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BENEFICIAL AND HARMFUL ARTHROPODS DIVERSITY OF SEMI ORGANIC CHILI IN SANDY SOIL OF PALANGKA RAYA CITY

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ABSTRACT
Palangka Raya's city has marginal sandy soil for agricultural development. Chili are commonly grown in this area, but they face challenges due to pest attacks. The use of pesticides to control pests has a detrimental effect on the beneficial arthropod population. To address this issue, it is necessary to adopt semi-organic farming systems. The research aims to determine the population, diversity, and dominance. The research was conducted from October 2020 to January 2021 at the Laboratory of the Department of Agronomy, Faculty of Agriculture, University of Palangka Raya. We employed 3 trapping techniques, namely Sweep net, Pitfall trap, and Light trap on sandy areas covering approximately 600 m^2. Chili plants were treated using organic and inorganic fertilizers, trichocompost, and bioinsecticide. The results of the study showed that beneficial arthropods caught were 453 individuals during six periods of observation, with Predators (67.82%), Parasitoids (10.60%), Pollinators (1.46%), and Detritivores (2.93%), respectively. The harmful arthropods caught were 94 individuals (17.18%). Chili plant diversity index (H') ranged from low to high category (H' = 0.6-2.48), while the dominance index (D) was classified as low to high (D = 0.1-1.73). The evenness index (E) of the community fluctuated before stabilizing (E = 0.52-1.65). Arthropods family abundance (N1) was classified as less to sufficient (N1 = 1-1.67).

KEY WORDS
Diversity, beneficial arthropods, pest arthropods, chili.

Tanjung Pinang Village is located in Pahandut District, Palangka Raya City, and has a total area of 48.26 km2 (40.43%). Agricultural development has been planned in Palangka Raya City, particularly on marginal lands containing quartz sand soil. This area is intended to cultivate crops such as chilies as well as other types of horticultural commodities including watermelons, melons, oranges, papayas, durians, and crystal guava (Statistics of Palangka Raya, 2018). The Tanjung Pinang sub-district's quartz sand area measures approximately 33.6 ha. Quartz sand soil has the potential for chili cultivation. There are no significant obstacles to enhancing the productivity of the soil, as long as there is an adequate supply of agricultural lime, manure, and inorganic fertilizers (Firmansyah et al., 2011; BPTP Central Kalimantan, 2012).

The findings of (Melhanah *et al*., 2015[a]) indicated a relatively high diversity and abundance of arthropods obtained in sweet corn, long beans, and mustard greens agroecosystem. Arthropods were more abundant on sweet corn and long beans that had not been treated with synthetic insecticides (Melhanah *et al*., 2015[b]). Additionally, Melhanah *et al*., (2021) found that there were more beneficial arthropod families than pest arthropod families. Beneficial arthropod families numbered 36 (62.07%), including predators, parasitoids, pollinators, detritivores, and neutral insects, while pest arthropods numbered 22 families (37.93%). Pests' attacks are a common problem in chili cultivation. Several human pest-control activities include the use of chemical pesticides, which harm the presence of beneficial arthropods. To address this issue, it is necessary to implement organic or semi-organic farming systems to conserve and utilize beneficial arthropods.

Melhanah *et al*., (2018) suggested that organic vegetables have the potential to be developed for the conservation of beneficial arthropods such as natural enemies and neutral insects, as indicated by the following indicators, namely organic long beans have a higher predator species richness than conventional ones (R=2.71 and 1.81). Organic sweet corn and long beans exhibit predator dominance, specifically Gryllidae (C=0.33), Formicidae (C=0.46), and Miridae (C=0.11). Furthermore, organic sweet corn had a higher diversity of parasitoids and neutral insects than conventional crops (R=1.26 and 1.19). The study intends to investigate the diversity and abundance of beneficial and harmful arthropods in semi-organic chili cultivation on sandy soil in Palangka Raya City.

