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Biodiversity of Arthropods in Shallot Plantations Applied with Botanical Pesticide Djengkol Peel Extract on Peat Land

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Abstract. The application of botanical pesticides has reported positive effects on increasing arthropod diversity indices in agriculture. This study aims to assess the effect of botanical insecticides from djengkol skin extract on arthropod diversity in shallot plantations in peatlands. This research was conducted on shallot plants on peatland with a randomised group design consisting of four treatments and repeated five times. The treatments consisted of three types of doses of djengkol skin extract, namely 0.125 Kg/ha, 0.25 Kg/ha, 0.375 Kg/ha and a control. This study focused on calculating the index of diversity, evenness, dominance and richness of arthropods. The results showed that the arthropod collection was 2743 heads consisting of Insecta comprises 9 orders (60 families), Arachnida with 1 order (9 families) and Diplopoda with 1 order (1 family). Application of botanical insecticides to shallot plantings on peatlands can increase the index of diversity, evenness, dominance and richness of arthropods.

Keywords: biological control, integrated pest management, peat land, predator-prey interaction

Introduction

Being one of the important vegetable commodities for the community, shallots contain various nutritional content, besides that shallots also have high economic value. The high demand for shallots by the public in the market is because most of them are used as food seasoning. Data from the food crops and horticulture office of south Kalimantan province shows that shallot production is 4,617 tons per hectare (Ruslan, 2021).

Shallot cultivation in Indonesia, especially in South Kalimantan Island, is dominated by the use of chemical pesticides in terms of controlling plant-disturbing organisms, i.e. primary and secondary pests. Excessive use of chemical pesticides harms the presence of arthropod populations in agricultural environments (Büchs *et al.*, 2003). Environmental pollution by excessive use of chemical pesticides results in a decrease in biodiversity in agricultural landscapes, especially the diversity of various non-targeted organisms that plays vital role as natural i.e. predators, parasitoids and other useful organisms (Geiger *et al.*, 2010; Laet and Summers-Smith, 2007; Büchs *et al.*, 2003). In addition to these factors, the use of synthetic pesticides also causes resistance and resurgence of plant-insect pests interaction (Sánchez-Bayo, 2021; Wu *et al.*, 2020). It has been reported that the reduction of insect predators and parasitoids are a negative side effect of chemicals, which causes an increase in pest species due to a reduction in the population of natural enemies (Sánchez-Bayo, 2021; Gutiérrez *et al.*, 2020; Hu *et al.*, 2014).

The existence of arthropods in agricultural landscapes has an important role as an ecological function for the balance of the ecosystem. These ecological functions include decomposer, pollinator, predator and parasitoid (Ghiglieno *et al.*, 2020; Gardiner *et al.*, 2013). In addition, another important ecological function is as a bioindicator in determining environmental quality (Juan-Ovejero *et al.*, 2019). As a bioindicator, a arthropods can be used as a means of detecting changes that occur in the environment (Ghiglieno *et al.*, 2020; Büchs *et al.*, 2003). One alternative to improve environmental quality is to reduce chemical pesticide residues by switching to botanical pesticides in controlling insect pests.

The use of plant-based pesticides is increasingly important in line with the public's demand for processed products from organically produced food (Lengai *et al.*, 2020; Büchs *et al.*, 2003). Botanical pesticides are efficacious in managing different insect pests with diverse phytochemical compositions and are easily biodegradable (Ayil-Gutiérrez *et al.*, 2018). In addition, it has low toxicity against non-target organisms (Ayil-Gutiérrez *et al.*, 2018). The interaction between botanical pesticides and plant pests is natural (biochemical in nature) which allows no resistance to target pests

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(Gamito, 2010). Chemical compounds in essential oil extracts are specific targets for plant pests, but beneficial for pollinating insects and predators (Ngegba *et al.*, 2022; Wu *et al.*, 2020). It is deemed necessary to examine the effectiveness of botanical pesticides from various types of plants in more depth. Therefore, this study will examine the impact of the application of djenkol bean peel as a botanical insecticide on the diversity of arthropods in shallot cultivation on peatlands.

Materials and Methods

Time and place of research. The effect of applying djenkol bean peel as a botanical insecticide on arthropod diversity was carried out from 1st August-31st December 2022. The observation site was carried out on shallot plantations on peat land in Tegal Arum Village (-3°25'44", 11°44'69", 10.8 m, 284°) Banjarbaru City, south Kalimantan province, Indonesia. Identification of arthropod families was carried out at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, University of Lambung Mangkurat.

Treatment of djenkol bean peel powder as a vegetable insecticide. The study was conducted using a one-factor randomized block design, namely the administration of three different doses of djengkol skin extract powder (0.125 Kg/ha, 0.25 Kg/ha and 0.375 Kg/ha). Each treatment was replicated 5 times so that 20 experimental units were formed.

