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Terrestrial isopod (Crustacea, Isopoda) assemblages near a local road in a forested region from Oaș Mountains, North-Western Romania

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Abstract. Roads are in permanent expansion at the global level and have numerous negative effects, impacting even the litter-dwelling invertebrates from their vicinity. In this context, we studied the terrestrial isopod assemblages from the vicinity of a local road situated in a forested region in Oaș Mountains (North-Western Romania) with the direct collecting method, where we encountered 17 terrestrial isopod species. Most of them were native species related to forested and wet areas. We also recorded species that are endemic to the Carpathian Mountains and species that are rare in the country. Thus, we recorded *Trichoniscus provisorius*, mentioning it for the second time in the country, both distribution records being situated in North-Western Romania. The terrestrial isopod assemblages from the road edges were diverse, as the species number resembles the number previously registered in the natural areas of North-Western Romania. The synanthropic and generalist species and individuals were only a few, recorded especially in the vicinity of the Negrești-Oaș town. Because this local road is situated in the middle of a region covered with vast and natural forests, it did not succeed in modifying the isopod assemblages, which, even on the road edges, resemble the assemblages from the region's natural habitats.

Keywords: forests, human impact, transportation infrastructure, native species, litter-dwelling invertebrates.

Introduction

Litter-dwelling invertebrates are negatively affected by the road network, a fact manifested through the increased abundance of invasive species and some native generalist species in their vicinity (e.g., Delgado *et al.* 2013). This situation is also true for other invertebrates, whose abundance is higher at a distance from the road (Gagnon *et al.* 2024). The negative influence of this transportation infrastructure can be observed at a greater scale, too, with the increase in the number of roads affecting even ecosystems (Delgado *et al.* 2013). The influence of road networks on invertebrate assemblages was also registered in the case of terrestrial isopods (Vona-Túri *et al.* 2017, 2019). They are detritivores, contributing to the decomposition processes (see in: Zimmer 2002), a fact important especially in the vicinity of roads, where heavy metals and other toxic elements accumulate (e.g. Legret & Pagotto 2006, Werkenthin *et al.* 2014, Ciazela & Siepak 2016). These elements could also accumulate in isopods, which in this way become indicators for the presence of those toxins in the environment (e.g., Dallinger *et al.* 1992, Nannoni *et al.* 2015, Ghemari *et al.* 2017). Isopod assemblages can also offer valuable information about roadsides, reflecting their negative effects by changes registered in abundance and diversity (Vona-Turi *et al.* 2017, 2019). However, these effects are not uniformly applicable to all types of infrastructure, as in the vicinity of some abandoned railways, terrestrial isopod assemblages are diverse, comprising even rare and endemic species (Pop *et al.* 2021a,b). Also, in the case of insects like Collembola, density was more reduced near roads situated in the forest than further inside the forests, at some distance from the road (Hasegawa *et al.* 2015). Spiders and beetles, and especially species linked to forests, were negatively affected by the vicinity of the highway, but the same factor seems to favor the generalist species (Knapp *et al.* 2013). Moreover, road verges are considered important habitats in the case of some grassland invertebrates (Kaur *et al.* 2019). Thus, indeed, the impact of the road network on fauna seems to differ according to the taxa (Gagnon *et al.* 2024).

In North-Western Romania, there are numerous terrestrial isopod species related to wet areas and forests, species which even dominated the assemblages in many cases (e.g., Ferenți *et al.* 2013a,b, Ianc & Ferenți 2014, Ferenți & Covaciu-Marcov 2015). Thus, because invertebrate species linked to forests are negatively affected by roads (Knapp *et al.* 2013), we hypothesized that in a region like North-Western Romania with many isopods related to forests (Ferenți *et al.* 2013a,b, Ianc & Ferenți 2014, Ferenți & Covaciu-Marcov 2015), the impact of roads crossing the forest should reflect on the terrestrial isopod assemblages living on their verges. Because, at least in the case of pollinating insects, highway verges differ from other road-type verges, as they are more abundant on non-highway roads (Villemey *et al.* 2018), we supposed that in the case of terrestrial isopods, the negative effect of the local road from a forested region will be much reduced compared with the effects of highways and more closed with the effect of railways which does not negatively affect the isopods (Pop *et al.* 2021a,b). Therefore, we chose to study terrestrial isopod assemblages on the verge of a local road from a forested region in North-Western Romania that shelter diverse and relatively well-known terrestrial isopod assemblages (Ferenți *et al.* 2012, 2013a, b). The study's objectives were to establish the specific composition of the terrestrial isopod assemblages on the road verges and their diversity depending on their location and the surrounding habitats.