MATERIALS AND METHODS OF RESEARCH

Field research was conducted from October 2020 to January 2021 on the sandy soil of Jl. Telawang Raya, Tanjung Pinang Village, Pahandut District, Palangka Raya City, Central Kalimantan. Laboratory research was carried out at the Department of Agronomy, Faculty of Agriculture, University of Palangka Raya. In the field study, chili plants were grown on a plot of 600 m^2 of sandy soil. A semi-organic chili was planted on each plot using 70 kg/ha of Urea fertilizer, 40 kg/ha of TSP, and 150 kg/ha of chicken manure, combined with trichocompost containing mushroom species such as *Gliocladium* sp., T *Trichoderma longibrachiatum,* and *T.koningii*. Control of pests and diseases was implemented using mechanical methods and bioinsecticides, including weeds such as *Cassia alata* L. and *Chromolaena odorata* L.

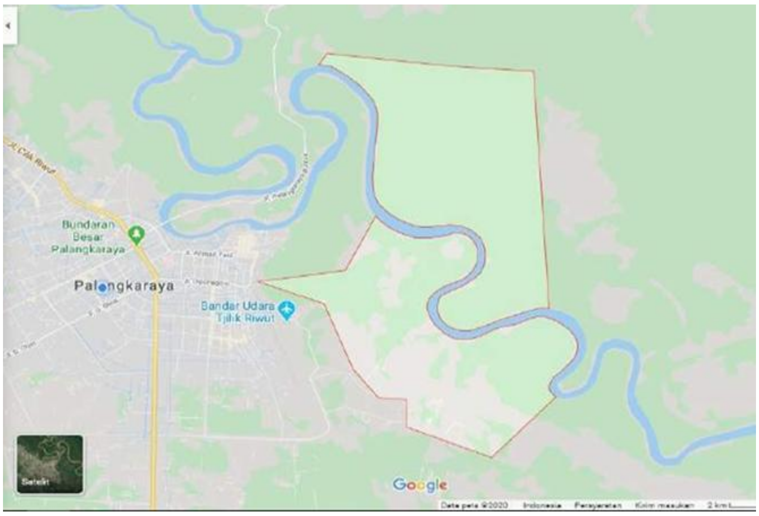

Figure 1 – Map of the Tanjung Pinang Village area, Pahandut District (Source: Map Data © 2020)

We used three trapping techniques to capture active insects during the day and at night namely, *Sweep net*, *Pitfall trap*, and *Light trap*. Dry and wet collection methods were used to preserve the captured arthropods. Arthropod identification was performed based on identification books by Borror *et al*. (1991), Reissig *et al*. (1986), and Kalshoven (1981), who focused on family-level morphological characteristics. Following are some of the aspects of the data analysis: 1) Abundance of beneficial arthropods; 2) Abundance of harmful arthropods; 3) Diversity indices of beneficial and harmful arthropods, including diversity index (H'), dominance index (D), evenness (E), and the total abundance of families in the sample (N1); and 4) Grouping and Percentage of Individual Abundance and Arthropod Family Abundance in Chili Plantation Based on Ecological Role. The Shannon-Wiener Index (Zar, 1984) was employed for the analysis of diversity indices and the abundance of arthropods.

The dominance and evenness of the number of individuals in each family were calculated using the evenness index (Odum, 1996).

Diversity index (H'); was calculated using the following formula:

$$H' = -\sum \left[\left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right) \right]$$

Where:

- H '= Shannon - Wiener diversity index; ni = Number of individual species;
- ln = natural logarithm;
- N = Total number of individuals from the sample.

Criteria: H '<1 (low diversity); 1 <H'≤3 (moderate diversity), and H'> 3 (high diversity).

The formula for measuring the dominance:

$$D = \sum_{i=1}^{s} (Pi)^2$$

Where:

- D = dominance index;
- Pi = comparison of the i-th proportion S = number of families.

Criteria: 0 <D ≤ 0.5 (low dominance), 0.5<D ≤ 0.75 (moderate dominance), 0.75 <D ≤ 1 (high dominance).

