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TAXONOMIC DIVERSITY OF LITTER AND SOIL INVERTEBRATES AND THE STRUCTURE OF DOMINANCE OF THEIR COMMUNITIES UNDER THE INFLUENCE OF NATURAL AFFORESTATION OF MODEL PLOTS IN WESTERN POLISSIA

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Background. Composition of tree species plays an important role in the structural and functional organization of soil invertebrates during the process of afforestation, which affects the trophic structure of soil invertebrate communities. The accumulation of dead plant residues depends on trophic specialization of the mesofauna complex, where saprophaga plays a significant role, particularly under the conditions of an increasing variety and thickness of litter. The aim of the research is to determine the current status of taxonomic diversity of litter-soil mesofauna, as well as the structural and functional organization of their communities in model plots with natural afforestation in Western Polissia.

Materials and Methods. The model plots are located on the area of Western Polissia that belongs to the mixed forest zone with the dominance of pine; meadow vegetation is located on the places of drained swamps or logged forests. The studied model plots are located in Kolesa (six transects) and Kulevytske tracts (three transects). The sampling of litter-soil mesofauna was accomplished in 2019 by means of Barber pitfall traps, and its inventory was conducted by standard in soil zoology methods.

Results and Discussion. The conducted research revealed high taxonomic diversity of litter-soil mesofauna on the transects of both model plots. Altogether we found the representatives of about 170 genera of 64 families from 6 classes of 3 phyla. The diversity of invertebrates within Kolesa model plot (180 taxa) is a bit lower compared to Kulevytske one (200 taxa). The obtained data allow us to estimate the changes taking place in the mesofauna communities under the influence of natural afforestation process. Despite the fact that all the invertebrate communities consist of approximately the same number of species (taxa) and have similar quantitative indicators of dynamic density, they show their own specifics in terms of the ratio of invertebrate trophic specialization.

Conclusion. The study found that litter-soil invertebrates are largely dependent on the composition of ecosystem plant component and the condition of the habitat created during the ecological succession. Considering the investigated transects as separate biogeocoenotic ecosystems, we can conclude that the more vegetation approaches its natural status (forest), the more dominant saprophaga trophic group of mesofauna becomes.

Keywords: mesofauna, litter-soil invertebrates, taxonomic diversity, dominance structure, trophic groups, Polissia

INTRODUCTION

Changes in the structural and functional organization of soil invertebrates during afforestation occur on the basis of species which have inhabited the area and adapted to the conditions that prevailed before the afforestation process (Wardle *et al.*, 2004). Composition of tree species plays an important role in this process, which affects the trophic structure of soil invertebrate communities, and, as a result, influences the functioning of a whole ecosystem (Jones *et al.*, 1997; Peng *et al.*, 2022; Hedeněc *et al.*, 2023). The accumulation of dead plant residues affects the redistribution of invertebrates in mesofauna complex depending on their trophic specialization. The efficient and complete destruction of dead plant residues is possible due to the fact that a significant part of litter and soil invertebrate fauna belongs to saprophaga. The ecological role of this trophic group in different ecosystems is increasing along with the variety and thickness of litter in them (Tsaryk & Yavornytskyi, 2020). Soil invertebrates are closely related to the vertical distribution of humus and rhizosphere. The lower limit of humus layer often coincides with the presence and activity of most soil invertebrates, especially saprophaga. Phytophaga of litter and soil, in contrast, are tightly connected with the rhizosphere. A greater mobility of zoophaga mainly depends on their prey location having no typical spatial niches.

The aim of the research is to determine the current status of taxonomic diversity of litter and soil mesofauna, as well as the structural and functional organization of their communities in model plots with natural afforestation in Western Polissia.

MATERIALS AND METHODS

The model plots are located on the area of Western Polissia that belongs to the mixed forest zone according to the physical and geographical zoning of Ukraine; the main type of vegetation here is pine forest, often with the inclusion of birch and alder (Barbarych, 1977). Meadow vegetation also plays a significant role in the landscape structure here; the meadows are located on the places of drained swamps or logged forests (Mokryi *et al.*, 2011). The model plots of the studied transects are located in two groups: Kolesa and Kulevytske tracts (**Fig. 1**).

