Jurnal Pro-Life, Volume 10 Nomor 3, November 2023

Prolife
Jurnal Pendidikan Biologi, Biologi, dan Ilmu Serumpun
https://ejournal.uki.ac.id/index.php/prolife

Diversity of Insect Herbivores and Natural Enemies That Have Association with Shallot Cultivation in Organic and Conventional Farm in Balige

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Article History

Received : 24 September 2023
Approved : 12 October 2023
Published : 30 November 2023

Keywords
insects diversity, insects herbivore, parasitoid, predator, true shallot seed

ABSTRACT

Balige will be a centre for producing onions from true shallot seeds (TSS). Some of the obstacles encountered in shallot cultivation are pest and disease attacks. The frequency of pesticide use has been carried out intensively. This research aims to compare insect diversity and determine the presence of herbivorous insects and natural enemies in the cultivation of true shallot seeds in organic and conventional farming systems in the vegetative and generative phases in the Balige highlands, Tobasa Regency. This research was carried out on an area of 2000 m2 at the Gurgur, Balige Experimental Garden and Plant Pest and Disease Laboratory, Faculty of Agriculture, University of North Sumatra. Medan from August to December 2017. This research used five insect traps (Sweeping Nets, Pitfall Traps, Light Traps, Yellow Sticky Traps, and Hand Picking) and was repeated eight times. Insects are identified to their families and their role in the ecosystem is also determined. The composition of pests found in shallot plants, both organic and conventional, is dominated by Tephritidae and Noctuidae. The composition of predators found in organic and conventional shallot plants is Formicidae and Forficulidae followed by Coccinelidae, Carabidae, Staphylinidae, Coenagrionidae, Corduliidae, and Anthocoridae. The parasitoid composition is Tachinidae. There are differences in the diversity (H'), evenness (E') and dominance (C) index values in organic and conventional shallot plants, the highest H' (2.885) is in the generative phase of organic plants, the highest E' (0.822) in the generative phase in conventional plants and the lowest C (0.094) in the generative phase in organic plants.

INTRODUCTION

Shallots are an important agricultural commodity for Indonesian people. The development of shallot production in Indonesia in the 2000–2019 period tends to increase with an average growth of 4.20% per year. Household consumption of shallots is usually for cooking spices and fried onions, during the 2005-2019 period it fluctuated with an upward trend, the average consumption of shallots in the last five years was 2.73 kg/capita/year with growth in the same period experiencing an increase of 2.67% per year. So Indonesia is still importing from several countries to meet its domestic demand for shallots. The five countries where the highest imports of shallots in 2018-2019 are Thailand, Spain, the United States, Italy and Japan. Where the highest import volume is Thailand at 35.57% (Pusat Data dan Sistem Informasi Pertanian, 2020).

The high demand for tubers as planting material and the relatively expensive price of tubers makes farmers use tubers from their propagation or tubers from previous harvests. This will certainly reduce further production because the tubers used are harvested without distinguishing between tuber production technology for seeds or consumption and there is an accumulation of pathogens carried in the tubers (Wiguna et al. 2013). So the use of True shallot seed (TSS) as a source of shallot propagation and production is considered much better than the conventional method usually used by farmers.

Botanical shallot seeds or true shallot seeds (TSS) are an alternative technology that has the potential to be developed to provide shallot seeds throughout the year in Indonesia. TSS offers several advantages including healthier plants, high propagation ratio (1:200) and long shelf life (>2 years). It is very contradictory if we still use propagation from tubers, where the storability of tuber seeds is low (1-4 months) and is very limited depending on the dormancy period and variety, and the need for seeds is very large, namely 1.5 tons per ha. The need for so many seeds in the form of tubers makes storage difficult (Rosliani et al, 2022).

TSS production technology is still in the process of development, causing TSS production to not be able to meet the need for shallot planting material. One of the obstacles to TSS production is the low percentage of flowering and the formation of capsules and seeds (seed set). Apart from that, information is also urgently needed regarding the diversity of insects in shallot plantings from TSS because plant pest organisms (OPT) are a limiting factor in crop production in Indonesia, both in food crops and in horticulture and plantations (Kadi, 2014).

