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BIODIVERSITY OF ARTHROPODS AND DISEASES ON INDIGENOUS VEGETABLES IN CENTRAL KALIMANTAN

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ABSTRACT
The Dayak tribe consumes wild indigenous vegetables as a part of their diet. However, there is limited information available about the pests and diseases affecting these vegetables. To address this, a study was conducted to investigate and identify the presence of natural enemies such as parasites and predators, as well as to assess the dominance of arthropods and the occurrence of diseases. The parameters studies included the symptoms of pest and disease attacks, the dominance index and incidence of diseases, and the order and family classifications of arthropods, based on the morphology of pests, parasites, and predators, respectively. Results revealed that the arthropods identified were composed of 8 orders, 36 families and 660 individuals. The predator population was found to be 94.46% on the soil surface, while the population of nocturnal insects was 74.19%. The presence of pests was predominantly found on the canopy, accounting for 92.83%. The arthropod dominance index was categorized as high, with values of 0.58 and 0.75, dominated by yellow mites (Tarsonemidae) and weaver ants (Formicidae). On the other hand, the dominance index of nocturnal insects was only 0.15. The disease incidence of Solanum ferox caused by *Colletotrichum* sp was 5%, lower than that observed in *Helminthostachys zeylanica*, *Allium schoenoprasum*, and *Ceratopteris thalictroides* caused by *Curvularia* sp (45.8%), but still considered to be in the non-hazardous category.

KEY WORDS
Exploration, identification, pest, disease, indigenous vegetable.

Indigenous vegetables are gaining significant recognition, especially in developing countries, where they serve as a cost-effective and vital source of vitamins and minerals for rural communities facing poverty and unemployment. These vegetables play a crucial role in ensuring food security (Bua and Onang, 2017). Additionally, the nutritional content of wild vegetables including carbohydrates, protein, fat, fiber, and vitamin C is sought after by communities aiming to adopt a natural and healthy lifestyle (Chotimah et al., 2018). Central Kalimantan has more than 15 000 species, offering direct or indirect support for sustainable food security (Susilawati et al., 2015). Among these valuable resources are indigenous vegetables, which play a crucial role in meeting the mineral and vitamin requirements of the Dayak community. The most commonly consumed vegetables in this region include bajei (*Ceratopteris thalictroides*), kelakai (*Stenochlaena palustris*), kambang henda (*Curcuma xanthorrhiza*), teken parei (*Helminthostachys zeylanica*), bawang suna (*Allium schoenoprasum*), kanjat (*Gymnoptalum chochinense*), and rimbang masem (*Solanum ferox*) along with mushrooms (Irawan et al., 2006; Chotimah et al., 2013; Nion et al., 2018). However, there is a concerning issue of post-harvest losses, which account for approximately 10-30% of the total vegetable production, as reported by (Chotimah et al., 2018). Addressing this issue is crucial to fully harness the potential benefits of indigenous vegetables and ensure sustainable food availability. One of the major obstacles in agriculture is the presence of plant disease and insect pests, which have a detrimental impact on almost all crops. These pests and diseases can cause damage to the appearance, texture, aroma, nutritional value, and safety of vegetables. The disease caused the yield loss of around 25% (Lugtenberg, 2015) while insect pests can reduce crop production by up to 10.8% (Dhaliwal et al., 2015) worldwide. In central Europe, cereal crops suffer losses attributed to the common vole, which has the ability to multiply rapidly, leading to considerable economic losses in crop value (Heroldová and Tkadlec, 2011).

The tropical pest, cosmopolitan, and polyphagous armored *Aulacaspis tubercularis* caused up to 90% yield losses. The pest produced conspicuous pink blemishes on the mango fruits, which depreciate their commercial value and make them unacceptable for export markets (del Pino et al., 2020). The analysis to quantify and map maize storage losses using a geographic information system exhibited the highest maize losses after a one-year storage period with an average of 76% loss and 100% grain damage. The main storage pests identified were the maize weevil, *Sitophilus zeamais*, the larger grain borer, *Prostephanus truncatu*, angoumois grain mouth, and *Sitotroga cerealella* (García-Lara et al., 2019). Pests and disease produced damages aromatic plant development due to adversely affecting both the quantity and quality of biomass. The pests observed were leaf sap-sucking pests, defoliators, flower-feeding pests, fungal diseases, and root nematodes (Gahukar, 2018). An investigation by Nyamwasa et al. (2018) identified fifty-five soil-dwelling insect pests. Species numbers of Scarabaeidae and Termitidae were 36% and 30%, respectively. The three families including Agromyzidae, Pionidae, and Curculionidae were the most notorious soil-dwelling insect pests in East Africa.