The factors tested are as follows: T_0=without treatment; T_1=Djengkol skin extract powder 0.125 Kg/ha; T_2=Djengkol skin extract powder 0.25 Kg/ha; T_3=Djengkol skin extract powder 0.375 Kg/ha.

Land preparation for planting. The land that is used as the location for planting shallots is peat soil. The choice of peatland land is based on the fact that the province of south Kalimantan is predominantly peatland. Peatland processing is done by hoeing the soil to a depth of no more than 30 cm. Then the soil that is still clumped is destroyed and the remains of weeds are cleaned. Then make beds with a size of 2.5 m × 5 m. The finished beds are then given lime, which was done two weeks before planting. While the application of manure and NPK is given a week before planting. Furthermore, the beds that are formed are left for a week to dry. After the soil dries, small beds are formed, namely 1 m × 2 m and a small ditch is made between the beds to separate the beds.

Provision of shallot seeds as test plants. The shallot seeds used as test plants were the super phillip variety which had been stored for 75 days after harvest. The selection of seeds is carried out uniformly, namely in terms of size, tuber roots are still available and free from pests and plant diseases. The outer and dry shallot skin is cleaned, then to help shoot growth quickly, the end of the bulb is cut with a sterile knife. The next step is for the shallot seeds to stand until the cut marks dry and are ready to be planted.

Preparation of djenkol bean peel extract. The preparation of the extract begins with sorting the dry plant material, namely separating the dirt and damaged plant parts. Then the material that has been sorted is cut into small pieces and then dried and crushed using a blender until it becomes powder, then sifted using interwoven gauze. After that, the powder was weighed ±600 g. The extracted powders were soaked in methanol for 48 h at a ratio of 1:10 (w/v). The results of the soaking are then filtered using filter paper. Each filter was evaporated using a rotary evaporator at a temperature of 60-70 °C with a pressure of 400-450 mm/Hg to obtain a crude extract. The remaining methanol soaking is used to rinse the residue on the filter paper with 3-4 rinses. The extract obtained was then stored in a refrigerator with a storage temperature of ±40 °C until the desired time.

Extract ready for application. Extract that has been prepared and stored is then weighed at 2 g/plot using an analytical balance. There were 12 g of extract for every six replicate plots. The weighed extract was put into an erlenmeyer mixed with 16 mL tween adhesive and 5 mL methanol. The resulting mixture was then stirred using a stirrer with a speed of 700 rpm for 5 min. Then the extract results were ready to be applied to each of the tested plant plots with a spray volume of 500 L/ha.

Preparation for planting and fertilizing. The shallot seeds that had been previously prepared were planted with a spacing of 20 cm × 20 cm. The type of fertilizer and the number of doses used was cow manure (15 tons/ha). Artificial fertilizers: TSP (120 Kg/ha, Urea (150 Kg/ha), ZA (300 Kg/ha) and KCl (150 Kg/ha).

Parameter observation. ***Population and types of arthropods.*** Arthropod sampling was conducted randomly on each plot of land and carried out eight times. The types of trap treatments used were yellow pan trap, swing nets, pitfall traps and soil sampling (±15 cm depth). The trapped insects were then put into plastic tubes filled with 70% alcohol cotton. The captured arthropods in each plot were combined into one based on the same treatment and then identified.

Identification of arthropod. The arthropod identification process was carried out under an OLYMPUS CX21 microscope compound with a Dino-eye AM4234 camera connected directly to the computer. Identification refers to the identification key book: Gibb and Oseto (2006) and Kingsley (1894).

Analysis of observation results. ***Data tabulation.*** Identified data was tabulated using open-source MS. Exel 2010. Then a diversity analysis was performed to find the Shannon-Wienner diversity index (H'), the Pielou species evenness index (E) (Simpson, 1949), dominance index (D) (Simpson, 1949), Simpson diversity index (Gamito, 2010) and the Margalef species richness index (R) (Gamito, 2010).

Results and Discussion

Arthropod abundance of individuals. The results of arthropods collected were 2743 individuals included in 3 classes, 11 orders and 70 families (Table 1). Arthropods included in the insect class (Insecta) were nine orders from 60 families, the spider class (Arachnida) was an order from 9 families and the millipedes class (Diplopoda) was an order from 1 family.

The highest abundance of individual arthropods was in the diptera order, namely 1245 individuals Fig. 1 with a fairly high number coming from the dolichopodidae family (922 individuals). The high number of individuals in this family is suspected because the location where the research is located is a watery soil ecosystem so it becomes a suitable habitat for its development (Bortolotto *et al.*, 2022; Hu *et al.*, 2014). Oviposition and larvae of the dolichopodidae family are mostly aquatic or semi-aquatic and the adults actively fly around their breeding grounds (Hernández, 2008; Prowell *et al.*, 2004).