Evenness index, which was calculated by formula:

$$E = H'/\ln S$$

Where:

- E = Evenness index H '= diversity index ln = natural logarithm;
- S = number of species (in this case family);

Criteria for environmental communities: 0.00 <E ≤ 0.50 (depressed community), 0.50 <E ≤ 0.75 (unstable community), 0.75 <E ≤ 1.00 (stable community.

Abundance index, which was calculated by formula:

$$N1 = \exp(H')$$

Where: N1 = Abundance index H '= diversity index.

Criteria for species abundance: 0 (none), 1-10 (less), 11-20 (enough), N1≥20 (many).

RESULTS AND DISCUSSIONS

The results from six observation periods revealed that the captured beneficial arthropods comprised nine orders, consisting of 37 families with a total population of 453 individuals. The arthropods were obtained through trapping methods including *sweep net*, *pitfall trap*, and *light trap* (Table 1).

Table 1 – Total number of beneficial arthropods on semi organic chili plant

ORDER	Family and number of individuals	The role of ecology	Total
COLEOPTERA	Silphidae (10); Coccinelidae (4); Curculionidae (1);Phalacridae (1)	Predator	16
ORTHOPTERA	Gryllidae (42); Mantidae (1);	Predator	43
	Blattidae (3)	Detritivor	3
DIPTERA	Tabanidae (31); Sarcophagiadae (6); Stratiomydae (2); Bombyliidae (2); Pipunculidae (1); Muscidae (2);	Parasitoid	44
	Asilidae (6); Syrphidae (1)	Predator	7
HYMENOPTERA	Formicidae (72)	Predator	72
	Vespidae (7); Apidae (6)	Pollinator	13
HEMIPTERA	Nabidae (1); Reduviidae (1)	Predator	2
ODONATA	Libellulidae (4); Gomphidae (3); Macromiidae (2); Coegrionidae (1); Corduliidae (1); Aeshnidae (1)	Predator	12
ISOPTERA	Termitidae (13)	Detritivor	13
ARANEIDA	Thomicidae (202); Lycosidae (12); Oxyopidae (11)	Predator	225
SCOLOPEN-DROMORPHA	Criptopidae (2)	Predator	2
	TOTAL		453

The sweep net catch yielded Class Insecta, which consisted of 6 orders and 30 families. 5 orders and 29 families were predators, 2 orders and 10 families were parasitoids, and one order acted as a pollinator. The *pitfall trap* captured arthropods from three classes: Arachnida, Insecta, and Chilopoda. These arthropods functioned as predators (7 orders and 8 families) and detritivores (2 orders and 2 families). The *light trap* catch resulted in 2 orders and 2 families of detritivores.