Unfortunately, there has been very limited information regarding the damage caused by pests and diseases on indigenous vegetables which can lead to a decline in both their quantity and quality. To address this problem, it is critical to have a comprehensive inventory of pests and diseases that affect indigenous vegetables in order to improve their quality. The overall objective of this study was to conduct a comprehensive exploration and inventory of pests, diseases, and natural enemies found on indigenous vegetables in both fields and markets, with the ultimate goal of reducing post-harvest losses and ensuring food security through proper vegetable management.

MATERIALS AND METHODS OF RESEARCH

Exploration for arthropods and disease was carried out purposively in two districts of Central Kalimantan Indonesia namely Palangka Raya and Katingan based on the indigenous vegetable abundance. The study locations were Pahandut, Sebangau, Katingan Hilir, and Tewang Sangalanggaring sub-districts, respectively (Figure 1).

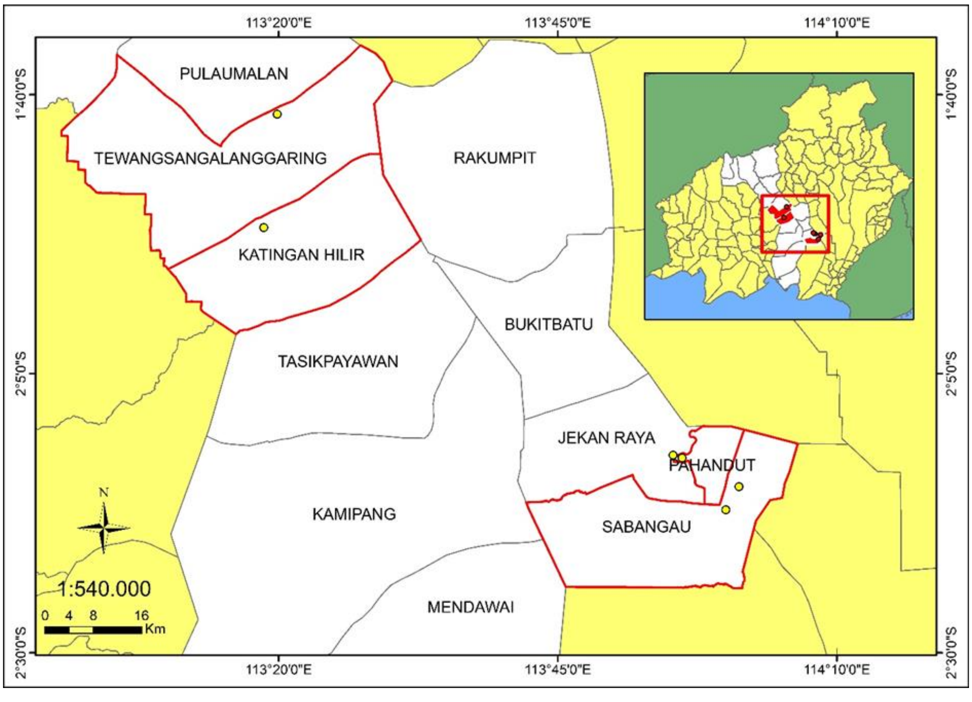

Figure 1 – Location of exploration

Some indigenous vegetables were selected for the study namely *Ceratopteris thalictroides*, *Helminthostachys zeylanica*, *Allium schoenoprasum*, *Gymnoptalum chochinense*, *Stenochlaena palustris*, and *Solanum ferox*. The observation was done by collecting these vegetable species from the field, their native habitat, and traditional market. The vegetables, then, were identified for their pests and diseases in the laboratory of the Agronomy Department, Faculty of Agriculture, University of Palangka Raya. Exploration and identification of diseases based on Semangun (2007) and Westcott (1971). Arthropods sampling was executed using a sweep net, light trap, and pitfall trap. The arthropod identification was done based on the identification books of Borror et al. (1991) and Kalshoven (1981) through the family morphologically. Identification of pathogens based on both macroscopic and microscopic characteristics with the appropriate fungal characteristics in the key of determination book (Alexopoulos and Blackwell, 1996; Barnett, 2000). The dominance Index of the pest was calculated using (Odum, 1971; Odum and Barret, 2005):

$$C = \Sigma (ni/N)2.$$

Where:

C: Dominance Index of species (Simpson);
ni: Number of individuals i-th;
N: Importance score (the total number of species).
Disease incidence percentage (%) is calculated using the formula:

$$\frac{\text{Number of plant/plant parts affected}}{\text{Total plants}} \times 100\%$$

Data were presented in various formats, including tables, charts, and both macroscopic and microscopic figures.

RESULTS AND DISCUSSION

The indigenous vegetables observed were presented in Figure 2. The vegetables were located in their natural habitat and traditional markets, and their abundance was found to vary with the seasons. During the observation, both Palangka Raya and Katingan districts were in the dry season, which led to limited availability of *Helminthostachys zeylanica*, *Ceratopteris thalictroides*, and *Gymnoptalum chochinense* and their availability in the traditional market. *Helminthostachys zeylanica* was found to grow well in humid areas under rubber treesPeat soils chemical properties

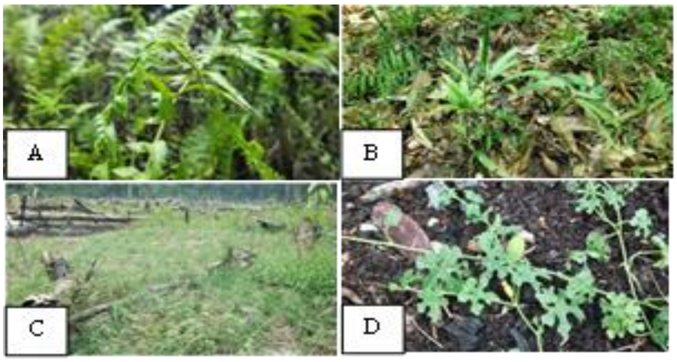

Figure 2 – Vegetables observed at the field. A. *Ceratopteris thalictroides* B. *Helminthostachys zeylanica* C. *Allium schoenoprasum* D. *Gymnoptalum chochinense*

The arthropod number trapped on the canopy, soil surface, and nocturnal were 8 orders, 36 families with a population density of 660 individuals. Insects collected from *Ceratopteris thalictroides*, *Stenochlaena palustris*, *Helminthostachys zeylanica*, *Allium* *schoenoprasum*, *Gymnoptalum chochinense*, and *Solanum ferox* belonged to 8 orders and 14 families, totaling 265 individuals. On the soil surface, there were 3 orders, 8 families, and 271 populations of arthropods trapped. The nocturnal traps captured 7 orders, 24 families, and 124 individuals. The identification process revealed the presence of 7 order of insect groups, one order of spider groups (Araneida) and one order of the mite group (Acarina). In conclusion, there were abundant populations of insects found in the canopy, soil surface, and at night. The highest population of arthropods was found in soil insects with a total of 271 individuals.

The composition of the arthropod community can be divided into three categories, which are phytophagous arthropods (pests), natural enemies (parasitoids and predators), and decomposers. These groups are shown in Tables 1 and 2 for indigenous vegetables.

Table 1 – Arthropod community structure (pest) on canopy (A), soil surface (B) and nocturnal arthropods (C) on *Ceratopteris thalictroides*, *Stenochlaena palustris*, *Helminthostachys zeylanica*, *Allium schoenoprasum*, *Gymnoptalum chochinense*, and *Solanum ferox*