Fig. 1. The localization of the studied transects within the model plots in Kolesa – 1 (51,474778 N 23,750621 E) and Kulevytske – 2 (51,434516 N 23,867931 E) tracts (Kovel District of Volyn Region)

Kolesa model plot, which lies on a moisty sandy placore, includes six transects: 1 – wet mesotrophic Pinetum myrtillosum, 2 – wet mesotrophic Betuletum myrtilloso-callunosum, 3 – Nardus stricta + Festuca rubra-Hieracium pilosella on the place of wet mesotrophic oak-pine forest, 4 – young Betuletum graminoso-variaherbosum, 5 – Betuleto-pinetum nardoso-callunosum pasture with the obvious regeneration of pine, 6 – young Betuleto-pinetum callunosum with the obvious regeneration of pine.

Kulevytske model plot lies within the floodplain of the Prypiat River and consists of three transects: 1 – Pinetum melampyroso-myrtillosum, 2 – Betuletum calamagrostidosum (canescentis) on the place of soggy eutrophic swamp, 3 – Poa pratensis + Elytrigia repens on the place of soggy eutrophic swamp.

The sampling and inventory of litter-soil mesofauna was accomplished in 2019 by means of Barber pitfall traps (Dunger & Fiedler, 1989). Material analysis was carried out by standard in soil zoology methods (Moretti *et al.*, 2017). The taxonomic composition of invertebrate communities was determined to species or higher cathegories (genus, family) depending on the community component (Burakowski, Mroczkowski & Stefańska, 1973, 1974; Harde & Severa, 1988; Rizun, 2003; Sverlova & Hural, 2005; Radchenko & Elmes, 2010). The ordering of animals into trophic groups was carried out according to Görres and Amador (2021). The dominance structure of invertebrate taxa was established after Tischler (1979).

RESULTS AND DISCUSSION

The conducted research revealed high taxonomic diversity of litter and soil mesofauna on the transects of both model plots. Altogether we found the representatives of about 170 genera of 64 families from 6 classes of 3 phyla. The diversity of invertebrates within Kolesa model plot (180 taxa) is a bit lower compared to Kulevytske one (200 taxa) (**Tables 1–3**).

Data presented in the tables allow us to estimate the changes taking place in the mesofauna communities under the influence of natural afforestation process.

Table 1. **Indicators of diversity (S) and dynamic density (N, ind. per sq. m) of invertebrate mesofauna of the research transects 1–3 within Kolesa model plot (the results are based on 100 trap-days)**

