

Diversity And Functional Composition of Ground Dwelling Arthropods in Vegetable Fields of Modinding District.

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Abstract. Ground dwelling arthropods contribute to decomposition, nutrient cycling, and biological control, and their community structure can reflect management intensity in agroecosystems. Intensive vegetable cultivation in Modinding District, South Minahasa Regency, North Sulawesi, commonly involves routine fertilizer and pesticide use, yet baseline information on soil associated arthropod diversity across major crops remains limited. This study assessed the diversity, functional roles, and population levels of ground dwelling arthropods in vegetable fields using pitfall trapping. Sampling was conducted at ten georeferenced points distributed across key vegetable producing villages, with traps operated for two days and repeated three times. Arthropods were sorted through macroscopic observation and identified using microscopic examination, primarily to order and family levels. Community diversity was quantified using the Shannon Wiener index. Overall, eight orders and seventeen families were recorded, representing decomposers, predators, herbivores, vectors, parasitoids, and omnivores. Decomposer groups, particularly Collembola, were generally dominant in several crop fields, while predator groups such as ants and spiders were also consistently present. Shannon diversity values across host crops ranged from 0.255 to 1.333, indicating low to moderate diversity and suggesting that some fields were characterized by strong dominance of a limited number of taxa. These findings provide baseline data for biomonitoring programs in Modinding and support the use of ground dwelling arthropod communities as practical indicators to evaluate ecological responses to vegetable production management.

Keywords: Collembola, Modinding, Pitfall trap, Shannon Wiener index, Vegetable fields

INTRODUCTION

Soil biodiversity is a key foundation for ecosystem functioning because it regulates processes such as organic matter decomposition, nutrient cycling, soil structure formation, and plant productivity. Recent research emphasizes that soil biota supports multiple ecosystem functions simultaneously and helps buffer ecosystems against disturbance, yet it is increasingly threatened by global change drivers and intensive land management (Creamer et al., 2022; Delgado-Baquerizo et al., 2025; Feng et al., 2024).

In agroecosystems, ground dwelling arthropods represent an important component of soil fauna that contributes to both soil functioning and crop related ecosystem services. These organisms occupy multiple trophic roles, including detritivores that accelerate decomposition

and nutrient release, and predators that contribute to natural pest regulation. Because they respond rapidly to changes in habitat conditions and management practices, arthropod communities are widely used as bioindicators to evaluate soil biological quality and the ecological sustainability of agricultural systems (Bhaduri et al., 2022; Gallese et al., 2025).

Agricultural intensification can markedly alter soil and surface active arthropod communities. Global evidence shows that land use conversion and intensification consistently reduce soil fauna abundance and richness, with particularly strong negative effects reported in tropical and subtropical regions (Phillips et al., 2024). In addition to habitat disturbance, pesticide exposure is a major driver of non target biodiversity loss in soils. Meta analytic evidence indicates that

pesticides reduce soil fauna abundance and diversity across studies, and that insecticides and multiple substance exposures often produce the most detrimental outcomes for soil fauna diversity (Beaumelle *et al.*, 2023). Microarthropods such as springtails are frequently reported as among the most sensitive soil fauna groups to pesticide exposure, supporting their relevance for biomonitoring programs in intensively managed agricultural landscapes (Joimel *et al.*, 2022).

Intensive vegetable production systems are commonly characterized by frequent soil disturbance, repeated fertilizer inputs, and routine pesticide applications. In Modinding District, South Minahasa Regency, North Sulawesi, vegetable farming typically relies on synthetic fertilizers such as nitrogen, phosphate, and potassium, alongside regular pesticide applications for pest and disease control. Such management may create strong environmental filters that restructure arthropod communities and potentially reduce beneficial functions linked to decomposition and biological control, but locally relevant baseline data are needed to assess these risks and support sustainable management pathways (Creamer *et al.*, 2022; Erktan *et al.*, 2024).

Field assessment of surface-active arthropods is often conducted using pitfall traps because this method is practical, cost-effective, and suitable for comparing communities across habitats when deployment is standardized. Methodological studies also demonstrate that trap number, spacing, and trap design influence capture efficiency, highlighting the need for consistent sampling protocols when arthropod diversity and abundance are compared among fields (Ahmed *et al.*, 2023). In Indonesia, several recent studies have reported soil arthropod community patterns under different land uses or management regimes, including the use of

pitfall traps and soil extraction methods, but evidence remains geographically limited and is not yet sufficient to establish baselines for many intensive vegetable producing landscapes (Adnan *et al.*, 2024; Kurniawan *et al.*, 2023).

This study addresses that research gap by providing standardized baseline information on ground dwelling arthropods across major vegetable fields in Modinding, including their diversity, abundance, and functional roles in the agroecosystem. The novelty of this work lies in documenting arthropod community structure across multiple host crops within an underrepresented highland vegetable production area in North Sulawesi, thereby supporting biomonitoring and early detection of management related ecological change. Accordingly, this study aims to quantify ground dwelling arthropod diversity in vegetable fields in Modinding, describe their ecological roles, and compare population levels among different host crops as baseline information for monitoring and management.