Role and order	Family	A	B	C	Total
Pest					
Orthoptera	Acrididae	7	2	8	17
Homoptera	Delpacidae	0	0	5	5
	Cicadellidae	0	0	2	2
	Cercopidae	0	0	2	2
	Aleirodidae	30	0	0	30
Hemiptera	Phyrhocoridae	0	0	5	5
	Alididae	0	0	1	1
Lepidoptera	Pyralidae	0	0	1	1
	Nymphalidae	2	0	0	2
	Satyridae	1	0	0	1
	Hesperidae	1	0	0	1
	Noctuidae	0	0	2	2
Coleoptera	Buprestidae	2	0	0	2
	Chrisomelidae	2	0	5	7
	Curculionidae	0	0	1	1
	Meloidae	1	0	0	1
Acarina	Tarsonemidae	200	0	0	200
Total		246	2	32	280

The dominant group on the vegetable canopies was pests, represented by 9 families and a total of 246 individuals. The largest population of mites belonging to the Acarina order was found on *Solanum ferox*, numbering 200 individuals. The remaining individuals belong to 4 families of predators. In contrast, the insects trapped on the soil surface showed a dominance of predators, with 5 families (256 individuals) recorded, the highest population of which was Hymenoptera (Formicidae) on *Allium schoenoprasum* (242 individuals).

The rest of the individuals belonged to parasitoid insects (Hymenoptera, Chalcididae, 4 individuals) and decomposers (Orthoptera, Blattidae, 9 individuals), with only 2 individuals belonging to the pest group (Orthoptera, Acrididae). The number of individuals caught using a light trap was lower (32 individuals) compared to the natural enemies, parasitoids, and other beneficial insects, which totaled 92 individuals. Figure 3 shows the arthropod pests on some indigenous vegetables.

The abundance presence of natural enemies such as predators and parasitoids in wild indigenous vegetables is believed to be the result of an environment that is not exposed to pesticides, providing a suitable habitat for them to thrive. This is consistent with the findings of Untung (2006) that the high natural enemies population in an ecosystem is influenced by the presence of favorable conditions for them to carry out their functions. Additionally, the presence of Blattidae, a type of decomposer insect is beneficial for soil fertility in the tropics, as noted by Borror et al. (2005).

Naturally, there were arthropod interactions occurred among the phytophagous guilds, natural enemies, and decomposers (Figure 4).

Table 2 – Arthropod community structure (natural enemies and decomposers) on canopy (A), soil surface (B), and nocturnal arthropods (C) on *Ceratopteris thalictroides*, *Stenochlaena palustris*, *Helminthostachys zeylanica*, *Allium schoenoprasum*, *Gymnoptalum chochinense*, and *Solanum ferox*

Role and order	Family	A	B	C	Total
Predator					
Orthoptera	Gryllidae	0	3	15	18
	Tettigonidae	2	2	1	5
Hemiptera	Gerridae	0	0	1	1
	Miridae	0	0	1	1
	Pentatomidae	1	0	0	1
Hymenoptera	Formicidae	0	242	3	245
	Vespidae	1	8	0	9
	Sphecidae	0	0	2	2
Coleoptera	Elateridae	0	0	1	1
	Carabidae	0	0	1	1
	Cucujidae	0	0	2	2
	Coccinellidae	12	0	0	12
Araneida	Lycosidae	0	1	1	2
	Salticidae	3	0	0	3
Total Predator		19	256	28	303
Parasitoid					
Hymenoptera	Chalcididae	0	4	0	4
	Scelionidae	0	0	1	1
	Ichneumonidae	0	0	1	1
	Braconidae	0	0	32	32
Total Parasitoid		0	4	34	38
Decomposers					
Orthoptera	Blattidae (S)	0	9	30	39
Total Decomposers		0	9	30	39
Total		19	269	92	380