In efforts to control pests, farmers currently still rely on insecticides because other methods, such as the use of resistant varieties and natural enemies, have not been widely used. Pest control using insecticides is common practice, but failure to control pests still often occurs. Based on searches, researchers have not found research related to insect diversity in shallot plantings from botanical seeds in organic and conventional farming systems. Therefore, it is necessary to carry out research on the diversity of insects in shallot plantings from botanical seeds in an effort to plan environmentally sound pest control in order to realise sustainable agriculture, especially in the Balige highland area.

RESEARCH METHOD

Method

Field observations were carried out at the Gurgur Experimental Garden, Balige, Toba Samosir Regency, North Sumatra, from August to December 2017. The observation location was located at an altitude of 1,340 m above sea level with an average temperature, humidity, and rainfall of 17–29 oC, 85.04%, and 155 mm, respectively. Observations were carried out at two planting locations, namely organic and conventional planting systems with an area of 1000 m2 each. In organic planting, the planting medium is mixed with manure, there is absolutely no application of chemical (inorganic) fertiliser, and only two pesticide applications are made. In conventional plantings, inorganic fertilisers and chemical pesticides are applied regularly and on a scheduled basis. Identification of insect specimens was carried out at the Pest Laboratory, Agrotechnology Study Programme, Faculty of Agriculture, University of Sumatera Utara.

Observation and Sampling of Insects

Insect sampling was carried out using pitfall traps, yellow sticky traps, swing net traps, light traps, and direct picking (hand picking). Insect sampling was carried out 8 times, 4 times in the vegetative phase and 4 times in the generative phase, namely at 10, 17, 24, and 31 days after transplanting, and in the generative phase, namely at 37, 51, 65, and 79 days after transplanting.

Traps are traps made from plastic cups with a volume of 250 ml. The glass is filled with 70% alcohol and placed on the ground. At each research location, twenty traps were installed. Traps are installed for 3 x 24 hours starting at 07.00 WIB, and the traps are given a roof to protect them from rainwater. The swing net trap is made of light and strong material and is used to catch insects around the plant canopy. The trap is swung eight times, following the flow of the fence. In the morning, around 07.00-09.00 WIB, and in the afternoon, 17.00-18.00 WIB. Light traps use LED lights as a light source. The lamp is placed above a basin containing 70% alcohol. Installation was carried out at 18.00–06.00 WIB, and at each research location, two light traps were placed. The yellow sticky trap measures 20 x 30 cm; its height is adjusted to the age and canopy of the plant. Nine traps were installed in each location. Traps are installed for 3x24 hours, starting at 07.00 WIB. Direct quotations were carried out deliberately (purposive sampling) at the research location in the morning around 07.00-09.00 WIB and in the afternoon at 17.00-18.00 WIB.

The caught insects are stored in a viyal bottle containing 70% alcohol solution and then identified to family level in the laboratory. Identification of insects is done based on their morphological characteristics. Insect identification using reference to the book by Borror et al. (1992).

Data Analysis

Differences in insect diversity were measured using the Shannon diversity index $H' = -\sum pi \ In \ pi$. Evenness index E'=H'/ln S. Species dominance for each cropping system is measured based on the Simpson dominance index $C = \sum (ni/N)2$.