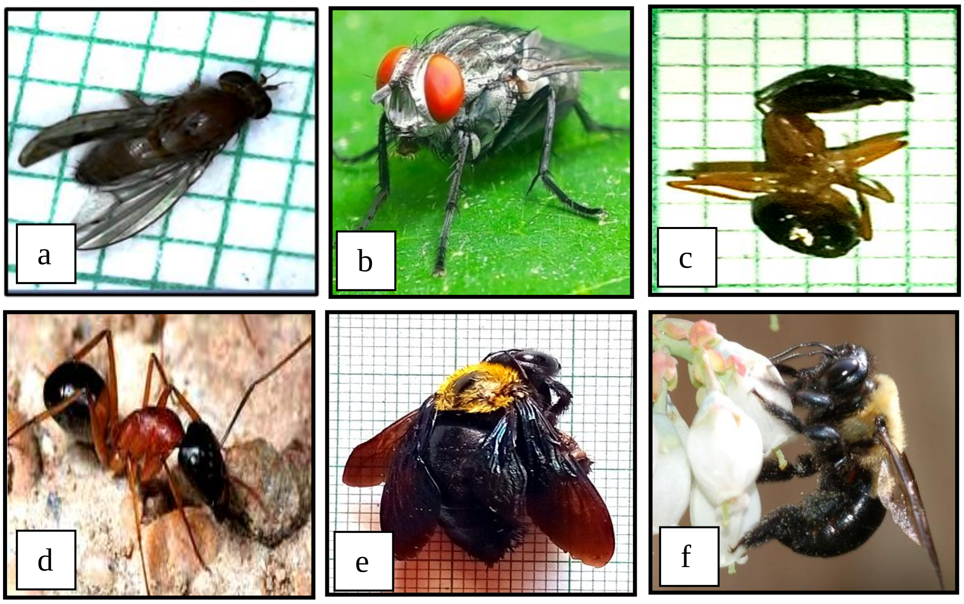

Figure 2 – Catch results using sweep net traps based on role and largest population size (a-f): a). The order Diptera (Tabanidae) which acts as a parasitoid, and b). The comparison; c). The order Hymenoptera (Formicidae) which acts as a predator, and d). The comparison; e). The order Hymenoptera (Apidae) which acts as a pollinator, and f). The comparison. (Source: Personal Documentation, 2020; Purnomo, 2010)

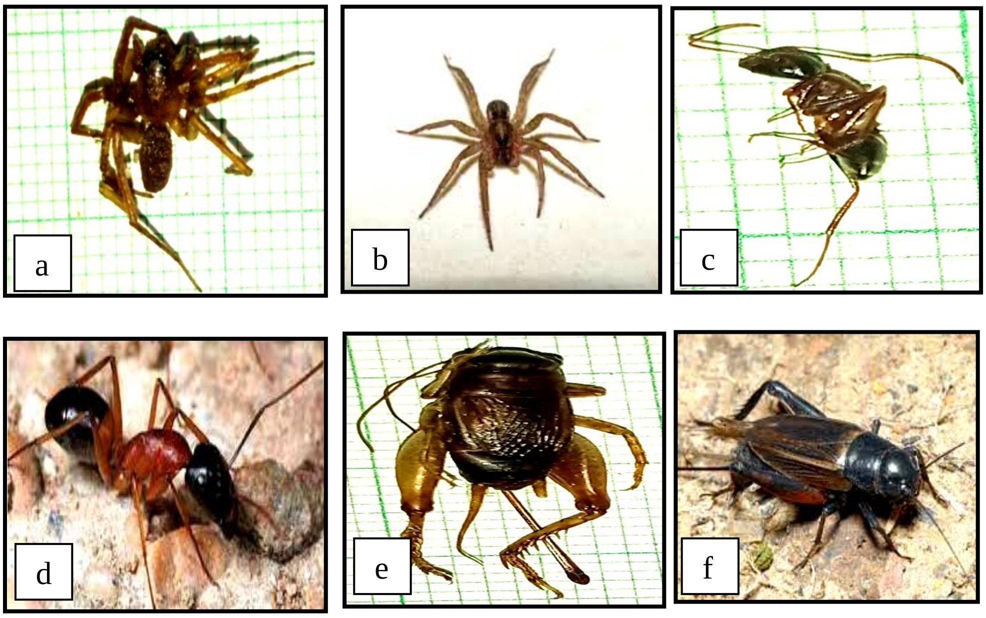

Figure 3 – Catch results with Pitfall Traps based on role and largest population number: a). The Araneida order (Thomisidae) which acts as a predator and b). Comparison; c) The Hymenoptera order (Formicidae) which acts as a predator and d). Comparison; e). The Orthoptera order (Gryllidae) which acts as a predator and f) Comparison (Source: Personal Documentation, 2020; Purnomo, 2010)

The sweep net trap captured 21 individuals, the highest population among the parasitoid family Stratiomidae of the Diptera order. The *pitfall trap* captured a total of 334 individuals, with the Thomisidae family of Araneida order being the most abundant (202 individuals). Notably, the Thomisidae family acted as predators and was abundant in the surface area of mature chili plants during the reproductive phase (8 weeks after planting (WAP).