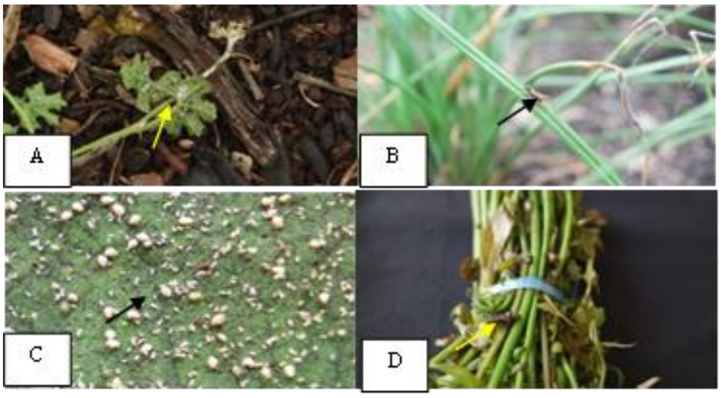

Figure 3 – Arthropod pests. A) Homoptera, Aleirodidae on *Gymnoptalum chochinense*; B). Orthoptera, Acrididae on *Allium schoenoprasum*; C). Yellow mites (Acarina, Tarsonemidae) on *Solanum ferox*; D). Larvae (Lepodoptera, Satiridae) on *Stenochlaena palustris*

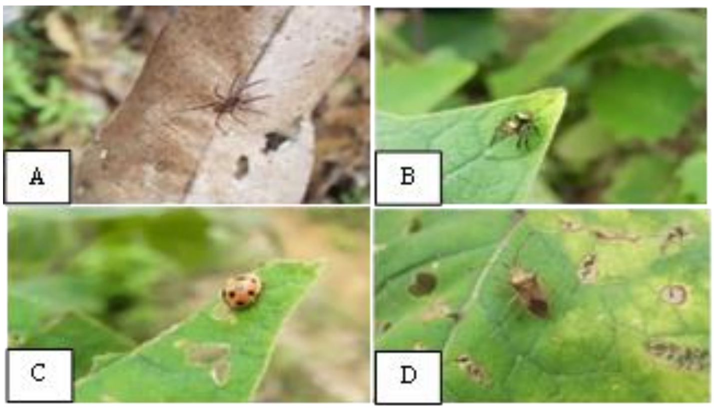

Figure 4 – Predator arthropods A).and B). Jumping spider, predator (Araneida, Salticidae). C). Ladybug, predator (Coleoptera, Coccinellidae); D). Stink bugs, predators (Hemiptera, Pentatomidae)

The majority of the insects found on the soil surface and nocturnal insects were dominated by predator and parasitoid groups, which need to be protected and preserved. On the other hand, the larger population of pests on the vegetable canopy was believed to have been caused by human intervention in managing pests and diseases through the use of chemical fertilizers and pesticides, leading to a decrease in the population of natural enemies.

Table 3 – Percentage of interaction occurred (inter-guilds) on *Ceratopteris thalictroides*, *Stenochlaena palustris*, *Helminthostachys zeylanica*, *Allium schoenoprasum*, *Gymnoptalum chochinense*, and *Solanum ferox*

Location / Trap	Guilds	Arthropod number (individuals)	Total (%)
Vegetables canopy (Sweep net)	Pest	246	92.83
	Predator	19	7.17
		Total	100
Soil surface (Pitfall trap)	Pest	2	0.74
	Predator	256	94.46
	Parasitoid	4	1.48
	Others insect	9	3.32
		Total	100
Nocturnal (Light trap)	Pest	32	25.81
	Predator	28	22.58
	Parasitoid	34	27.42
	Others insect	30	24.19
		Total	100

The use of pesticides can harm natural enemies, leading to a decrease in their population and efficiency, as well as disrupting the food chain. The interactions between pests, predators, parasitoids, decomposers, and plants in croplands can help control insect pests in safely and sustainably manner. To preserve this balance, it’s important to adopt Integrated Pest Management (IPM) which takes into account the protection of the environment and sustainability. IPM is the deployment of a variety of methods of pest control designed to complement, reduce or replace the application of synthetic pesticides (Dinakaran et al., 2014; Melhanah et al., 2015; Pretty and Bharucha, 2015).

The dominance of the family in the insect community was determined by the Simpson dominance index (Odum and Barret, 2005) presented in Figure 5.