Composition of the role of arthropods. The role of arthropods found in shallot cultivation on peatlands was divided into; predators, parasitoids, herbivores, detrivores and others (Fig. 2). The identification results showed that the composition of each included predatory insects (55.7%), parasitoids (30.3%), herbivores (12.4%), detritivores (0.4%) and other arthropods (1.2%).

The composition of the role of arthropods in planting shallots on peat with djenkol bean peel powder treatment showed that the dominant collection results were natural enemies, namely predators and parasitoids. The results of this study are in line (Thei *et al.*, 2020), namely arthropods that are more dominant in the rice planting environment with nurseries, cropping, fertilizing and pest and disease control systems with predators and phytophagous following local farming systems.

Diversity index (H'), evenness (E), dominance (D) and species richness (R). ***Diversity index (H').*** The diversity index (H') of arthropods in shallot plants with botanical pesticide treatment of Djengkol skin (Table 2) was categorized as moderate, namely H'=2.64-2.91. In this can be seen based on the Shannon-Wiener diversity index according to Hatta *et al*. (2022), which states that the diversity index in the population is said to be moderate if 1.5<H'<3.5, which means that the types of arthropods present in the four treatments are quite diverse and the ecosystem conditions are quite balanced.

Evenness index (E). The Evenness index (E) in shallot planting treated with djenkol bean peel botanical pesticides (Table 2) ranged from 0.67-0.76. So that the Evenness index value E<1 can be seen in the four treatments (Table 2). According to Hatta (Hatta *et al.*, 2022), this E value ranges from 0-1. The smaller the E value, the smaller the population uniformity, meaning

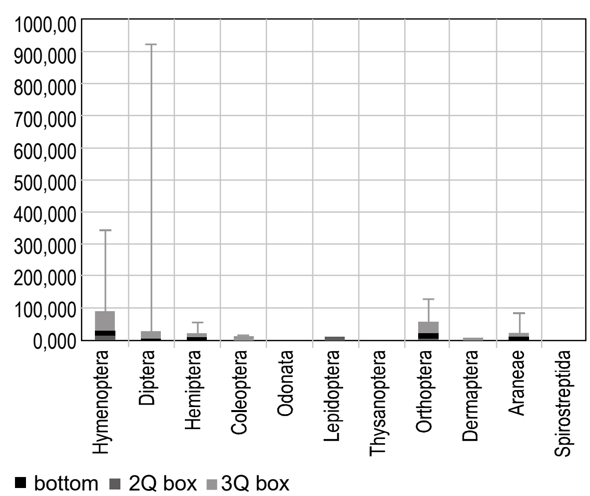

Fig. 1. Average number of individuals within an arthropod order collected from Shallot Plantations Applied with botanical pesticide djengkol peel extract on peat land.

Table 1. Number of classes, orders, families and individuals of arthropods collected

Class	Order	Family	Individual	Each group (%)
Insecta	Hymenoptera	Braconidae	86	
		Pompilidae	46	
		Crabronidae	95	
		Ampulicidae	95	
		Ichneumonidae	26	
		Evaniidae	7	
		Vespidae	2	
		Chalcididae	17	
		Formicidae	346	
		Scelionidae	15	
		Pteromalidae	3	
		Bethylidae	22	
		Eulophidae	54	
			814	29,67
	Diptera	Stratiomyidae	1	
		Tipulidae	3	
		Bibionidae	2	
		Ephydridae	8	
		Muscidae	85	
		Calliphoridae	8	
		Syrphidae	112	
		Acroceridae	10	
		Tephritidae	1	
		Drosophilidae	17	
		Tachinidae	5	
		Rhinophoridae	7	
		Agromyzidae	32	
		Dolichopodidae	922	
		Limoniidae	1	
		Simuliidae	1	
		Ceratopogonidae	30	
			1245	45,39
	Hemiptera	Rhyparochromidae	14	
		Cydnidae	53	
		Corixidae	23	
		Reduviidae	2	
		Aphididae	49	
		Delphacidae	14	
		Membracidae	25	
		Miridae	1	
		Cicadelidae	3	
			184	6,71
	Coleoptera	Carabidae	13	
		Dytiscidae	31	
		Chrysomelidae	37	
		Gyrinidae	2	
		Nitidulidae	0	
		Anobiidae	7	
		Curculionidae	2	
		Eliteridae	5	
		Scarabaeidae	2	
		Phalacridae	2	
		Coccinellidae	14	
			115	4,19

