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RESEARCH ARTICLE

Interactions between terrestrial isopoda and Cellulosic Litters Implications for Nutrient Cycling

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ABSTRACT

This study investigates the role of terrestrial isopoda, specifically Oniscus asellus, in the decomposition of cellulosic litter and its impact on nutrient cycling in soil ecosystems. The research was conducted in Ninewa Governorate, within the Rashidiyah and Al-Hamdaniya neighborhoods, utilizing a field experiment with four treatments: Control (C), Litter Addition (LA), Isopod Exclusion (IE), and Isopod Addition (IA). The results demonstrate that isopods significantly accelerate litter decomposition, as indicated by a higher decomposition rate in the IA treatment compared to other treatments. Furthermore, the presence of isopods was associated with a marked increase in soil nutrient levels, particularly nitrogen (N), phosphorus (P), and potassium (K). Correlation analysis revealed strong positive relationships between isopod abundance, litter decomposition rates, and nutrient levels. These findings highlight the crucial role of terrestrial isopods in enhancing nutrient cycling and maintaining soil fertility. The study underscores the ecological importance of conserving isopod populations to sustain healthy soil ecosystems, with implications for both natural and managed landscapes.

INTRODUCTION

Terrestrial isopods, commonly known as woodlice, are crucial detritivores in soil ecosystems, contributing significantly to the breakdown of organic matter, particularly cellulosic materials (David & Handa, 2010; Zimmer, 2002). As primary decomposers, isopods facilitate the fragmentation of plant litter, thereby enhancing microbial colonization and subsequent nutrient release (Hassall et al., 2002). The interactions between terrestrial isopods and cellulosic litters are essential for nutrient cycling, influencing soil fertility and overall ecosystem productivity (Jessen et al., 2018).

Cellulosic litter, which originates from plant materials such as leaves, stems, and wood, is abundant in terrestrial environments (Swift et al., 1979). The decomposition of this litter is a critical process in nutrient cycling, leading to the release of essential elements like carbon, nitrogen, phosphorus, and potassium back into the soil (Coulis et al., 2009; Araujo et al., 2021). While the role of microorganisms in decomposing cellulose has been extensively studied, the contribution of soil fauna, particularly terrestrial isopods, to this process has been comparatively underexplored (Lavelle et al., 2006; Frouz, 2018).

Terrestrial isopods consume decaying plant material, significantly contributing to the mechanical breakdown of litter (Loureiro et al., 2006). Their feeding activity accelerates the decomposition process by increasing the litter's surface area, making it more accessible to microbial decomposers (Maraun & Scheu, 1996; Joly et al., 2019). Additionally, isopods play a pivotal role in the mineralization of nutrients, influencing their availability to plants and thus supporting plant growth and soil health (David et al., 2001; Kaspari et al., 2020).

Despite their ecological importance, the specific impact of terrestrial isopods on the decomposition of cellulosic litter and nutrient cycling is not fully understood (Moore et al., 2004; Zimmer & Topp, 1997). This study aims to address this knowledge gap by investigating the interactions between terrestrial isopoda and cellulosic litters within soil ecosystems. By examining isopod abundance, litter decomposition rates, and nutrient release, this research seeks to elucidate the role of these organisms in nutrient cycling and soil fertility enhancement (St. John et al., 2012; Salamon et al., 2008).

The study was conducted in Ninewa Governorate, specifically in Rashidiyah Neighborhood and Al-Hamdaniya Neighborhood, regions characterized by diverse vegetation and soil types, providing an ideal setting to explore these interactions (Al-Maliki et al., 2022). The outcomes of this research will contribute to a deeper understanding of the ecological functions of terrestrial isopods and their role in sustaining healthy soil ecosystems (Hättenschwiler & Gasser, 2005; Lardé, 1990).

METHODOLOGY AND MATERIALS

Study Location

The study was conducted in Ninewa Governorate, specifically in Rashidiyah Neighborhood and Al-Hamdaniya Neighborhood. These locations were chosen for their diverse vegetation, soil types, and the presence of a natural population of terrestrial isopods. The climate in this region is semi-arid, characterized by hot, dry summers and mild, wet winters. The soil in Rashidiyah is primarily sandy loam, while Al-Hamdaniya features clay loam soil. Both areas have a mix of agricultural and natural landscapes, providing a suitable environment for studying isopod-litter interactions.