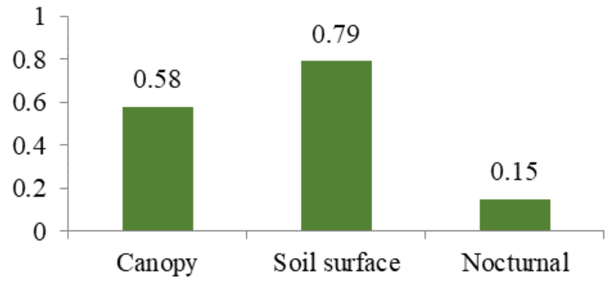

Figure 5 – Fluctuation of the dominance index on indigenous vegetables

According to Melhanah et al. (2021), the dominance index is 0 <D ≤ 0.5 (low dominance); 0.5 <D ≤ 0.75 (moderate dominance); and 0.75 <D ≤ 1 (high dominance). Figure 5 presented that high dominance (0.79) occurred on the soil surface, moderate dominance (0.58) on the canopy, and low dominance on (0.15) arthropods nocturnal. The value was due to the larger number of diverse families and the little bit number of individuals obtained. The species dominance has a close association with the diversity of organisms in the community. The findings of Oka (2005) stated that diversity and dominance were negatively correlated, meaning the high level of diversity and the low level of dominance. The dominance index in the vegetable environment is needed to detect any environmental disturbance or pollution, for example, such as side effects of synthetic pesticides used and

other chemicals as well as non-target biota. diversity declines when few species dominate. According to Crawfors et al. (2021), diversity declines when few species dominate.

The symptoms of pathogen attack on the leaves and fruit found in some vegetables were spots, dry rot of fruits, and necrosis on the tips of leaves (Figure 6).

Figure 6 – Diseases symptoms on vegetables. A. Fruit dry rot of *Solanum ferox* B. Leaves spots on *Allium schoenoprasum* C. *Helminthostachys zeylanica* leaves spot. D. Necrosis on *Gymnoptalum chochinense*

Solanum ferox which was attacked by fungus had inward basin spots associated with mycelium. The dark brown spots developed widely, simultaneously, in the middle of the spots consisted of a seta and conidium of fungus. The severe attack and the continued symptoms cause the whole fruit to dry out, wrinkle, and eventually rot. In our study, the symptoms and diseases found in macroscopic as mycelium fungus. According to (Sucianto and Abbas, 2019) the number of species of the genus Colletotrichum was the cause of fruit rot and vegetables resulting the losses to the harvest. In addition, the pathogen Colletotrichum could attack cereal plants, legumes, vegetables, and fruits. The results of symptomatic tissue isolation in vegetables are shown in Figure 7.

Figure 7 – Pathogen culture on PDA isolated from vegetables. A. *Helminthostachys zeylanica* B. *Ceratopteris thalictroides*

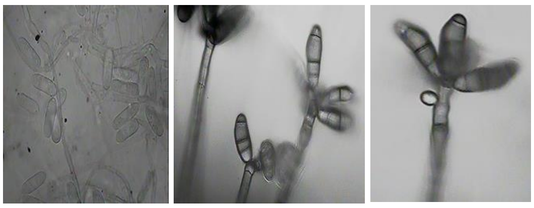

Figure 8 – Microscopic pathogen morphology A. *Colletotrichum* sp. B-C *Curvularia* sp (400x)

Mycelium fungus growth on PDA media was grayish-white to black. The direction of the growth was lateral, and their mycelium structure was rough. Microscopic characteristics of Colletotrichum sp was cylindrical, hyaline, single cell with a blunt tip (Figure 8A) (Suharti and Kurniaty, 2013). The fungus of Colletotrichum sp. belongs to the class Deuteromycetes (Imperfect fungi), order Melanconiales and family Melanconiaceae (Westcott, 1971). Based on the microscopic identification, Curvularia sp caused the leaf spot (Figures 8B, 8C). The Curvularia sp colony was dark brown, velvety, or cotton-like. Conidiophores were single or in groups, appear simple or branched, straight or crooked, 3 septa conidia, bent in a third cell that was wider and more brown than other cells and thin-walled (Suharti and Kurniaty, 2013).

On the leaves of the *Helminthostachys zeylanica*, *Ceratopteris thalictroides*, *Allium schoenoprasum,* and *Solanum ferox* Curvularia fungus infected, the brownish-yellow fused leaf spot showed that the fungus produced toxins as a means of pathogenicity. Old patches could get holes. If there were many spots on the leaves, the leaves turned yellow quickly and fall immediately without yellowing first. Spots were often found on stems, leaf stalks, or fruit stalks, but spotting was very rare in fruit. The frequency of occurrence and the percentage of disease attacks caused by pathogenic fungi in local vegetables can be seen in Figure 9.