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	Class	Order	Family	Individual	Each group (%)
		Odonata	Coenagrionidae	2	0,07
		Lepidoptera	Hesperiidae	7	
			Noctuidae	1	
			Erebidae	1	
				9	0,33
		Thysanoptera	Thripidae	1	0,04
		Orthoptera	Pyrgomorphidae	1	
			Gryllidae	129	
			Gryllotalpidae	10	
			Acrididae	36	
				176	6,42
		Dermaptera	Carcinophoridae	5	0,18
	Arachnida	Araneae	Deinopidae	2	
			Lycosidae	82	
			Salticidae	25	
			Linyphiidae	50	
			Theridiidae	1	
			Anyphaenidae	17	
			Oxyopidae	7	
			Desidae	3	
			Araneidae	4	
			191	6,96	
	Diplopoda	Spirostreptida	Spirostreptidae	1	0,04
Total	3	11	70	2743	100

that the distribution of the number of individuals of each type is not the same and there is a tendency for one number of individuals to dominate and vice versa the greater the value of E, no individual species dominates.

Dominance index (D). The Dominance index value (D) obtained on shallot planting treated with djenkol bean peel botanical pesticides (Table 2) was categorized in the low category range (D=0.15-0.24). The results

Table 2. Diversity Index (H'), evenness (E), dominance (D) and species richness (R)

Description	Treatment			
	T_0	T_1	T_2	T_3
Diversity index (H')	2.91	2.84	2.64	2.86
Evenness index (E)	0.76	0.74	0.67	0.75
Dominance index (D)	0.15	0.18	0.24	0.20
Species richness (R)	7.08	7.11	7.81	7.39

Description : T_1=Djenkol bean skin powder 0.125 Kg/ha; T_2=Djenkol bean skin powder 0.25 Kg/ha; T_3=Djenkol bean bark powder 0.375 Kg/ha.

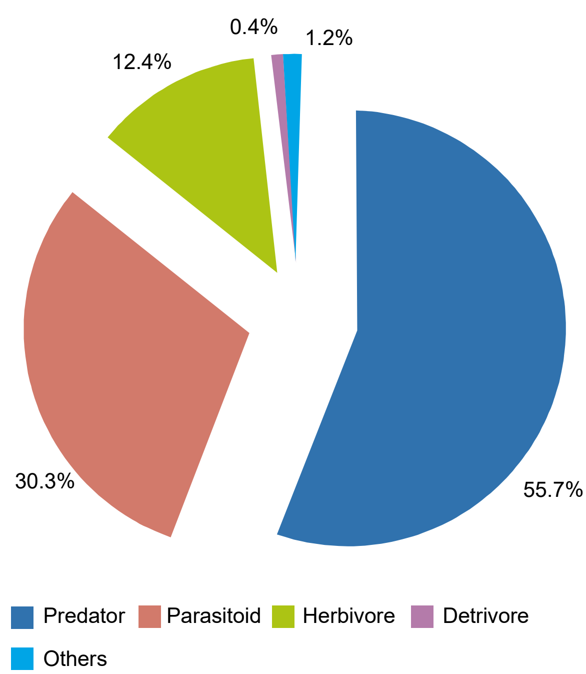

Fig. 2. The percentage of arthropod roles found in onion plants.

of this study are in line (Srivastava *et al.*, 2022) with the findings of the Simpson's index ranging from (D=0.171-0.193). This shows that shallot cultivation has various arthropod species and no single species dominates. In line with the statement of Mokam *et al.* (2014), which states that if the dominance index value is <1 then the arthropod species are diverse, conversely if the dominance index value=1, then the arthropod species are not diverse. The existence of various arthropods in a homogeneous environment is also influenced by soil characteristics, topography, vegetation, weather and other environmental factors that also regulate the existence of each arthropod species (Outhwaite *et al*., 2022; Adler and Courtney, 2019).

Species richness index. The species richness index (R) value obtained in shallot planting treated with djenkol bean peel botanical pesticides (Table 2) was categorized in the high category range (R=7.08-7.81). Arthropod species richness and high diversity index indicate a balance of phytophages and their natural enemies, thus revealing the potential of natural pest control mechanisms in ecosystems (Thei *et al.*, 2020). The relative species richness of the arthropod community follows the growth of shallot plants in that ecosystem. This is following the criteria for the wealth index according to (Price *et al.*, 2011) that the value of R>5 is high.

Conclusions

The application of botanical pesticide of djengkol fruit peel extract in shallot cultivation has a positive effect on arthropod diversity in peatland. The level of arthropod diversity, namely predators, parasitoids, herbivores and detrivores, has an optimal role in supporting the sustainability of good agricultural practices including shallot cultivation.

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Conflict of Interest. The authors declare that they have no any conflict of interest.

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