Taxon	1*			2			3		
	S	N	%	S	N	%	S	N	%
Lumbricidae	2	0.4	0.1	2	1.4	0.3	2	1.4	0.4
Oniscoidea	1	16.4	3.3	1	10.6	2.5	1	8.5	2.3
Aranei	1	115.6	23.1	1	46.6	10.9	1	54.2	14.9
Opiliones	1	3.5	0.7	1	11.8	2.8	1	2.6	0.7
Chilopoda	2	1	0.2	2	1.1	0.3	0	0	0.0
Diplopoda	6	13.3	2.7	4	8.4	2.0	1	0.5	0.1
Blattidae	1	14	2.8	1	0.2	0.0	1	0.5	0.1
Tettigoniidae	0	0	0.0	0	0	0.0	2	1.4	0.4
Dermaptera	1	0.4	0.1	1	0.2	0.0	0	0	0.0
Cicadidae	0	0	0.0	1	0.2	0.0	1	8.7	2.4
Hemiptera	2	6.2	1.2	2	7.2	1.7	2	3.8	1.0
Carabidae	11	39	7.8	19	77	18.0	21	33	9.0
Staphylinidae	11	67	13.4	6	19	4.5	5	35	9.6
Coccinellidae	0	0	0.0	*1*	0.1	0.0	1	0.2	0.1
Cantharididae	1	0.2	0.0	*1*	0.4	0.1	1	0.7	0.2
Adephaga (lar.)		4.1	0.8		2	0.5		0.5	0.1
Formicidae	3	163.9	32.7	5	210.8	49.4	8	180	49.4
Chrysomelidae	2	1.9	0.4	2	0.7	0.2	1	2.2	0.6
Silphidae	1	22.6	4.5	3	1.3	0.3	1	1	0.3
Tenebrionidae	0	0	0.0	0	0	0.0	1	2.4	0.7
Buprestidae	0	0	0.0	0	0	0.0	1	0.2	0.1
Elateridae		0.8	0.2		1.3	0.3		13.8	3.8
Cerambycidae	1	0.2	0.0	1	0.1	0.0	0	0	0.0
Scarabaeidae	1	18.5	3.7	3	15.3	3.6	2	0.2	0.1
Erotylidae	1	0.6	0.1	0	0	0.0	0	0	0.0
Ipidae	1	0.4	0.1	0	0	0.0	0	0	0.0
Curculionidae		7.3	1.5		6.4	1.5		5.8	1.6
Diptera	1	0.8	0.2	0	0	0.0	0	0	0.0
Tenthredinidae	2	0	0.0	2	0.2	0.0	0	0	0.0
Trichoptera		2.1	0.4		3.5	0.8		5.3	1.5
Panorpidae	1	0.2	0.0	1	0.1	0.0	1	0.9	0.2
Alleculidae	0	0	0.0	1	0.4	0.1	1	1	0.3
Lepidoptera (lar.)	2	0.4	0.1	3	0.5	0.1	1	0.9	0.2
Mollusca	2	0.6	0.1		0	0.0		0	0.0
Total	58	501.4	100	64	426.8	100	57	364.7	100

Note: * Research transects (see their description in Material and Methods)

Table 2. **Indicators of diversity (S) and dynamic density (N, ind. per sq. m) of invertebrate mesofauna of the research transects 4–6 within Kolesa model plot (the results are based on 100 trap-days)**

Taxon	4*			5			6		
	S	N	%	S	N	%	S	N	%
Lumbricidae	1	4.8	1.1	1	0.4	0.1	1	1	0.3
Oniscoidea	1	14.4	3.3	1	9.5	2.8	1	5.3	1.4
Aranei	1	52.6	12.0	1	50	14.9	1	45.5	12.1
Opiliones	1	12.1	2.7	1	1.7	0.5	1	1	0.3
Chilopoda	1	1.3	0.3	1	0.9	0.3	1	0.3	0.1
Diplopoda	7	8	1.8	4	2.4	0.7	3	2.9	0.8
Tettigoniidae			0.0			0.0	1	0.5	0.1
Hemiptera	6	8.8	2.0	4	3	0.9	5	4.3	1.1
Cicadidae	2	5.6	1.3	2	4.3	1.3	3	6.8	1.8
Blattidae	1	0.9	0.2	1	1	0.3	1	0.3	0.1
Orthoptera		0	0.0	1	0.1	0.0			0.0
Carabidae	18	42.3	9.6	14	20	6.0	10	111.8	29.7
Staphylinidae	8	40.5	9.2	5	52	15.5	4	16.2	4.3
Cantharidae		0.6	0.1		0.9	0.3		0.9	0.2
Adephaga	1	7.1	1.6	1	4.3	1.3	1	1.2	0.3
Formicidae	4	200	45.4	5	168	50.2	8	139	36.9
Chrysomelidae	1	1.8	0.4	3	1	0.3	2	2.1	0.6
Silphidae	3	2.4	0.5	1	0.9	0.3	2	7	1.9
Tenebrionidae			0.0		0.1	0.0		0.3	0.1
Buprestidae			0.0			0.0		0.2	0.1
Elateridae	5	2.8	0.6	3	1.7	0.5	1	0.7	0.2
Scarabaeidae	1	14.5	3.3	2	3.8	1.1	2	1.9	0.5
Coleoptera sp.			0.0			0.0		0.7	0.2
Curculionidae	6	9.6	2.2	5	5.8	1.7	7	23.9	6.3
Diptera		0.3	0.1	1	0.7	0.2		0.2	0.1
Tenthredinidae	1	0.1	0.0	1	0.7	0.2	1	0.5	0.1
Trichoptera		7.7	1.7		1.1	0.3		0.5	0.1
Panorpidae		1.1	0.2			0.0			0.0
Lepidoptera	1	0.3	0.1			0.0	2	1.4	0.4
Mollusca	2	0.5	0.1	2	0.4	0.1	2	0.2	0.1
Total	72	440.1	100	60	334.7	100	75	376.6	100

