Eurasia Specialized Veterinary Publication

International Journal of Veterinary Research and Allied Science

2024, Volume 4, Issue 1, Page No: 7-19

Available online at: www.esvpub.com/

Variation in the Ground-Dwelling Insect Community in Southern Santa Fe Province, Argentina

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ABSTRACT

The preservation of biodiversity is essential due to the profound impacts of human activities on natural ecosystems. Human-induced factors, including the expansion of agricultural boundaries, the introduction of non-native species, and deforestation, are among the primary causes of biodiversity changes. Insects, as a key component of entomofauna, serve as valuable indicators of environmental health and play essential roles in ecological processes such as pollination and organic matter decomposition. This study examines the understory entomofauna at the Faculty of Veterinary Sciences at the National University of Rosario, Argentina. Multiple sampling sessions were conducted in 2022 at 5 distinct microsites characterized by different levels of herbaceous, shrub, and tree vegetation. Arthropods were collected using pitfall traps, yielding 2,631 specimens of 68 morphospecies distributed in 5 classes, 15 orders, and 43 families. Among them, the class Insecta exhibited the highest richness and abundance, comprising 82.35% of the morphospecies and 35.80% of the total collected specimens. Despite only two species being represented, the class Malacostraca dominated in abundance, accounting for 58.57% of the captured individuals. Analysis of the biodiversity of the microsites showed that sites 5 and 1 harbored the highest diversity. The low similarity observed between the microsites suggests that changes in the surrounding landscape significantly affect the entomofaunal composition. The findings of this research provide an important reference point for the understory entomofauna in the Faculty of Veterinary Sciences. The diversity observed underscores the ecological significance of this habitat, with special emphasis on species such as *Armadillidium vulgare* and Enthomobryidae sp. due to their contributions to ecosystem functions. This study provides a foundation for future comparative research and emphasizes the importance of integrating biodiversity considerations into conservation strategies and environmental management policies.

Keywords: Argentina, Soil fauna, Anthropization, Understorey

Received: 08 January 2024
Revised: 10 March 2024
Accepted: 10 March 2024

How to Cite This Article: Schanzempch NMN, Rimoldi PG. Variation in the Ground-Dwelling Insect Community in Southern Santa Fe Province, Argentina. Int J Vet Res Allied Sci. 2024;4(1):7-19.

Introduction

The preservation of biodiversity is a key concern in global conservation. Understanding biodiversity remains a worldwide challenge, especially considering the environmental impact of human activities on natural ecosystems [1]. Various anthropogenic factors, including habitat destruction, overexploitation, pollution, deforestation, and the spread of non-native species, are the primary forces driving alterations in species diversity and community composition across the globe [2-4].

Entomofauna is the most dominant animal group on Earth, with the number of documented species exceeding 3 times that of all other known animal species combined. These organisms established themselves on the planet over Three hundred fifty million years ago, playing a fundamental role in ecological balance. Their significance is so profound that without arthropods, life as we know it would be drastically different, highlighting their essential contribution to ecosystem diversity [5].

The level of disruption in a local ecosystem is often assessed by examining the presence or absence of different arthropods, along with changes in their abundance, diversity, and the composition of biological groups. Insects, in particular, serve as highly effective bioindicators commonly utilized to evaluate and track the environmental quality of specific ecosystems [6]. This is due to their remarkable diversity, widespread distribution, ease of identification, straightforward sampling methods, manageable size, predictable responses to environmental shifts, and cost-effectiveness as an assessment tool [7].

Furthermore, entomofauna play essential roles in multiple ecological processes, including pollination, seed dispersal, soil aeration, and organic matter decomposition. They also contribute to nutrient cycling, function as parasites, and serve as biological control agents. Additionally, they form a crucial component of food chains, enhance soil fertility and structure, and influence ecological interactions within their habitats [8].