Trapping methods such as a sweep net, pitfall trap, and light trap successfully captured 94 individuals from five orders, and nine families of harmful arthropods, as demonstrated by the research findings from six observation periods (Table 2).

Table 2 – Total number of harmful arthropods on Semi organic chili plant

Order	Family and number of individual	The role of ecology	Total
Coleoptera	Nitidulidae (23); Scarabaedae (7); Chrysomelidae (2)	Pest	32
Orthoptera	Grillotalpidae (26); Acrididae (2)	Pest	28
Homoptera	Aleyrodidae (26)	Pest	26
Hemiptera	Pentatomidae (5)	Pest	5
Lepidoptera	Pieridae (2); Geometridae (1)	Pest	3
Total			94

The sweep net trap captured 26 individuals from Order Homoptera, Family Aleyrodidae (26 individuals), which was the highest population. Similarly, the pitfall trap yielded the highest population of 26 individuals, but from different orders and families, including Order Orthoptera, Family Gryllotalpidae, and Order Coleoptera, Family Nitidulidae.

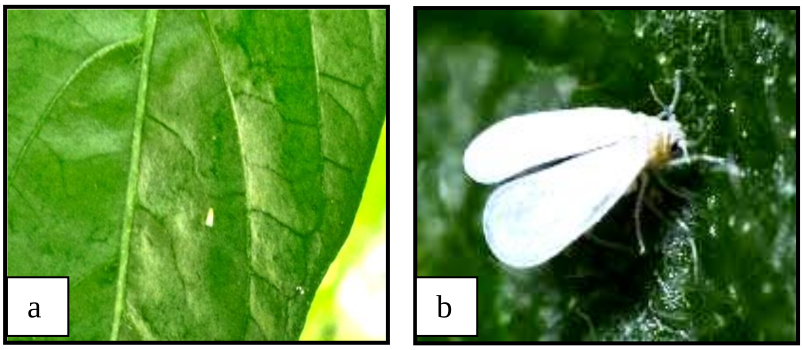

Figure 4 – Catch results using sweep nets based on role and largest population size:
a). The order Homoptera (Aleyrodidae) which acts as a pest and b). Comparison
(Source: Personal Documentation, 2020; Purnomo, 2010)

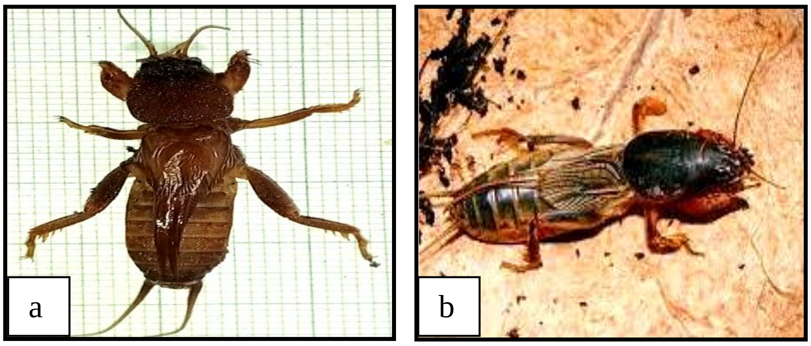

Figure 5 – Catch results with Pitfall Traps based on Role and Largest Population Number:
a). the Orthoptera order (Gryllotalpidae) which acts as a pest and b) comparison
(Source: Personal Documentation, 2020; Purnomo, 2010).

During the six observation periods, the study found that the Diversity index (H') in chili plants from low to high category (H' = 0.6-2.48). The Dominance index (D) ranged from low to high (D = 0.1-1.73). The community's Evenness index (E) fluctuated before stabilizing (E = 0.52-1.65). Arthropods family abundance (N1) belongs to the criteria of less to sufficient (N1 = 1-1.67) (Table 3).