Note: * Research transects (see their description in Material and Methods)

Table 3. **Indicators of diversity (S) and dynamic density (N, ind. per sq. m) of invertebrate mesofauna of the research transects within Kulevytske model plot (the results are based on 100 trap-days)**

Taxon	1*			2			3		
	S	N	%	S	N	%	S	N	%
Lumbricidae	1	3.1	0.5	1	1.7	0.3	1	2.9	0.6
Oniscoidea	1	26.6	4.4	2	70.5	12.8	1	23	4.4
Aranei	1	109	18.0	1	53.7	9.8	1	61	11.7
Trogulidae		0.1	0.0			0.0			0.0
Opiliones	1	2.1	0.3	1	31.1	5.7	1	11	2.1
Chilopoda	1	2.3	0.4	1	6.8	1.2	2	4.6	0.9
Diplopoda	5	53.8	8.9	4	148	26.9	3	23	4.4
Tettigoniidae		0	0.0		0	0.0		5.6	1.1
Dermaptera	1	0.3	0.0		0	0.0		0	0.0
Hemiptera	3	5.5	0.9		6.5	1.2	2	3.7	0.7
Cicadidae		0	0.0		4.4	0.8	2	26	5.0
Blattidae	2	3.3	0.5	1	1.1	0.2		0.2	0.0
Carabidae	21	84	13.9	21	33	6.0	17	27	5.2
Staphylinidae	7	34.3	5.7	4	58.1	10.6	3	28	5.4
Cantharidae	1	1.3	0.2	1	0.4	0.1	1	0.2	0.0
Coccinelidae		0	0.0		0	0.0		3.2	0.6
Dytiscidae		0.1	0.0		0	0.0		0	0.0
Adephaga	2	3.2	0.5	2	8.2	1.5	1	2.9	0.6
Formicidae	4	198	32.7	6	46.2	8.4	5	242	46.5
Chrysomelidae	2	11.6	1.9	4	18.2	3.3	1	4.9	0.9
Silphidae	3	1.6	0.3	3	40.5	7.4	1	6	1.2
Scolytidae	1	0.1	0.0	1	0.1	0.0		0	0.0
Tenebrionidae		0.1	0.0		0.3	0.1	4	11	2.1
Elateridae	1	1	0.2	3	3.1	0.6	7	12	2.3
Cerambicidae		0.3	0.0			0.0			0.0
Scarabaeidae	2	28.4	4.7	1	4.1	0.7	1	1.4	0.3
Coleoptera		0.1	0.0		1.7	0.3			0.0
Curculionidae	2	15.1	2.5	1	0.3	0.1	8	9	1.7
Diptera		0.2	0.0		0.2	0.0		0.2	0.0
Tenthredinidae	1	0.1	0.0	1	0.4	0.1	1	0.2	0.0
Trichoptera		19.2	3.2		8.1	1.5		7.6	1.5
Panorpa		0	0.0	1	1	0.2		0	0.0
Lepidoptera	1	1.1	0.2	1	1.6	0.3	1	1.5	0.3
Mollusca	1	0.3	0.0	1	0.7	0.1	4	2.5	0.5
Total	65	606.2	100	62	550.0	100	68	520.6	100

Note: * Research transects (see their description in Material and Methods)

Despite the fact that all the invertebrate communities consist of approximately the same number of species (taxa) and have similar quantitative indicators of dynamic density, they still show their own specifics in terms of the ratio of invertebrate trophic specialization (**Fig. 2–3**).