These characteristics result in arthropod communities fluctuating in response to varying degrees of both natural and human-induced disturbances. Their abundance, diversity, and biological composition are closely linked to ecosystem functionality, reflecting habitat heterogeneity, ecological development, and recovery. Similarly, the structural composition of arthropod populations provides insight into the extent of ecosystem fragmentation and isolation within a given landscape [9].

In recent years, Argentina has experienced significant landscape simplification because of the expansion and intensification of agricultural activities. This has led to rapid landscape fragmentation [10] and a subsequent decline in biodiversity.

Research on arthropod communities in agroecosystems has been conducted in various provinces across the country. For instance, a study in Entre Ríos assessed arthropod biodiversity to guide conservation strategies [11]. Additional studies in the same province focused on evaluating diversity and abundance within agroecosystems [10, 12], as well as in a specific soybean crop [11]. In Santa Fe, similar research has analyzed arthropod diversity in different crop types, including soybeans [13].

This study examines the taxonomic richness of the understory entomofauna within the FCV-UNR property. This environment is characterized by both vertical variation (complexity) and horizontal variation (heterogeneity) in plant diversity. The findings serve as a baseline for future comparative analyses, particularly with ecosystems that have undergone significant modifications to their original vegetation, resulting in more homogeneous landscapes with simplified plant structures, such as agroecosystems.

Materials and Methods

Area of study

The Faculty of Veterinary Sciences at the National University of Rosario is situated in Casilda, the administrative center of the Caseros Department, in the southern region of Santa Fe province. Spanning approximately 240 hectares, this property was designated as a “Natural Protected Area” in 2007 (CD Resolution Nº 188/07) because of its significant role in providing a refuge for wildlife within an area primarily dedicated to agriculture **(Figure 1)**.

The local climate is temperate, with average temperatures ranging from 14 to 20 °C [14]. Rainfall patterns fluctuate throughout the year, with the highest precipitation levels occurring during spring and summer. Historically, before agricultural and livestock activities became dominant, the landscape was characterized by vast and dense grasslands [15].

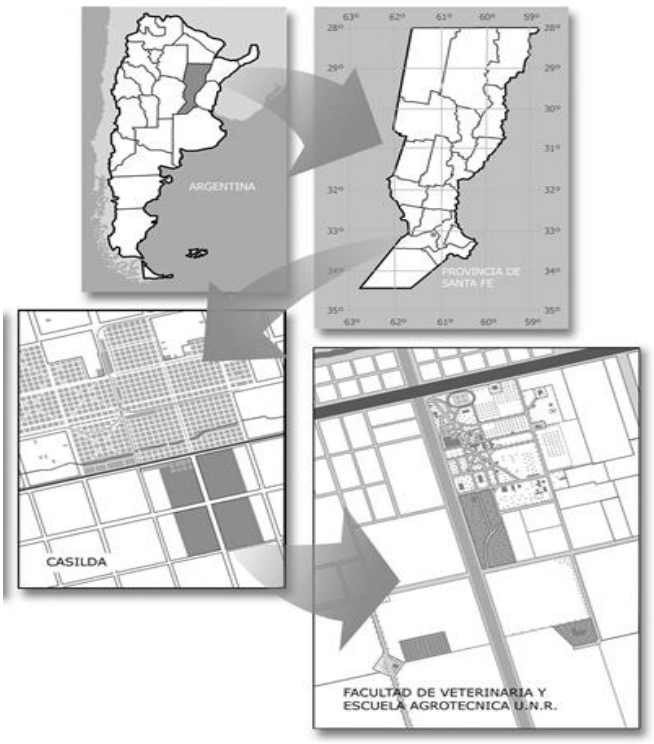

Figure 1. Faculty of Veterinary Sciences - National University of Rosario, Casilda, Santa Fe, Argentina.