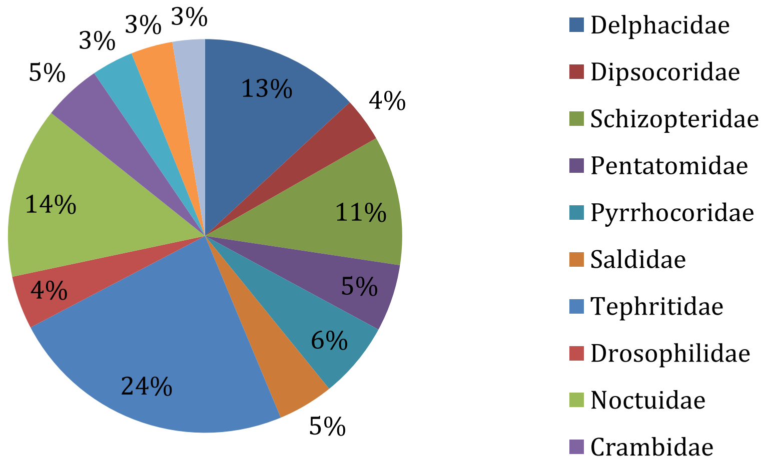
RESULTS AND DISCUSSION

Types of Pests and Natural Enemies

The results of observations and identification contained several pest species and several families of natural enemies. Several families of predators and parasitoids caught were: Anthocoridae, Corduliidae, Coenagrionidae, Formicidae, Forficulidae, Carabidae, Coccinelidae, and Staphylinidae for predators, while four families were found for parasitoids, namely: Ichneumonidae, Braconidae from the order Hymenoptera, Tachinidae, and Sarcophagidae from the order Diptera.

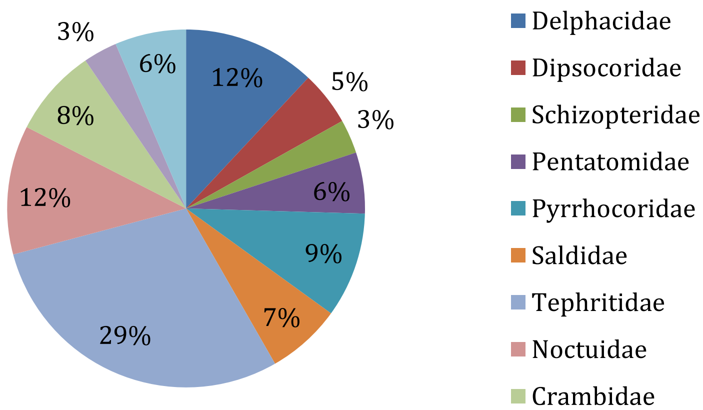
Herbivore Composition

The results of the research show differences in the composition of herbivore populations found in organic and conventional shallot plantations in the Balige highlands (**Figure 1**). The data obtained shows that 14 families of herbivores were found on organic plantations. Of the fourteen species of families found, Tephtritidae (24%), Noctuidae (14%), and Delphacidae (13%) had the highest population density compared to other pests such as Dipsocoridae, Schizopteridae, Pentatomidae, Pyrrhocoridae, Saldidae, Tephtridae, Drosophilidae, Crambidae, Pyrgomorphidae, Acrididae, and Crysomelidae



(n= 526 specimens)

Figure 1. Herbivore composition in organic shallot plantings



(n= 326 specimens)

Figure 2. Herbivore composition in conventional shallot plantings

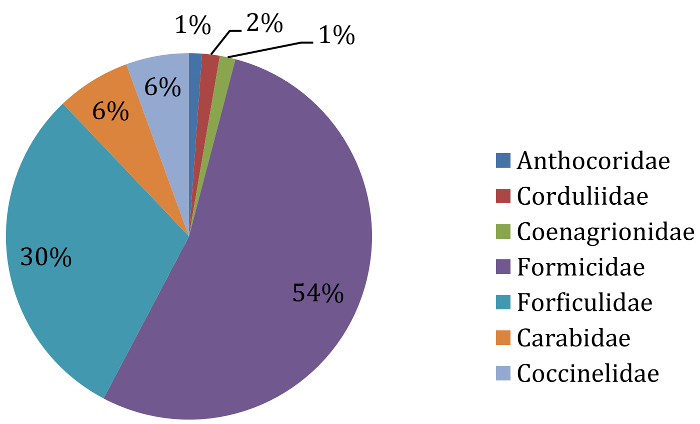
In conventional shallot plantings that were sprayed with insecticide every 2 weeks, 12 types of herbivores were found (**Figure 2**). Tephtridae (29%), Noctuidae (12%), and Delphacidae (12%) had a higher population density than other herbivore families, such as Tephritidae, Pyrrhocoridae, Crambidae, Saldidae, Acrididae, Pentatomidae, Dipsocoridae, Pyrgomorphidae, and Schizopteridae.