MATERIALS AND METHODS

Study area and study period

Field sampling was carried out in smallholder vegetable farms in Modinding District, South Minahasa Regency, North Sulawesi, Indonesia. The overall research activities, including sampling and laboratory work, were conducted for approximately six months. The sampled fields were located across key vegetable producing villages in the district, including Palelon, Wulurmaatus, Linelean, and Kakenturan.

Study design and sampling overview

To improve clarity and reproducibility, the core elements of the study design, sampling protocol, and analytical procedures are summarized in Table 1. This summary is provided to help readers quickly understand the number of sampling points, replication scheme,

sampling duration, identification approach, and diversity analysis used in the study.

Table 1. Summary of study area, sampling design, and analytical procedures

Component	Description used in this study
Study location	Modoinding District, South Minahasa Regency, North Sulawesi, Indonesia
Villages represented	Palelon, Wulurmaat, Linelean, Kakenturan
Study duration	Approximately six months (field and laboratory activities)
Surveyed cropping systems	Vegetable fields representing chayote (<i>Sechium edule</i>), carrot (<i>Daucus carota</i>), Chinese cabbage or pak choi (<i>Brassica chinensis</i>), cabbage (<i>Brassica oleracea</i>), potato (<i>Solanum tuberosum</i>), and red bean (<i>Phaseolus vulgaris</i>)
Number of sampling points	Ten georeferenced sampling points
Georeferencing	GPS used to record the position of each sampling point
Sampling method	Pitfall trapping to collect ground dwelling arthropods
Trap exposure time	Arthropods were collected from traps over 2 days per sampling round
Replication	Sampling was repeated three times
Specimen processing	Macroscopic observation for preliminary sorting, followed by microscopic observation for identification confirmation
Identification level	Primarily reported at order and family level
Response variables	Counts of individuals per taxon (population data)
Diversity metric	Shannon Wiener diversity index (H')
Diversity interpretation	For descriptive categorization, $H' < 1$ low diversity, 1 to 3 moderate diversity, and > 3 high diversity (Ejabf Journals)

Table 1 shows that the study applied a standardized pitfall trap approach at ten GPS marked sampling points distributed across multiple vegetable producing villages in Modoinding. Sampling was conducted with a fixed trap exposure time of two days and repeated three times, which is important because pitfall trap counts can be influenced by arthropod movement behavior and sampling design. Table 1 also summarizes the identification workflow observed macroscopically for initial sorting and then examined microscopically to confirm taxonomic identity, with reporting primarily at order and family levels. Finally, Table 1 clarifies that abundance data were analyzed descriptively and diversity was quantified using the Shannon Wiener index, with a commonly used categorization scheme applied for interpretation.

Arthropod sampling using pitfall traps

Ground dwelling arthropods were sampled using pitfall traps at each georeferenced point. Traps were checked

daily during the 48-hour exposure period, and captured arthropods were collected and preserved for further processing and the procedure was repeated three times to obtain replicated observations. Methodological literature emphasizes that pitfall trapping is a practical and cost-effective approach for surveying surface active arthropods, but trap captures are best interpreted as activity density because they reflect both abundance and movement.

Specimen observation and identification

Collected arthropods were examined using macroscopic observation to obtain preliminary information supporting identification, followed by microscopic examination to determine and confirm the taxa present in the sampled vegetable fields. Identifications were primarily reported at order and family levels to describe community structure and functional roles within the agroecosystem.

Population measurement and data analysis

Population data were obtained by counting all individuals collected using the pitfall trap technique at each sampling point. Abundance data were summarized descriptively, and community diversity was quantified using the Shannon–Wiener diversity index (H'), calculated from the proportional abundance of each taxon. For descriptive interpretation, H' values were categorized as low, moderate, or high using the classification summarized in Table 1.

RESULTS AND DISCUSSION

Across the sampled vegetable fields in Modinding, ground dwelling arthropods were recorded from eight orders comprising seventeen families, with functional roles spanning decomposers, predators, herbivores, vectors, parasitoids, omnivores, and pollinators. The community was

strongly dominated by decomposer groups, particularly Collembola, which were consistently the most abundant taxa in most crops. This dominance pattern is important because intensive land management and pesticide exposure are widely reported to restructure soil fauna communities and reduce overall diversity, often resulting in simplified assemblages dominated by a small number of taxa (Beaumelle *et al.*, 2023; Chiappero *et al.*, 2024; Joimel *et al.*, 2022; Tóth *et al.*, 2025).

To provide a clear overview of community size, richness, and diversity across crops, Table 2 summarizes total individuals, taxonomic richness, and the Shannon diversity index calculated from the abundance data reported for each crop field in the dataset.