Sampling was conducted between June (autumn-winter) and December (spring-summer) of 2022. Due to the diverse nature of the forest studied, distinct microsites with contrasting characteristics were chosen as sampling locations. Within each microsite, two uniform sampling areas were designated for collecting entomofauna.
The microsites were defined as follows:

- Microsite 1 **(Figure 2a)**: This area consists of an *Araucaria angustifolia* plantation, forming the tree stratum. There is no shrub layer, while the herbaceous layer is primarily composed of a dense cover of *Tradescantia fluminensis*. Scattered individuals of *Sonchus oleraceus* and *Cestrum parqui* are present, though the latter does not develop significantly. Additionally, underdeveloped specimens of *Ulmus* sp. and Morus alba appear occasionally.
- Microsite 2 **(Figure 2b)**: A plantation of Morus alba constitutes the arboreal layer. The shrub layer is sparse, with *Baccharis punctulata* and *Ligustrum lucidum* present but poorly developed. The herbaceous layer is also sparse, dominated by patches of various grasses, the most prominent being *Cortaderia selloana*, *Taraxacum officinale*, and *Xanthium cavanillesii*.
- Microsite 3 **(Figure 2c)**: The tree stratum consists of a *Gleditsia triacanthos* plantation. The shrub layer is primarily composed of *Baccharis punctulata*, distributed throughout the site but not densely packed, alongside occasional regenerating individuals of *Gleditsia triacanthos* and *Ligustrum lucidum*, the latter being minimally developed. The herbaceous layer is sparse, occupying the few open spaces available, with Taraxacum officinale and spiny-leaved species of the *Carduus* genus being the most frequent.
- Microsite 4 **(Figure 2d)**: This area is dominated by *Quercus suber* and *Quercus robur* in the tree stratum. There is no shrub or herbaceous layer, and the ground is covered by a leaf litter layer approximately 6 cm thick.
- Microsite 5 **(Figure 2e)**: The arboreal layer is absent. The shrub layer is dense, primarily composed of *Baccharis punctulata*, with sporadic young specimens of *Gleditsia* sp. emerging. The herbaceous layer consists of grass clusters dominating certain areas, while *Taraxacum officinale* and *Sonchus oleraceus* are observed in others.

a) b) c) d) e)

Figure 2. Microsites that made up the study area on the premises of the Faculty of Veterinary Sciences of the National University of Rosario.

In each sampling area, 2 plastic pitfall traps (8 cm in diameter and 10 cm deep) were installed **(Figure 3)**. These traps were filled with two hundred milliliters of a 20% ethylene glycol solution, along with a drop of detergent to reduce surface tension. Ethylene glycol served to prevent evaporation while also preserving the collected specimens. The traps remained in the field for five consecutive days each month during the sampling period, resulting in a total trapping effort of three hundred trap days, calculated as follows: 5 areas per microsite × 2 traps per area × 6 months × 5 days per month = 300 trap days.

All collected specimens were stored in 70% alcohol for further identification and analysis.

Figure 3. a, b, c) fieldwork, d) laboratory, and e) pitfall trap scheme.

Total diversity (gamma diversity) was calculated as described by Halffter and Moreno [16], who define it as the total number of morphospecies found across all sites within the study area. In this case, it refers to the morphospecies recorded in the various microsites included in the study.

Additionally, the following metrics were calculated: (a) taxonomic richness (S), representing the total number of morphospecies in a given sample; (b) relative abundance, expressed as the percentage of each morphospecies relative to the total number of individuals; and (c) alpha diversity (within-area/microsite diversity), which includes both species richness and the structure of the community. Alpha diversity was assessed using the Shannon-Wiener diversity index which quantifies the overall diversity of a sample by considering two primary factors: richness and evenness. This index reflects the relative importance of each morphospecies and indicates the evenness of their distributions across the sample. The formula for the index is $H' = -\Sigma (pi \times \log2\ pi)$, where pi represents the proportion of individuals belonging to a particular species in the sample. The value of H' ranges from zero, when only one species is present, to the maximum (H'max), which corresponds to log2 S.