Table 3 – Diversity Index (H'), Dominance Index (C), Evenness Index (E), and Arthropod Abundance Index (N1) in Semi-Organic Chili Plants based on the age of observation and caught in 3 traps

Plant Age (WAP)	*Sweep net (canopy)*				*Pitfall trap (soil surface)*				*Light trap (nocturnal)*			
	H'	C	E	N1	H'	C	E	N1	H'	C	E	N1
2	0	1	0	1	1.65	0.24	1.65	9.88	0	0	0	0
4	2.31	0.12	0.81	14.2	1.48	0.29	0.76	8.70	0.6	0.5	1	2.82
8	1.95	0.16	0.93	10.2	1.73	0.38	0.65	7.35	0	1	0	1
10	1.85	0.25	0.74	14	1.29	0.35	0.72	7.48	0	0	0	0
11	2.06	0.18	0.86	11.9	0.73	0.63	0.52	4.80	0	1	0	1
12	2.48	0.1	0.94	16.7	1.06	0.50	0.59	7.17	0	0	0	0

Note: WAP - weeks after planting.

The arthropod diversity index (H') values for chili plants canopies and ground surfaces, observed five times, fall within the moderate diversity category (1 < H' ≤ 3.32) (Table 3). According to Wardani *et al* (2015), moderate diversity may indicate a relatively low level of ecosystem stability. The diversity index (H') values for arthropods on the ground surface and nocturnal insects at observation ages 11 and 4 WAP were categorized as low diversity (H'<1). Yasurruni (2018) stated that low diversity contributed to a low number of families and individuals and limited variety.

The efficacy of the pitfall trap was demonstrated by the capture of only four families at 11 WAP, while the light trap captured only one family at 4 WAP. The dominance index (C) for chili crops in capture results varies between low dominance (C < 0.5), moderate dominance (0.5<D≤0.75), and high dominance (0.75<D≤1), with low dominance indicating no dominant arthropod individual. Moderate dominance (C = 0.50-0.63) was observed in the pitfall trap capture results at observation ages 11 and 12 WAP, while dominance (C = 1) was obtained in the sweep net capture results (2 WAP) and light trap capture results (8 and 11 WAP). These results highlight the importance of determining dominance in chili cultivation (Melhanah *et al*., 2021).

The evenness index (E) values in capture results were classified into stable (0.75 < E ≤ 1.00) and labile communities (0.50 < E ≤ 0.75). Stable arthropod communities are found in plant canopy (Ages 4, 8, 11, and 12 WAP), ground surface (2 and 4 WAP), and nocturnal insects (4 WAP). Labile communities were observed in the plant canopy (Age 10 WAP) and ground surface (4, 8, 10, 11, and 12 WAP).

The abundance of arthropod families (N1) in large chili plants was categorized into sufficient and insufficient criteria. Sufficient criteria were observed in the canopy of plants (4-12 WAP), while the insufficient criteria were found in the canopy, (2 WAP), ground surface (2-12 WAP), and nocturnal insects (4, 8, and 11 WAP). Agustinawati *et al*. (2016) provide criteria for family abundance, with values ranging as follows: 0: absent, 1 - 10: insufficient, 11 - 20: sufficient, and N1 ≥ 20: very abundant.

The data on arthropod's semi-organic chili cultivation, from vegetative to generative phases have been categorized based on ecological roles. The data includes individual and family abundance, highlighting the importance of understanding these phases. Individual abundance data is presented in Table 4, while family abundance data is shown in Figure 6.

Table 4 – Grouping and percentage of arthropod individual abundance by ecology's role according to the number of individuals and families caught in 3 traps

No.	Role	Sweep net		Pitfall trap		Light trap		Total	
		∑ Indv	%	∑ Indv	%	∑ Indv	%	∑ Indv	%
1.	Predator	41	28.27	330	85.27	0	0	371	67.82
2.	Pest	38	26.20	53	13.69	3	20	94	17.18
3.	Parasitoid	58	40	0	0	0	0	58	10,60
4.	Pollinator	8	5.51	0	0	0	0	8	1,46
5.	Detritivore	0	0	4	1.03	12	80	16	2.93
Total		145	100	387	100	15	100	547	100

Note: Indv. - Individuals.