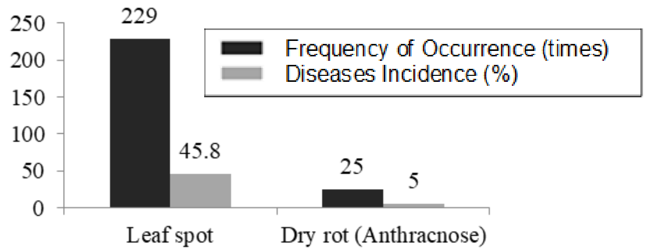

Figure 9 – Frequency of occurrence and diseases incidence on indigenous vegetables

The percentage of fruit dry rot disease caused by fungus in the *Solanum ferox* caused by *Colletotrichum sp*. was 5% while the leaf spot disease in *Helminthostachys zeylanica*, *Allium schoenoprasum*, *Ceratopteris thalictroides* and *Solanum ferox* leaves caused by *Curvularia sp*. was 45.8%, this showed that leaf spot disease was the highest percentage (Table 2). According to Irawan et al. (2015), if the percentage of disease was 25-50%, plant diseases have not been categorized as dangerous, whereas if the percentage of diseases reached 50-75% then plant diseases were categorized as dangerous and if the percentage of diseases was above 75% then plant diseases were included in critical conditions so it needed to be done better control. A wide range of ornamentals, fruits, and vegetables are infected with Colletotrichum species. It was determined that 22 isolates of Colletotrichum were found associated with symptomatic leaves and stems of two *Campanula spp*., *Ceanothus thyrsiflorus*, *Coreopsis lanceolata*, *Cyclamen persicum*, *Hydrangea paniculate*, *Liquidambar styraciflua*, *Mahonia aquifolium*, and *Rhyncospermum jasminoides*. The study evaluated the pathogenicity of certain representative isolates, and it was found that all of them were pathogenic and caused symptoms similar to those observed in private gardens and nurseries (Guarnaccia et al., 2021). This research enhances our comprehension of *Colletotrichum spp*. linked with diverse vegetable host and offers valuable insights for a successful disease management plan.

Traditionally, *Solanum ferox* has been grown by sowing seeds directly in the field, or in polybags or seedling trays in a nursery. However, the cultivation of *Solanum ferox* on intensively used land has become impractical due to the presence of soil-borne pathogens like Fusarium wilt, bacterial wilt, and Phytophthora. To increase the resistance of these susceptible plants against these pathogens, grafting has been implemented. This technique results in earlier harvesting, higher vigor, yield, and fruit quality. *Solanum torvum* has been used as a disease-resistant rootstock for *Solanum ferox* due to their compatibility (Soon & Ding, 2021).

It needs an environment-based control strategy, but it also helps in maintaining a minimum pest population for the survival of natural enemies. Efforts are needed to reduce the negative impacts of chemical use and climate change on local vegetable production resources and systems as well as on the socio-economic aspects of farmers. To prepare the anticipation, various technologies that can be applied by farmers need to be applied and prepared. This is intended so that the development of local vegetable crops can be done more focused and innovative as effort to preserve local vegetable germplasm and support food and nutrition diversification through alternative food sources.

CONCLUSION

The results indicated that a total of 8 orders, 36 families, and 660 individual arthropods were identified. The predator population on the soil surface accounted for 94.46%, while in nocturnal insects it amounted to 74.19%. The presence of pests was relatively high on the surface of the canopy, with a proportion of 92.83%. The dominance index of arthropods on both the plant canopy and soil surface was quite high, with values of 0.58 and 0.75, respectively. This dominance was primarily due to the prevalence of Family Tarsonemidae and Family Formicidae. However, the dominance index of nocturnal insects was lower at 0.15. The incidence percentage of Colletotrichum sp. fruit rot disease on *Solanum ferox* was found to be 5%. On the other hand, the incidence of Curvularia sp. leaf spot disease on *Helminthostachys zeylanica*, *Allium schoenoprasum*, and *Ceratopteris thalictroides* was higher at 45.8%. Fortunately, this level of incidence is still considered harmless.

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