The similarity in morphospecies composition between different areas or microsites was calculated using Jaccard's index [17].

The taxonomic classification for higher taxa was based on the work of Borror *et al*. [18], while the categorization of most genera and species followed Morrone and Coscarón [19] and Claps *et al*. [20]. The material collected was identified at the order and family level, with species identification performed when feasible. The remaining specimens were classified as distinct "morphospecies" or recognizable taxonomic units. Identifying specimens at the species level is often a lengthy process and can be impractical due to the limited availability of expert taxonomists for certain groups. Moreover, achieving high taxonomic resolution does not necessarily enhance ecological insights despite the considerable effort involved [21].

The community's trophic structure was analyzed by categorizing each morphospecies into one of four primary trophic groups, based on existing literature: herbivores, predators, detritivores, and ants. Ants were treated as a distinct group, given that many species are opportunistic and utilize a wide range of food sources [22].

Results and Discussion

A total of 2,631 individuals were collected and categorized into 5 classes, 15 orders, and 43 families **(Figure 4; Table 1)**. Among the 68 morphospecies identified, 51.47% (35 species) were identified at the species level, 22.05% (15 species) at the genus level, 25% (17 species) at the family level, and one species was classified as a morphospecies distinct from the others. From these findings, the gamma diversity for the understory at the Faculty of Veterinary Sciences, National University of Rosario, was determined to be 68 morphospecies.

Table 1. The taxonomic diversity of the entomofauna observed in the microsites was examined within the grounds of the Faculty of Veterinary Sciences, National University of Rosario.

Familia	Especie/ Morfoespecie	GT	Sampling sites/microsites									
			Autumn-winter					Spring-festival				
			1	2	3	4	5	1	2	3	4	5
Araneidae	Araneidae sp.	PRE		4	1		2	4	2	2	9	11
	Alpaida gallardoi	PRE									6	
Clubionidae	Clubionidae sp.	PRE									3	3
Gnaphosidae	Gnaphosidae sp.	PRE									2	3
Lycosidae	Lycosidae sp.	PRE			3		1	7	3	4	9	16
Tetranychidae	Tetranychidae sp.	PRE				1			1			
Sclerosomatidae	*Holmbergiana weyenberghi*	PRE									3	5
Gonyleptidae	*Pachyloides thorellii*	PRE										2
Scolopendridae	*Rhysida* sp.	PRE									1	2
Pseudonannolenidae	*Pseudonannolene meridionalis*	DET				1	1	8	5	1	12	10
Armadillidae	*Armadillidium vulgare*	DET						216	364	631	166	147
Porcellionidae	*Porcellio laevis*	DET						1	11	5		
Blatidae	*Blattidae* sp.	DET						22	19	12	5	26
Enthomobryidae	*Enthomobryidae* sp.	DET						28	14	16	54	76
Carabidae	*Calosoma argentinense*	PRE						3	1	1		