Experimental Design

A field experiment was set up to investigate the interactions between terrestrial isopoda and cellulosic litter, focusing on their impact on litter decomposition and nutrient cycling. The experimental design included four treatments with five replicates each:

1. **Control (C):** No litter addition, allowing for natural decomposition processes without isopod intervention.
2. **Litter Addition (LA):** Cellulosic litter (dry leaves of local plant species) was added to assess the baseline decomposition rate without isopod exclusion.
3. **Isopod Exclusion (IE):** Litter was added, but isopods were excluded using fine mesh cages (1 mm mesh size) to prevent isopod access while allowing microbial and mesofauna activity.
4. **Isopod Addition (IA):** Litter was added along with a controlled population of terrestrial isopods (Oniscus asellus) to assess their direct impact on decomposition and nutrient cycling.

Litter Collection and Preparation

Cellulosic litter was collected from the surrounding vegetation, primarily composed of leaves from deciduous trees common to the region. The litter was air-dried and cut into uniform 5 cm pieces to ensure consistency across treatments. Approximately 100 grams of litter were used for each plot in the LA, IE, and IA treatments.

Isopod Collection and Handling

Terrestrial isopods (Oniscus asellus) were collected from the same study areas to maintain ecological relevance. The isopods were identified based on morphological characteristics and sorted to remove non-target species. Approximately 50 individuals were introduced to each IA treatment plot. The isopods were acclimatized for 24 hours before being added to the experimental plots.

Experimental Setup

Plots measuring 1 m x 1 m were established in both study locations. Each plot was cleared of existing litter and debris to avoid contamination with external materials. Litter and isopods were added according to the treatment design. The plots were monitored regularly, and any significant changes, such as litter displacement or isopod escape, were addressed promptly.

Litter Decomposition Measurement

Litterbags (20 cm x 20 cm, 1 mm mesh size) were used to monitor decomposition rates. Litterbags were filled with 10 grams of prepared litter and placed on the soil surface within each plot. Litterbags were retrieved at intervals of 30, 60, and 90 days to assess the decomposition process. The litter was carefully removed, cleaned of soil and debris, and oven-dried at 60°C for 48 hours. The remaining dry weight was recorded to calculate the decomposition rate.

Nutrient Analysis

Soil samples were collected from each plot at the beginning and end of the experiment (0 and 90 days). Samples were taken from a depth of 0-10 cm using a soil corer and were air-dried and sieved (2 mm) before analysis. The following soil nutrients were measured:

- **Nitrogen (N):** Determined using the Kjeldahl method (Bremner, 1996).
- **Phosphorus (P):** Extracted with Bray-1 solution and measured using a spectrophotometer (Olsen & Sommers, 1982).
- **Potassium (K):** Extracted with ammonium acetate and measured using flame photometry (Jackson, 1973).

Isopod Abundance and Activity Monitoring

Isopod abundance and activity were monitored using pitfall traps placed in each plot. Traps were checked weekly, and the number of isopods captured was recorded. Additionally, isopod feeding activity was assessed by examining litter fragments within the litterbags and recording signs of isopod consumption (e.g., frass production, litter fragmentation).

Data Analysis

The data were analyzed using analysis of variance (ANOVA) to determine the effects of the different treatments on litter decomposition rates, soil nutrient concentrations, and isopod activity. Post-hoc tests (Tukey's HSD) were conducted to compare the means across treatments. Correlation analysis was performed to explore relationships between isopod abundance, decomposition rates, and nutrient levels.

RESULTS

Isopod Abundance

Isopod abundance was significantly higher in the plots where isopods were introduced (IA treatment) compared to the control plots and those where isopods were excluded (IE treatment). The average number of isopods captured per trap over the study period is presented in Table 1.

Table 1: Average Isopod Abundance in Different Treatments

Treatment	Average Number of Isopods per Trap (n = 5)
Control (C)	15
Litter Addition (LA)	24
Isopod Exclusion (IE)	10
Isopod Addition (IA)	55