The presence of fruit flies from the Tephritidae family dominates both types of organic and conventional planting; this is supported by shallot planting areas where various types of fruit and vegetables are found, including jackfruit, mango, avocado, orange, cabbage, cauliflower, guava, potato, and coffee. This is what causes the presence of the fruit fly family from the Tephritidae family. This is in accordance with the statement (Sharma & Ramniwas, 2023) that Tephritidae is a large family with highly patterned wings that are phytophagous pests throughout the world. They are highly adaptable, ecologically diverse, have successfully invaded a wide range of ecosystems, and are major pests of many types of fruiting plants.

The existence of a higher population of noctuidae, or armyworms, compared to other types of herbivores is because shallots are known to be host plants for these herbivores. Armyworm pests have a rapid spread and are polyphagous pests capable of attacking 350 plant species, including shallot plantings. In fact, several species of Noctuidae have been reported to be resistant to insecticide applications (Chen at al., 2023).

Predator

In **Figure 3**, it can be seen that the predators are the most dominant of the seven families found in onion plantations. In organic shallot planting, the Formicidae family is at 54%, followed by Forficulidae at 30%, Carabidae at 6%, Coccinelidae at 6%, Anthocoridae at 1%, Corduliidae at 2%, and Coenagrionidae at 1%. Likewise, in conventional shallot planting (Figure 4), the Formicidae family was found to be the most abundant at 61%, followed by Forficulidae, Coccinelidae, Carabidae, Staphylinidae, Coenagrionidae, Corduliidae, and Anthocoridae, respectively, at 21%, 6%, 5%, 3%, 2%, 1%, and 1%.



(n= 1223 Specimens)

Figure 3. Predator composition in organic shallot plantings

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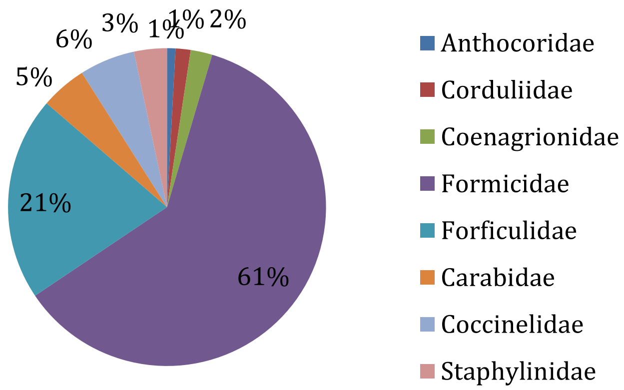


(n= 1046 Specimens)

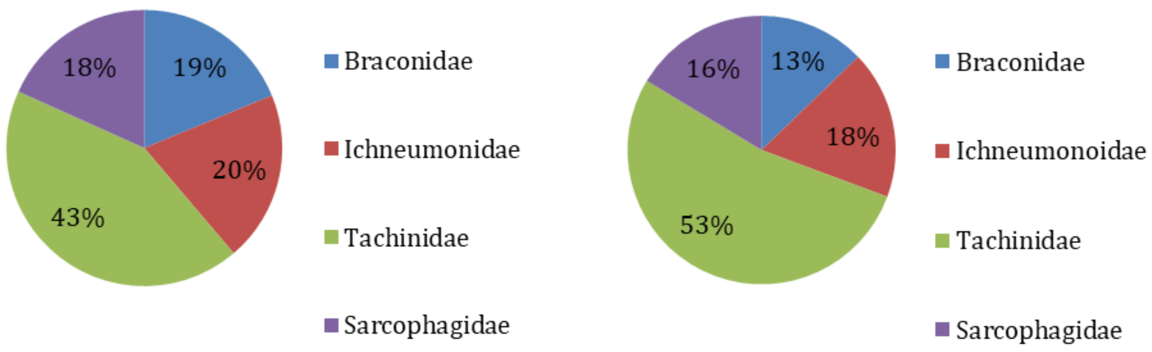
Figure 4. Predator composition in conventional shallot plantings

Ants (Hymenoptera: Formicidae) are predatory arthropods that dominate shallot plantings in both plantations. The high population of Formicidae in organic and conventional plantations is caused by the condition of the land being quite good, having a loose soil structure, and ants being known to be predators of other athropods such as collembola, whose populations are quite abundant in both plantations. Ecologically, it is one of the most important groups of insects and shows extraordinary abilities in visual learning and orientation; this adds to the roaming capabilities of the Formicidae family as part of the predatory insects (Yilmaz and Spaethe, 2022).