This high population in the field supports the importance of parasitoid insects in pest management. The population of beneficial arthropods in the field was high, with 453 individuals (82.82%), primarily composed of natural enemies (predators and parasitoids) of 429 individuals (78.43%), pollinators and detritivores as many as 24 individuals (4.39%). The harmful (pest) group consists of 94 individuals (17.18%). The high number of parasitoids in the sweep net captures (58 individuals, 40%) requires the preservation of chemical insecticides (Table 4). Melhanah et al., (2020) also pointed out that organic long beans have a higher number of parasitoids than conventional long beans. This is consistent with the viewpoint of Sadrian et al. (2019) that the crucial role of parasitoid insects is their ability to control pests, and that their populations in the field are relatively high.

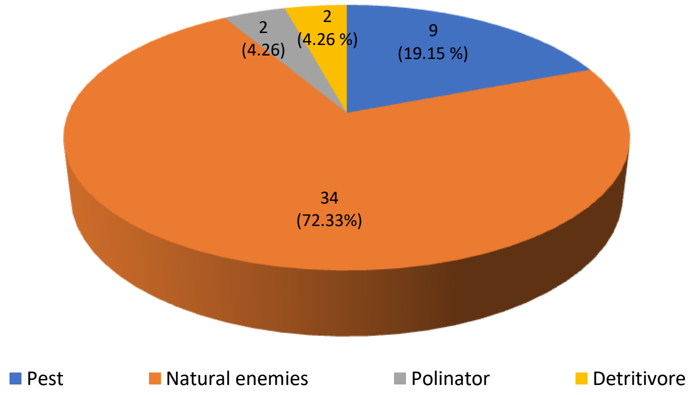

Figure 6 – Percentage composition of the abundance of arthropod families in the chili crops planting area

The high population of natural enemies is also supported by the large number of families, including 34 (72.33%), 24 (51.06%), and 10 (21.27%) (Figure 1). Predators include the Insecta class, Arachnida, and Chilopoda, while parasitoids consist of the Insecta class. Spider predators from the Araneida family consume caterpillar larvae, while dominant predators included the Diptera order (Tabanidae family), Hymenoptera order (Formicidae family), and Orthoptera order (Gryllidae family).

Pollinator insects, found in 2 families (4.26%), namely the Apidae and Megachilidae families, play a crucial role in plant pollination. Detritivore insects, found in the Isoptera (Termitidae family) and Orthoptera order (Blattidae family) (4.26%), contribute to organic matter decomposition. The harmful insect group comprised 9 families (19.15%), including Coleoptera (Chrysomelidae, Nitidulidae, Scarabaeidae families), Orthoptera (Acrididae, Gryllotalpidae families), Homoptera (Aleyrodidae family), Hemiptera (Pentatomidae family), and Lepidoptera (Geometridae and Pieridae families). These insects contribute to the overall ecosystem.

CONCLUSION

The study revealed that beneficial arthropods were found in chili, with 453 individuals, mainly predators, parasitoids, pollinators, and detritivores. Harmful arthropods were captured at 17.18%. The diversity index in chili ranged from low to high, indicating varied species presence. The dominance index showed different levels of species prevalence. The evenness index showed fluctuations before stabilizing, suggesting changes in species distribution over time. Family abundance varied from less to sufficient, reflecting different levels of arthropod family representation.