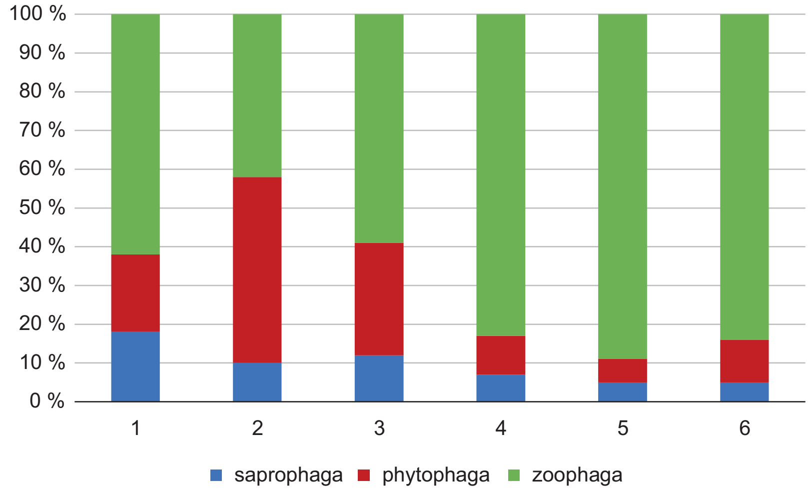

Fig. 2. The ratio of trophic groups of litter-soil invertebrate mesofauna of the research transects within Kolesa model plot (see the transects description in Material and methods)

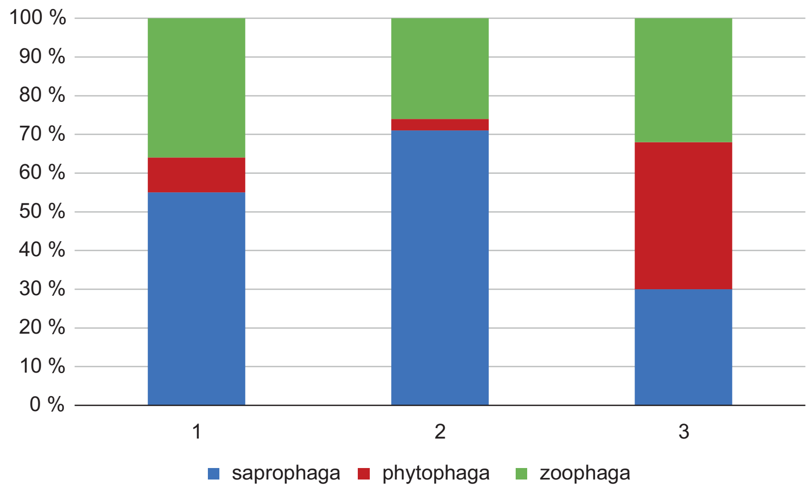

Fig. 3. The ratio of trophic groups of litter-soil invertebrate mesofauna of the research transects within Kulevytske model plot (see the transects description in Material and methods)

CONCLUSION

Considering the investigated transects of Kolesa and Kulevytske model plots as separate biogeocoenotic ecosystems, it can be concluded that each of them has its own typical characteristics. The more phytocoenosis approaches its natural status (forest) in terms of species composition, the more dominant saprophaga trophic group of mesofauna becomes.

We found that litter-soil invertebrates are largely dependent on the composition of ecosystem plant component and the condition of habitat created by phytocoenosis during the ecological succession. The process of natural afforestation cannot be regarded as exclusively positive as the penetration of invertebrate species with different trophic specialization indicates profound and often unpredictable changes of litter and soil invertebrate communities. Such changes are the manifestations of energy perturbations which lead to an optimal ecosystem condition in the course of time (Whittaker, 1975; Auclerc *et al.*, 2022), which is exactly what we observe in our survey.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Animal Rights: This article does not contain any results of studies with animal subjects performed by the any of the authors.