	Calosoma granulatum	PRE						1					
	Galerita collaris	PRE						8		4			
	Clivina platensis	PRE							1				
	Blennidus loxandroides	PRE						6	8	3			
	Argutoridius bonariensis	PRE	2					12	6	1			
	Trirammatus striatulus	PRE		1				11	4	7			
	Pterostichini sp.	PRE							2	2			1
	Arthrostictus chlaenioides	PRE						1					
	Notiobia cupripennis	PRE						2	1				
	Carabidae sp. (larvas)	PRE						3		1	1		
Curculionidae	*Listroderes apicalis*	HER						4	2		1		
Elateridae	*Conoderus bellus*	HER							3	1			
	Heteroderes laurentii	HER						8	11				
	Elateridae sp. (larvas)	HER		1					1		1		
Nitidulidae	Nitidulidae (1 sp.)	DET						16	8	11	12	4	
Scarabaeidae	*Aphodius* sp.	HER						6	4	7	1	2	
Staphylinidae	Staphylinidae sp.	PRE						8	9	4		1	
Forficulidae	*Doru* sp.	PRE					1						
Anthomyiidae	*Anthomyia punctipennis*	DET						1	1	6	3		
Bibionidae	*Dilophus* sp.	HER									1	2	
Cecidomyiidae	Cecidomyiidae sp.	HER	14	2	17	2							
Chironomidae	*Chironomidae* sp.	DET				8			5	3			
Drosophilidae	*Drosophila melanogaster*	DET						1	3	2			
Limoniidae	*Limoniidae* sp.	?									5	3	
Phoridae	Phoridae sp.	DET	32	4	20	7	16						
Muscidae	*Bithoracochaeta calopus*	DET		5	3	1	2	1		8	1	4	
	Limnophora sp.	DET			1			2	2	11			
	Musca domestica	DET			1			9		3	1		
	Syllimnophora sp.	DET						5		9		2	
	Psilochaeta chalybea	DET								5			
Stratiomyidae	*Hermetia* sp.	DET									2		
Syrphidae	*Allograpta* sp.	PRE						1			2	4	
S/D	*Diptera* sp.	DET						2	1	3	1	3	
Formicidae	*Linepithema humile*	HORM		6	4		1	13	11	6	9	19	
	Acromyrmex lundi	HORM		2				7	1	8	3	9	
	Camponotus mus	HORM							1		1	6	
	Hypoponera argentina	HORM						3			2	4	
	Dorymyrmex brunneus	HORM								5			
	Pseudomyrmex gracilis	HORM						1		1		3	
Ichneumonidae	*Pimpla* sp.	PRE						1	2				
Scoliidae	*Campsomeris* sp.	PRE										2	
Vespidae	*Polistes* sp.	PRE						2	2			3	
	Isodontia sp.	PRE						1				1	
Apidae	*Apis mellifera*	HER									1	4	
Pentatomidae	*Nezara viridula*	HER						3			1	2	
Cicadidae	Cicadidae sp.	HER			1								
Lygaeidae	*Lygaeus alboornatus*	HER										3	

Nabidae	*Nabidae* sp.	PRE					1					1
Berytidae	*Jalysus* sp.	HER					1					3
Noctuidae	*Spodoptera frugiperda*	HER							1			
	Agrotis malefida	HER										2
Gryllidae	*Acheta assimilis*	HER	2	1	1		8	1	1	5	9	
Gryllotalpidae	*Neoscapteriscus* sp.	HER						2	2			

References: GT (trophic group), HER (herbivores), PRE (predators), DET (detritivores), and HORM (ants). Ants are considered a separate group because most species exploit diverse food sources opportunistically [22].

The highest taxonomic richness was found in the Class Insecta, comprising 56 morphospecies (82.35%) from nine orders and 33 families. This class accounted for 35.80% of the total collected individuals, with Enthomobryidae sp. being the most abundant, representing 19.95% (n = 188). The class Malacostraca, though containing only two species, contributed 58.57% of the total abundance, with a significant dominance of *Armadillidium vulgare* (n = 1524 (98.89%)). The eight morphospecies in the Class Arachnida made up 4.06% of the total abundance, with Lycosidae sp. being the most prominent. The Classes Diplopoda and Chylopoda contributed 1.44% and 0.11% of the total abundance, respectively.