Table 2. Ground dwelling arthropod abundance, richness, and diversity across vegetable crops in Modinding

Crop (host plant)	Total individuals (N)	Number of orders	Number of taxa	Shannon diversity index (H')
Chayote (<i>Sechium edule</i>)	247	6	11	1.626
Carrot (<i>Daucus carota</i>)	991	7	11	0.29
Chinese cabbage (<i>Brassica chinensis</i>)	3439	7	11	0.237
Cabbage (<i>Brassica oleracea</i>)	951	6	13	0.902
Potato (<i>Solanum tuberosum</i>)	89	4	4	0.351
Red bean (<i>Phaseolus vulgaris</i>)	44	6	6	1.303

Table 2 indicates strong contrasts among crops in both abundance and diversity. Chinese cabbage fields yielded the largest number of individuals, driven by extreme dominance of Hypogastruridae (Collembola), while cabbage fields showed the greatest richness in taxa among the surveyed crops. Diversity values ranged from very low in Chinese cabbage and carrot to moderate in chayote and red bean. This pattern is consistent with the ecological interpretation of Shannon diversity, where dominance by one taxon reduces evenness and depresses H' even when total abundance is high. In intensively managed systems, strong environmental filtering from repeated disturbance and chemical exposure can reduce soil fauna richness and diversity at

broad scales (Beaumelle *et al.*, 2023; Chiappero *et al.*, 2024).

A key implication of the abundance results is that high Collembola counts do not necessarily indicate high biodiversity. Collembola are important decomposers, but they are also among the most pesticide sensitive soil fauna groups, and their community composition and evenness can shift strongly under pesticide regimes (Joimel *et al.*, 2022). Additionally, pitfall trap catches should be interpreted as activity density rather than true absolute density, meaning that movement behavior and habitat structure can influence capture counts (Bruckner & Ott, 2024).

To clarify how ecosystem functions may be represented within each crop field, Table 3 summarizes the proportional

contribution of functional roles based on the recorded abundances.

Table 3. Functional role composition of ground dwelling arthropods by crop field

Crop	Decomposers (percent)	Predators (percent)	Herbivores (percent)	Other roles (percent)
Chayote	67.61	28.34	1.62	2.43
Carrot	95.16	3.43	0.4	1.01
Chinese cabbage	95.84	3.93	0.17	0.06
Cabbage	68.24	30.49	1.26	0
Potato	92.13	6.74	1.12	0
Red bean	50	36.36	2.27	11.36

Table 3 shows that decomposers dominated most crop fields, especially carrot, Chinese cabbage, and potato, where decomposers exceeded ninety percent of individuals. In contrast, cabbage and chayote supported much larger predator fractions, largely associated with Formicidae and predatory beetles and spiders. Red bean fields displayed the most functionally balanced profile, with decomposers comprising half of individuals, predators exceeding one third, and the presence of vectors, which in this dataset were represented by Aphididae.

From an agroecosystem perspective, a higher share of predators may be beneficial because ground dwelling predators contribute to natural regulation of herbivorous pests, while decomposers support nutrient cycling. Ants are widely recognized as ecologically important components of ground arthropod communities and are increasingly studied as contributors to ecosystem functioning in managed landscapes. The relatively high predator proportion in cabbage and chayote fields may therefore indicate greater potential for biological control functions in those habitats, although verifying this would require additional measurements such as predator identity at finer taxonomic resolution, habitat complexity, and pesticide use intensity.

Overall, these findings provide baseline evidence that arthropod community structure differs strongly among host crops in Modinding, with several

crops showing low diversity and strong dominance by decomposers. Because pesticides have been repeatedly shown to reduce soil fauna diversity and because Collembola are sensitive to pesticide exposure, future monitoring in this landscape would benefit from linking arthropod patterns to detailed records of pesticide active ingredients, application frequency, and soil properties.

CONCLUSION

This study provides baseline information on ground dwelling soil insects in vegetable fields of Modinding District, South Minahasa, North Sulawesi. The survey recorded eight orders comprising seventeen families, with ecological roles represented by decomposers, predators, herbivores, vectors, parasitoids, and omnivores. The Shannon Wiener diversity index ranged from 0.255 to 1.333 across host crops, indicating low to moderate diversity and suggesting that several crop fields were characterized by high dominance of a limited number of taxa. Community structure differed among crops. Several fields showed strong dominance of decomposers, particularly Collembola from Hypogastruridae, whereas some fields had a higher proportion of predators such as ants (Formicidae). These results support the use of soil and ground dwelling insects as practical indicators for biomonitoring in intensive vegetable production landscapes. Given that farmers reported routine applications of insecticides, fungicides, and

herbicides, future monitoring should integrate detailed pesticide use records and habitat measurements to better explain variation in diversity and functional composition across crops and villages.

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