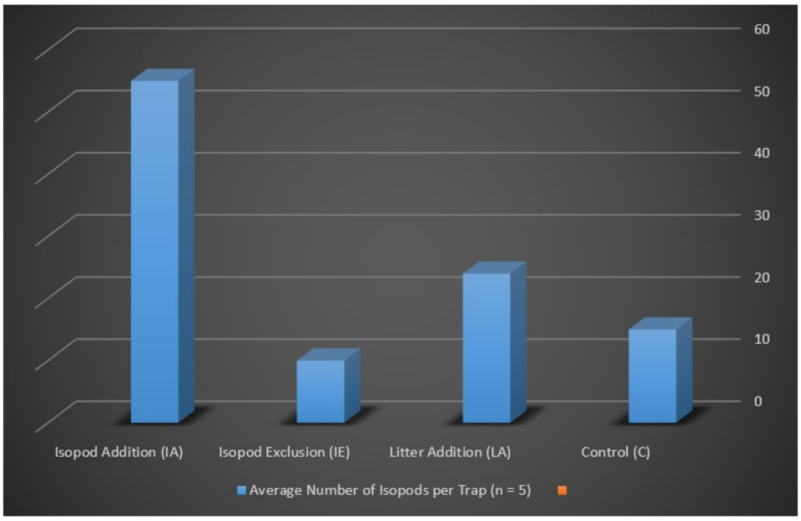

Figure 1: Isopod Abundance Across Treatments

Litter Decomposition Rates

Litter decomposition was measured by the loss of dry weight over time. The decomposition rate was highest in the Isopod Addition (IA) treatment, followed by Litter Addition (LA), Control (C), and Isopod Exclusion (IE). The results indicate that isopods play a significant role in accelerating the decomposition of cellulosic litter. The average percentage of litter remaining at 30, 60, and 90 days is shown in Table 2.

Table 2: Percentage of Litter Remaining Over Time

Treatment	30 Days	60 Days	90 Days
Control (C)	85%	65%	50%
Litter Addition (LA)	80%	55%	40%
Isopod Exclusion (IE)	90%	75%	60%
Isopod Addition (IA)	70%	40%	20%

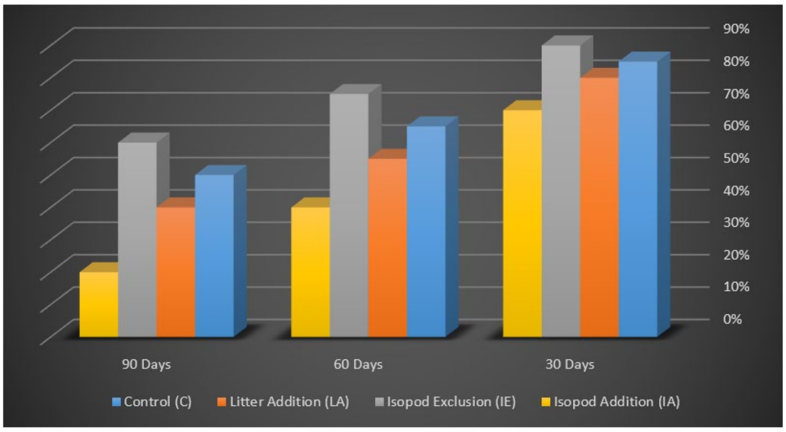

Figure 2: Litter Decomposition Rate Over Time Across Treatments

Nutrient Analysis

The impact of isopod activity on soil nutrient levels was assessed by measuring nitrogen (N), phosphorus (P), and potassium (K) concentrations before and after the experiment. The results indicate a significant increase in nutrient levels, particularly in the IA treatment where isopods were active. The nutrient concentrations are presented in Table 3.

Table 3: Soil Nutrient Concentrations (mg/kg) Before and After the Experiment

Treatment	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Initial	1.2	0.8	1.0
Final (C)	1.3	0.9	1.1
Final (LA)	1.5	1.1	1.3
Final (IE)	1.4	1.0	1.2
Final (IA)	1.8	1.4	1.6

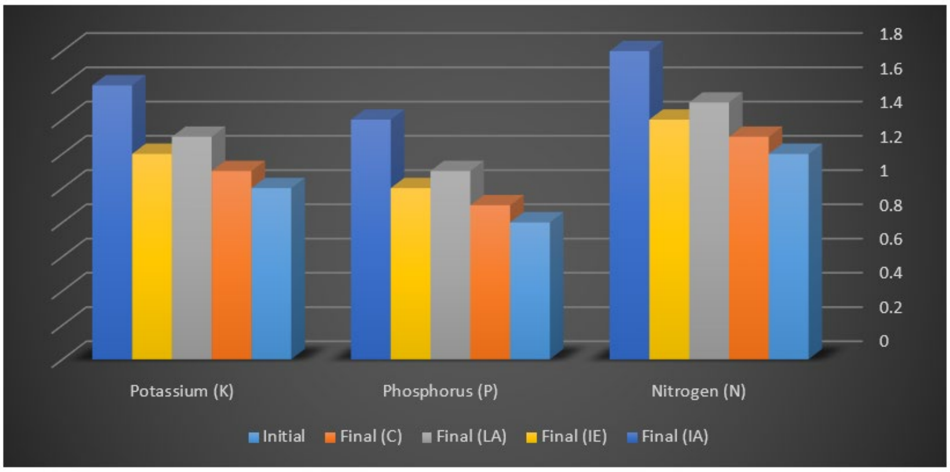

Figure 3: Change in Soil Nutrient Levels Across Treatments

Correlation Between Isopod Activity, Decomposition Rates, and Nutrient Levels

A correlation analysis revealed significant positive relationships between isopod abundance, litter decomposition rates, and increases in soil nutrient concentrations. The correlation coefficients are summarized in Table 4.