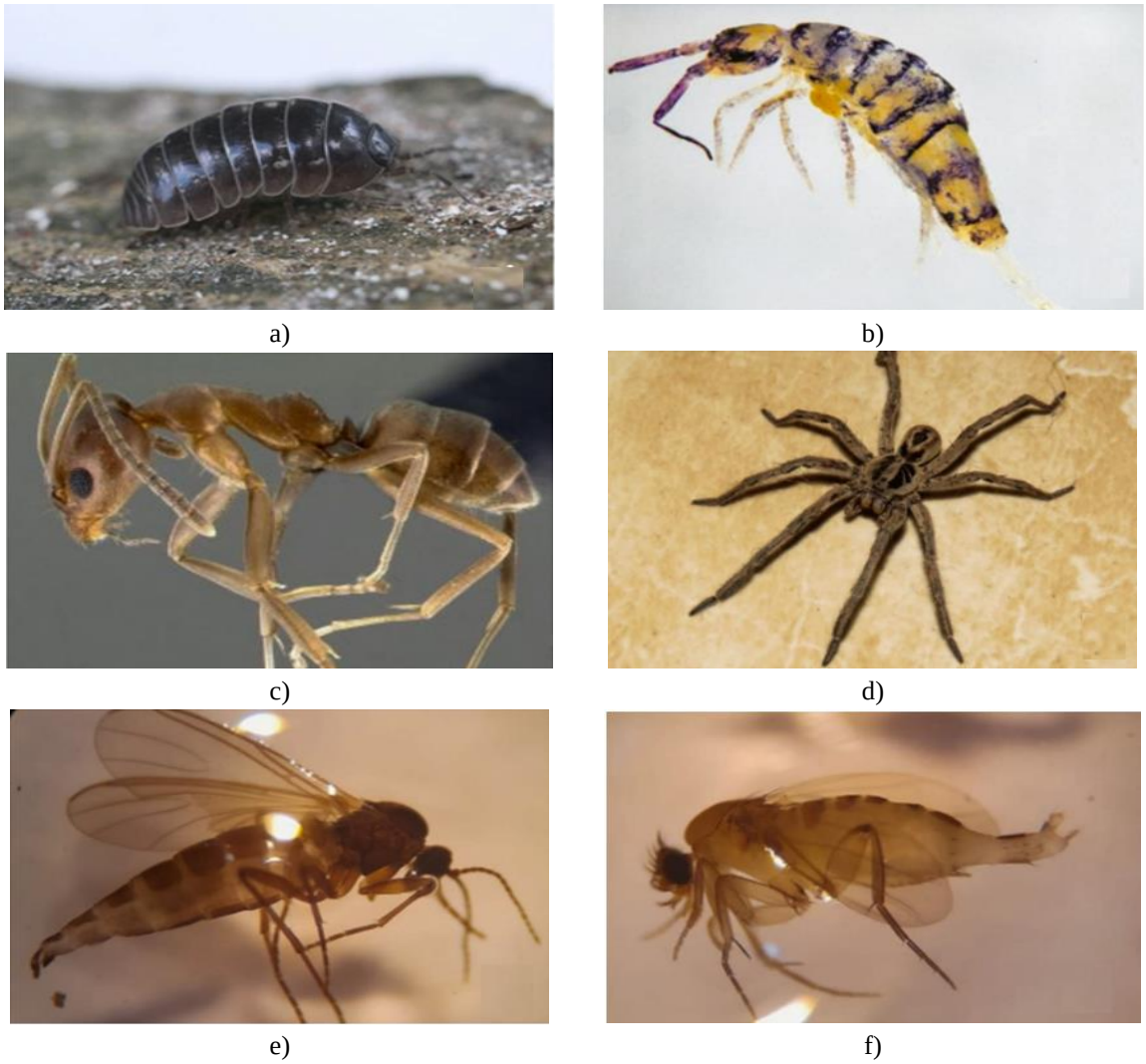

Figure 4. a) *Armadillidium vulgare*, b) Enthomobryidae sp., c) *Linepithema humile*, d) Lycosidae sp., e) Cecidomyiidae sp., and f) Phoridae sp.

Regarding diversity across microsites, determined through the Shannon-Wiener index, the highest biodiversity was observed in microsites 5 and 1, with values of H' = 2.51 and H' = 2.48, respectively. Microsite 4, with H' =

2.13, showed slightly lower diversity but was still relatively high. The microsites exhibiting the lowest diversity were microsite 2 (H' = 1.67) and microsite 3 (H' = 1.36).