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REFERENCES

1. Agustinawati, & Wahid, M. H. T. A. 2016. Soil Surface Arthropod Diversity in Chilli (Capsicum annum L.) Plants with Different Cropping Systems in Sigi Regency. J. Agrotekbis. 4 (1): 8 – 10 [Indonesian].
2. Badan Pusat Statistik Kota Palangka Raya. 2018. Pahandut Sub-district in Figures 2018. BPS Kota Palangka Raya. [Indonesian].
3. Borror D.J, D.M. De Long and C.A. Triplehorn. 1991. An Introduction to The Study of Insects. Saunders College Publishing, Philadelphia.
4. BPTP Kalteng. 2012. Utilisation of Quartz Sand Soil for Farmland is Not a Big Deal. Online. Info Aktual. Accessed 12 Agustus 2020. [Indonesian].
5. Firmansyah, M. A. N. Yuliani, W.A. Nugroho Hermanto. 2011. Assessment of Inorganic Fertilisation Package for Seedless Watermelon in Quartz Sand Soil. Proceedings of the National Seminar on Accelerating Agricultural and Rural Development Based on Innovation and Local Resources. Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian, Bogor. pp : 304-310 [Indonesian].
6. Kalshoven. L.G.E. 1981. The Pest of Crops in Indonesia. Revised and translated by P.A. Van Der Laan. P.T. Ichtiar Baru Van Hoeve, Jakarta.
7. Melhanah, D. Saraswati and L. Supriati. 2015b. Arthropod Diversity and Abundance in Sweet Corn, Long Bean and Mustard Agroecosystems on Peatland. Seminar Nasional Bidang Ilmu Pertanian BKS-PTN Wilayah Barat. Palangka Raya, 20-21 Agustus 2015. [Indonesian].
8. Melhanah, Rahmawati Budi Mulyani, and Mario Satrio. 2021. Biodiversity and Arthropod Abundance in Semi Organic Rice in a Swamp Lowland of Palangka Raya City. Akta Agrosia 24(2):39–44.
9. Melhanah., D. Saraswati and L. Supriati. 2015a. Arthropod communities in sweet corn and long bean agroecosystems with and without insecticide treatment on peatland. J. Agripeat. 16(1):36-44. [Indonesian].
10. Melhanah., Supriati, L and Saraswati, D. 2018. Potential of Organic Farming System in Conserving Natural Enemies of Neutral Pests and Insects in Vegetable Crops on Peatland. J. Agripeat. 19 (1):44-50. [Indonesian].
11. Melhanah., Supriati, L., and Saraswati, D. 2020. Community Structure of Nocturnal Arthropods in Organic and Conventional Sweet Corn and String Beans in Peatlands. Jurnal Daun. 7 (1): 11-12. Fakultas Pertanian, UMPR. Palangka Raya [Indonesian].
12. Odum, E.P. 1996. Fundamentals of Ecology. Gadjah Mada University Press, Samingan, Tjahjono.eds. Yogyakarta. [Indonesian].
13. Purnomo, H. 2010. An Introduction to Biological Control. CV Andi Offset. Yogyakarta. [Indonesian].
14. Reissig, W.H, E.A. Heinrichs, J.A. Litsinger, K. Moody, L. Fiedler, T. W. Mew and A.T Barrion. 1986. Illustrated Guide to Integrated Pest Management in Rice in Tropical Asia. International Rice Research Institute Los Banos Lguna Philippines, Manila.
15. Sadrian Noor Effendi, Elly Liestiany, Dewi Fitriani. 2019. Diversity of Insects Associated with Large Red Chili Plants (Capsicum annum L) in North Loktabat Village, Banjarbaru. J. Proteksi Tanaman Tropika 2(01):76-80. [Indonesian].
16. Wardani, N, W., Rohman, F., Masjudhi. 2015. Diversity and abundance of predatory arthropods in monoculture and polyculture broccoli (Brassica oleracea) farms in Sumberbrantas village, Bumiaji sub-district, Batu city. Program Study of Agroecotechnologi. Faculty of Agriculture. Universitas Mataram. [Indonesian].
17. Yasurruni, K. 2018. Abundance and diversity of soil surface arthropods in cayenne pepper (Capsicum annum L.) cropping ecosystems in Kuripan, West Lombok. Faculty of Agriculture. Universitas Mataram. [Indonesian].
18. Zar, J.H. 1984. Biostastical Analysis: Second Edition. Prentice Hall Inc. Englewood Cliffs, New Jersey.