Parasitoid

Figure 5 (A) shows that the Tachinidae family has the highest density of pest parasitoids in organic shallot plantings, followed by the Ichneumonidae family at 20%, Braconidae at 19%, and Sarcophagidae at 18%. Likewise, in conventional plantings **(B)**, the Tachinidae family was found to be the most abundant, followed by Ichneumonidae (18%), Sarcophagidae (16%), and Braconidae (13%).

The fact that there are more parasitoids overall in organic plantations than in conventional ones is influenced by a number of factors that help parasitoids survive in the ecosystem. In organic farming, we avoid the use of insecticides and carry out biological control by utilising refugia plants planted around shallot plantations. Salat-Moltó et al. (2023) stated that well-coordinated and planned organic farming at the landscape level is a much more promising strategy for improving biological control than concentration on individual land management. Apart from that, organic farming also increases arthropod predators, although it is influenced by the surrounding vegetation.



A (n= 410 Specimens) B (n= 336 Specimens)

Figure 5. Composition of parasitoids in shallot plantings. (A) Organic and (B) Conventional

Diversity (H'), Evenness (E') and Dominance (C) index values in organic and conventional shallot planting

From **Table 1**, it is known that the highest diversity is found in the generative phase of organic shallot plantations, namely 2,885 consisting of 9 orders and 33 insect families, while the lowest number of individual insects is the Pentatomidae family with 4 individuals and the largest is Formicidae with 306 individuals. Meanwhile, conventional shallot planting in the vegetative phase had the lowest diversity, namely 2,637, consisting of 10 orders and 31 insect families. The lowest number of individual insects was Pentatomidae, numbering 3, and the largest was Isotomidae, numbering 341, followed by Formicidae with 321 individuals.

Based on **Table 1**, it is known that the decrease in the total number of individual insects and the number of families in conventional shallot plantations is caused by the scheduled use of pesticides, thereby reducing the number of individual insects and insect families in conventional shallot plantations in the phase where control uses two types of insecticides at once. This causes various damages and destroys the diversity of herbivorous insects and also beneficial insects. Insecticide application is effective in partially controlling herbivores but simultaneously also kills parasitoid predators, which actually have the potential to control herbivores biologically. This is in accordance with Stuligross et al. (2023), who stated that the factors that influence the presence of beneficial insects are the application of insecticides and the presence of flowering plants, so it is important to pay attention to the presence of refugia plants around the main plantings and minimise the application of insecticides. The limiting factors above can influence insect behaviour, such as pollination ability and predation.

Table 1. Diversity index values (H'), evenness (E') and dominance (C) in organic and conventional shallot plantings.

Observation	Organic		Conventional	
	Vegetative	**Generative**	**Vegetative**	**Generative**
H'	2,693	2,885	2,637	2,712
E'	0,708	0,814	0,751	0,822
C	0,114	0,094	0,134	0,124

The highest evenness is found in the generative phase of organic and conventional planting. Observations show that the evenness of insect species in this planting environment is high because E' > 0.6. This shows that the land ecosystem is in good condition. In Table 1, the evenness index value shows that the generative phase is better than the vegetative phase. This shows that the evenness or distribution of insect types in the generative phase is better than in the vegetative phase. The diversity of a community depends on the number of species and the evenness of the number of individuals in each species present. The lowest dominance is found in organic plantings in the generative phase of 0.094; this illustrates that the pattern of dominance of the species in the community is relatively spread across each species.

CONCLUSIONS

There are differences in the composition of herbivorous, predatory, and parasitoid insects on the two plants. There are differences in the diversity (H'), evenness (E), and dominance (C) index values in semi-organic and conventional shallot plantings; the highest H' is in the generative phase of organic planting, namely 2.885; the highest E' is in the generative phase of planting. Conventional is 0.822, and the lowest C belongs to the generative phase in semi-organic planting, namely 0.094.

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