From the Jaccard index analysis, similarity was assessed based on species presence or absence in each microsite. The results can be interpreted as the percentage of shared morphospecies, which provides insight into the degree of similarity between communities. A value closer to 1 indicates higher similarity [23], but the microsites in this study displayed low similarity overall, with values ranging from 0.28-0.59. The most similar pair was microsite 2 and microsite 3 (Jaccard index = 0.59), sharing 28 morphospecies. Other pairs exhibited lower similarity scores. These results suggest that most species in one community were not found in the other, indicating distinct ecological compositions across the microsites **(Table 2)**.

Table 2. The Jaccard index for biota pairs was observed in the microsites at the Faculty of Veterinary Sciences, National University of Rosario.

MICROSITES	Microsites 1	Microsites 2	Microsites 3	Microsites 4	Microsites 5
Microsites 1	1	0.53	0.58	0.4	0.4
Microsites 2	0.53	1	0.59	0.35	0.28
Microsites 3	0.58	0.59	1	0.33	0.31
Microsites 4	0.4	0.35	0.33	1	0.52
Microsites 5	0.4	0.28	0.31	0.52	1

Pitfall traps are widely used for sampling arthropods that move along the ground [24]. However, the results from this method primarily reflect surface activity rather than the specific population sizes of individual species [25].

In this research, the number and size of the traps were similar to those used in previous research carried out in comparable environments [25-27]. These conditions are believed to provide a reasonable estimate of the richness and abundance of surface-dwelling fauna in the study areas.

The number of insects captured by pitfall traps is directly influenced by the size of the traps. Studies have shown that, with a constant trap density, increasing the diameter of the traps leads to higher abundance and diversity of Carabids, spiders [28], and ants [29]. Work *et al*. [28] suggest using traps with diameters larger than 10 cm to effectively capture larger species, particularly those over 10 mm in size.

A limitation of this method is its dependence on factors such as the population density and activity levels of different species. The locomotor activity of organisms is influenced by weather conditions and the physical characteristics of the surrounding environment [30]. Generally, greater mobility is seen with higher temperatures, while activity tends to decline during rainy weather. Variations in terrain, such as surface roughness or differences in vegetation structure, may also affect the capture rates of pitfall traps.

Despite these limitations, pitfall traps remain a quick, efficient, and cost-effective method for conducting biodiversity surveys across a variety of habitats.

Classifying samples as morphospecies or recognizable taxonomic units is often considered a reliable method for ecological studies focused on biodiversity and conservation [31]. This approach is time-efficient and helps overcome challenges posed by the scarcity of expert taxonomists for the various arthropod groups. However, this method can lead to overestimations in species numbers, and misclassifications can occur, complicating the analysis and interpretation of the collected data [32].

To address these challenges, considerable effort was made to identify a large proportion of the captured specimens down to the species level. Some of the specimens were sent to experts for more precise identification, though the sheer volume of species and taxa involved made this task quite complex.

The richness, abundance, and species composition of arthropod communities are closely connected to the landscape structure. The distribution of these organisms is greatly shaped by the environment's configuration. In regions where human activities, such as intensive farming, have significantly altered the landscape, notable changes in the abundance and diversity of arthropod communities are observed [33]. Species respond differently to environmental disturbances, leading to variations in their abundance or even local extinction in disturbed areas [34].

It is widely accepted that less disturbed areas, such as natural corridors, habitat edges, vegetation patches, and uncultivated plots, are essential not only for increasing landscape diversity but also for maintaining and enhancing biological diversity in landscapes dominated by agricultural practices [26]. These less disturbed microhabitats

offer shelter and resources for a variety of species, thereby supporting sustainability and biodiversity in regions with intensive agriculture.