Table 4: Correlation Coefficients Between Isopod Activity, Litter Decomposition, and Soil Nutrient Levels

Variables	Correlation Coefficient (r)
Isopod Abundance vs. Decomposition Rate	0.89
Isopod Abundance vs. Nitrogen (N) Level	0.81
Decomposition Rate vs. Nitrogen (N) Level	0.86

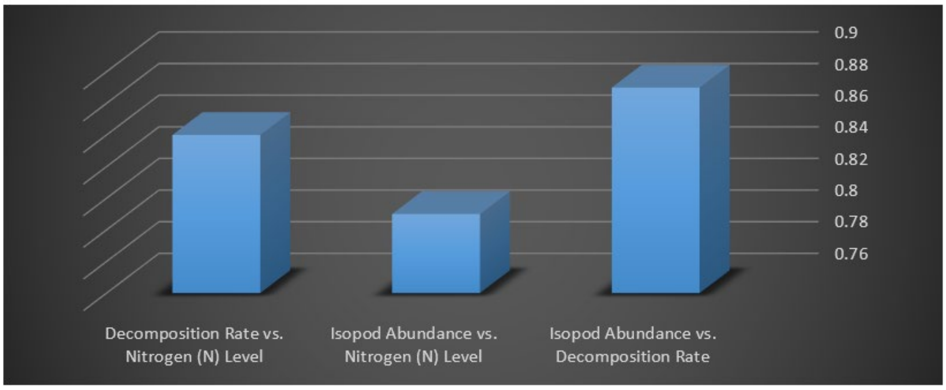

Figure 4: Correlation Between Isopod Abundance and Litter Decomposition Rate

DISCUSSION

The results of this study highlight the significant role that terrestrial isopods play in the decomposition of cellulosic litter and the subsequent nutrient cycling within soil ecosystems. The presence of isopods was found to substantially accelerate the breakdown of cellulosic materials, as evidenced by the increased decomposition rates in the Isopod Addition (IA) treatment compared to the Isopod Exclusion (IE) treatment. These findings align with previous research that emphasizes the role of soil fauna, particularly detritivores like isopods, in enhancing litter decomposition through physical fragmentation and microbial facilitation (David & Handa, 2010; Zimmer, 2002).

The study also revealed that the activity of isopods has a positive impact on soil nutrient levels, particularly nitrogen (N), phosphorus (P), and potassium (K). The increase in these essential nutrients in the IA treatment suggests that isopods not only contribute to the physical breakdown of litter but also enhance the mineralization process, making nutrients more available for plant uptake and overall soil fertility. This observation supports the hypothesis that isopods play a dual role in both mechanical litter breakdown and in facilitating nutrient cycling through their feeding and digestive processes (Hassall et al., 2002; Maraun & Scheu, 1996).

Moreover, the strong positive correlations between isopod abundance, litter decomposition rates, and nutrient levels underscore the interconnectedness of these processes. The findings suggest that areas with higher isopod populations could experience more rapid nutrient cycling and, consequently, increased soil fertility. This has important implications for ecosystem management, particularly in agricultural and forested areas where maintaining soil health is critical for productivity (Lavelle et al., 2006; Kaspari et al., 2020).

However, the study also highlights the variability in isopod effects depending on the environmental context. For instance, the different soil types in Rashidiyah (sandy loam) and Al-Hamdaniya (clay loam) might influence isopod activity and, consequently, the decomposition process. Soil texture and moisture content are known to affect isopod behavior and efficiency in litter breakdown, which could explain some of the variability observed in the decomposition rates across the two sites (Joly et al., 2019; Moore et al., 2004).

CONCLUSION

This study demonstrates that terrestrial isopods significantly enhance the decomposition of cellulosic litter, thereby playing a critical role in nutrient cycling within soil ecosystems. The presence of isopods accelerates litter decomposition, leading to increased availability of essential nutrients like nitrogen, phosphorus, and potassium in the soil. These findings emphasize the importance of conserving isopod populations and other soil fauna to maintain soil health and fertility, which is crucial for sustaining productive ecosystems.

The results also suggest that soil management practices that encourage the activity of detritivores, such as maintaining organic matter on the soil surface, could enhance nutrient cycling and improve soil fertility. Future research should explore the specific interactions between isopods and different types of litter and how these interactions vary across different environmental conditions.

Overall, this study contributes to a deeper understanding of the ecological functions of terrestrial isopods and their role in sustaining healthy soil ecosystems, with significant implications for both natural and managed landscapes.

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