eyed Spider (*Oxyopes lineatipes*)

Spiders are a type of hunting spider often found in rice fields. In their life cycle, the spider undergoes incomplete metamorphosis, where the female will lay eggs and then hatch into tiny spiders. Morphologically, spiders have differences between the order Oxyopidae; they have a reddish-brown line and two white lines extending down their abdomen. It has eight irregular eyes. Six of the eyes are more significant, and the other two eyes are smaller and have two body segments, namely: the cephalothorax, which is a combination of the head and chest (thorax), and the other body parts are in the form of the abdomen or abdomen, which have an elongated round shape on the legs. Hairs or thorns are all over the legs (Koneri, 2016).

In looking for prey, *Oxyopes lineatipes*, including hunting spiders, do not form a web to catch their prey. This spider likes dry habitats and usually lives in the leaf canopy. In searching for prey, this spider always hides from its prey until the prey is close enough to be struck. Spiders have a sucking mouth type where the fangs of the *Oxyopes lineatipes* spider can paralyze their prey. After that, the liquid in the prey's body, can kill 2-3 moths every day, so its presence is significant in preventing the increase in the population of a new generation of insect pests (Saenong et al., 2020). In the research carried out, spiders found that when chili entered the generative phase, these spiders were active during the day and became predators of the moth plant pest (*Spodoptera sp.*), which caused 87% damage to the sweet corn plant research area.

Figure 7. Sharp-Eyed Spider (*Oxyopes lineatipes*)

3.8. Jumping Spider (*Marpissa sp.*)

The *Marpissa sp.* spider, often known as the jumping spider, is a predator with a petite body that makes this spider invisible when hiding behind the leaves. Jumping spiders carry out imperfect metamorphosis, starting from eggs and becoming young.

The body parts of the jumping spider are black with white hair all over the body and have a body length of 8.21 mm with eight eyes arranged in two rows with a 4-4 arrangement pattern. The hunting method of the *Marpissa sp.* spider is by jumping and ambushing its prey and killing it by piercing it with its fangs and sucking the liquid in the prey's body.

Jumping spiders were found in the morning and afternoon. An adult spider can prey on 2-8 prey per day (Saenong et al., 2020). In the research area, the jumping spider is a predator of the seed fly pest (*Aterigona sp.*), which causes 27 % damage to the research area, and is a predator of moths (*Spodoptera sp.*), which causes 87% damage to sweet corn plants.

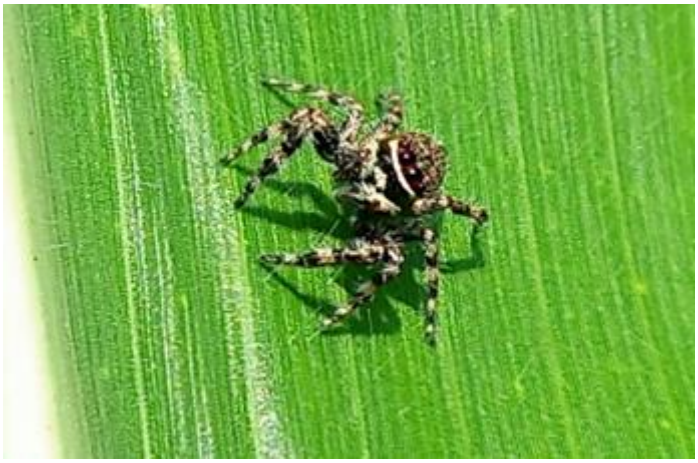

Figure 8. Jumping Spider (*Marpissa sp.*)

4. CONCLUSION

This study found eight predatory species, including orange-tailed needle dragonfly (*Agriocnemis femina*), army dragonfly (*Orthetrum sabina*), red ant (*Solenopsis invicta*), robber fly (*Promachus rufipes*), dome beetle (*Coccinella transversalis*), spiders (*Xysticus sp.*), sharp-eyed spiders (*Oxyopes lineatipes*) and spiders (*Marpissa sp.*).

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