AUTHOR CONTRIBUTIONS

Conceptualization, [I.T.; V.Y.; OR]; methodology, [I.T.; V.Y.]; validation, [I.T.; O.R.]; formal analysis, [I.T.; V.Y.; O.R.].; investigation, [I.T.; V.Y.]; resources, [I.T.; V.Y.; O.R.]; data curation, [I.T.; O.R.]; writing – original draft preparation, [I.T.; O.R.]; writing – review and editing, [O.R.]; visualization, [O.R.] supervision, [O.R.]; project administration, [I.T.; O.R.]; funding acquisition, [I.T.; V.Y.; O.R.].

All authors have read and agreed to the published version of the manuscript.

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ТАКСОНОМІЧНЕ РІЗНОМАНІТТЯ ПІДСТИЛКОВО-ҐРУНТОВИХ БЕЗХРЕБЕТНИХ І СТРУКТУРА ДОМІНУВАННЯ ЇХНІХ УГРУПОВАНЬ ПІД ВПЛИВОМ ПРИРОДНОГО ЗАЛІСНЕННЯ МОДЕЛЬНИХ ДІЛЯНОК НА ЗАХОДІ ПОЛІССЯ

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Вступ. Важливу роль у структурно-функціональній організації ґрунтових безхребетних під впливом природного заліснення відіграє склад деревних порід, який формуватиме трофічну структуру угруповань ґрунтових безхребетних. Нагромадження мертвих рослинних залишків залежить від трофічної спеціалізації комплексу мезофауни, у якому сапрофаги відіграють провідну роль, особливо за умови збільшення різноманіття і товщини підстилки. Мета досліджень – з'ясувати сучасний стан таксономічного різноманіття підстилково-ґрунтових безхребетних мезофауни, а також структурно-функціональну організацію їхніх угруповань на ділянках із природним залісенням.

Матеріали та методи. Модельні ділянки розміщені на території заходу Полісся, яке належить до зони мішаних лісів з домінуванням сосни; лучна рослинність представлена у місцях осушених боліт і знищених лісів. Досліджувані ділянки розташовані в урочищах Колеса (шість трансект) і Кулевицьке (три трансекти). Збір підстилково-ґрунтових безхребетних проводили у 2019 р. методом відлову пастками Барбера, а камеральне опрацювання матеріалу здійснювали згідно з загальноприйнятими у ґрунтовій зоології методиками.

Результати. Дослідженнями встановлено високе таксономічне різноманіття підстилково-ґрунтової мезофауни на трансектах обох модельних ділянок. Загалом виявлено представників близько 170 родів із 64 родин шести класів, які належать до трьох типів. Різноманіття безхребетних модельної ділянки Колеса (180 таксонів) є трохи нижчим, порівняно з модельною ділянкою Кулевицьке (200 таксонів). Отримані дані дають нам змогу оцінити зміни в угрупованнях безхребетних мезофауни, які виникають унаслідок впливу процесу природного заліснення. Незважаючи на те, що практично всі угруповання безхребетних сформовані приблизно тією ж кількістю видів (таксонів) і мають подібні кількісні показники динамічної щільності, вони виявляють свою специфіку у співвідношенні трофічних груп.

Висновки. Дослідженням встановлено, що підстилково-ґрунтові безхребетні є значною мірою залежні від складу рослинної компоненти екосистеми й умов оселища, сформованого під час екологічної сукцесії. Вважаючи досліджувані трансекти окремими біогеоценозними екосистемами, робимо висновок про те, що чим більше їхня рослинність наближається до природного стану (ліс), тим характернішим для неї стає домінування сапрофагів.

Ключові слова: мезофауна, підстилково-ґрунтові безхребетні, таксономічне різноманіття, структура домінування, трофічні групи, Полісся

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