The understory at the Faculty of Veterinary Sciences of the National University of Rosario provides a particularly stable environment throughout the year. The leaf litter layer and the shade provided by the vegetation act as buffers against extreme weather. This stabilization helps retain moisture during dry periods and lowers surface temperatures in summer, fostering microclimates that are beneficial to soil organisms [35]. These microenvironments serve as safe refuges for feeding and reproduction, playing a critical role for epigean species. This stable and minimally disturbed environment provides an ideal habitat for the persistence and growth of soil fauna, underscoring the need to conserve such areas to maintain biodiversity and ecosystem functions.

The findings of this study align with the above, revealing the previously unknown diversity in this area. The 2 most abundant morphospecies, *Armadillidium vulgare*, and Entomobryidae sp., a springtail species from the order Collembola, represent 65.07% of the total individuals captured. These species provide valuable ecosystem services, including organic matter decomposition, soil structure improvement, pest control, nutrient cycling, and soil aeration.

Springtails are pan-phytophagous, feeding on decaying organic material, and considered detritivores, though their food preferences can vary under different conditions. Most springtails consume pollen, spores, algae, and fungal mycelium [36]. Within this group, some taxa are particularly sensitive to environmental changes and have only been found in stable ecological environments. This characteristic makes Collembola a useful indicator in studies of anthropogenic impacts [37].

Armadillidium vulgare (Latreille, 1804; Isopoda: Oniscidea) is recognized as a potential bioindicator for soil and agroecosystem health due to its widespread distribution (cosmopolitan), ease of taxonomic identification, and its dominance among detritivores in temperate climates [38].

Populations of *A. vulgare* are highly responsive to pesticide use and tillage practices, with noticeable variations in density between conventional and organic farming systems, as well as differences in biomass, which tends to be higher in no-till or reduced tillage environments [39]. Pesticides and herbicides contribute to increased mortality and reduced growth and reproductive success by diminishing the nutritional value of leaf litter [40]. Mortality rates also rise due to habitat simplification and the decreased availability of shelter, often caused by certain tillage methods [41].

Conclusion

This preliminary and descriptive study has established a valuable reference point for the epigean entomofauna inhabiting the understory of the FCV-UNR property. Through extensive fieldwork, 2631 individuals were collected, leading to the identification of 68 morphospecies. The calculated diversity index, H' = 2.12, offers a quantitative representation of the wide variety of species within this ecosystem and can be used to gauge the overall health of the area [42]. This measure also highlights the intricate relationships and diversity of life forms within the understory, acting as a crucial indicator for evaluating ecological stability and resilience [43].

Soil organisms have often been overlooked, as their ecological roles—such as functioning as ecosystem engineers, decomposing litter, and managing biotic stress—have been substituted by practices reliant on non-renewable energy sources [44]. However, the diversity, abundance, and functions of soil invertebrates are highly sensitive to environmental disturbances and changes associated with activities like tillage, the use of fertilizers and pesticides, logging, burning, and other agricultural practices. These human activities can disrupt soil faunal communities by altering organic matter inputs and modifying microhabitats, impacting the chemical and physical characteristics of soils [45, 46]. The extent of land use impacts on soil fauna is influenced by factors such as the type of land use, planting system (conventional or direct), crop diversity and rotation, and the types of inputs used [47].

These findings are crucial for enhancing the understanding of local biodiversity and provide a foundation for future comparative research. The opportunity to compare these results with ecosystems that are more heavily impacted or simplified, such as the agroecosystems that dominate the southern Santa Fe region, offers valuable insights into the effects of human activities on regional biodiversity. The data gathered in this study serves as a vital resource for shaping conservation and sustainable management strategies in the area, offering important guidance for biodiversity preservation and environmental management [48].

Ultimately, it is essential to recognize the significance of incorporating biological diversity into conservation planning and decision-making processes, which has direct implications for local and regional environmental policies.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

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