Materials and methods

Site description

The field study took place on 22 October 2022. All samples were collected on the same day from the same region. The studied region is situated in the northeastern part of Satu Mare County, in the region of Oaș Mountains, near Negrești-Oaș town. Our study focused on the terrestrial isopod assemblages on the road's verges that connect the Negrești-Oaș town with the touristic resort of local interest from Luna Șes. In the region of Luna Șes, there is a concentration of tourist offers (Herman 2012). The road runs, for the most part, parallel with the Talna River. The road passes a mountain region, the Oaș Mountains, which are volcanic (Pătrașcu 1993, Jurje *et al.* 2014, Kovacs *et al.* 2017), rich in mineral resources. Thus, there were mines in the region in the past, most of which are closed nowadays. Present industrial activities are represented by some still-functioning quarries. Even in the vicinity of the studied road, there are large and active stone quarries, but also abandoned mine openings. The region crossed by the studied road is mostly covered by vast, natural, predominantly beech forests. The forest from the Oaș Mountains and other surrounding mountain ranges are dominated by beech (Rob 2008), which was present in the region also in the past (Feurdean & Astaloș 2005). However, in the vicinity of the road surrounded by massive and compact beech forests, there are also sectors with wet areas surrounded by alders, small areas with secondary open areas with grassy vegetation, rocky areas surrounded by forests, and in the case of sector 1, also abandoned buildings.

Sampling

The terrestrial isopods were collected directly under different types of shelters present in the region (logs, stones, debris, etc.), as in other studies (Ferenți *et al.* 2013a, b, Pal *et al.* 2019, Pop *et al.* 2019). Also, we collected samples from the forest litter with the help of a litter sieve. The samples were collected from a maximum distance of 5 meters from the road edges (the edge of the asphalted part). Totally, on the road edge, we collected samples from 10 sites (10 road sectors). Sector 1 was the most downstream, situated right at the limit of Negrești-Oaș town, and sector 10 was the most upstream, situated in the region of Luna Șes touristic resort. Also, where it was possible (and in the case of most sectors, it was possible), we separated the samples from the lower edge of the road (which was situated towards the watercourse) from the ones situated on the upper edge of the road (from the opposite side and usually drier). Nevertheless, there were sectors where this separation was not possible (in the case when there were vertical concrete walls between the road and the watercourse as the road was situated right next to the water).

Species identification and data analysis

The isopods were preserved in test tubes with ethyl alcohol and subsequently determined in the laboratory according to the identification keys (e.g. Radu 1983, 1985, Farkas & Vilisics 2013, Giurginca 2022). After species identification, we calculated the percentage abundance of the isopod species, both totally and according to the sectors, roadside, and shelter types. Also, we calculated the frequency of occurrence using the same datasets. Subsequently, we calculated species diversity with the Shannon index and the similarity between the species composition of different datasets with the Jaccard index. The significance of the differences between sectors, roadsides, and shelter types was calculated with the help of Kruskal-Wallis and Mann-Whitney tests. Also, we used principal component analysis to observe the affinity of different terrestrial isopod species for different sectors, shelter types, and roadsides. The statistics were calculated in the Past software (Hammer *et al.* 2001).

Results

At the vicinity of the road between Negrești-Oaș and Luna Șes we identified 166 individuals which belonged to 17 terrestrial isopod species: *Ligidium hypnorum*, *L. germanicum*, *L. intermedium*, *Trichoniscus provisorius*, *Hyloniscus transsilvanicus*, *H. riparius*, *Cylisticus convexus*, *Porcellium conspersum*, *P. collicola*, *Protracheoniscus politus*, *Trachelipus difficilis*, *T. rathkii*, *T. arcuatus*, *T. nodulosus*, *Porcellio scaber*, *Armadillidium vulgare*, *A. versicolor*. Besides those species, we also identified a female from the *Trichoniscus* genus, which could not be assigned to a species. Thus, in reality, 18 terrestrial isopod species were present on the studied road edges. The best-represented species was *P. politus*. This species registered the highest percentage abundance (18.07%), as we collected 30 individuals. *P. politus* was followed by *L. hypnorum* with a percentage abundance of 14.45% and *P. conspersum* with a percentage abundance of 10.24% (Table 1).

Table 1. Percentage abundance (P%), frequency of occurrence (f%) of terrestrial isopod species in the ten sectors (S1 – S10) of the roadside from Oaş Mountains.

Identification		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	P%	f%
L. hypnorum	P%	-	31.25	66.66	20.00	13.79	-	-	-	-	-	14.45	21.73
	f%	-	50.00	50.00	66.66	33.33	-	-	-	-	-		
L. germanicum	P%	-	-	-	-	-	-	-	20.83	-	30.00	6.62	8.69
	f%	-	-	-	-	-	-	-	33.33	-	50.00		
L. intermedium	P%	-	-	-	-	17.24	-	-	-	-	-	3.01	4.34
	f%	-	-	-	-	33.33	-	-	-	-	-		
Trichoniscus sp.	P%	-	-	-	-	-	-	20.00	-	-	-	0.60	4.34
	f%	-	-	-	-	-	-	50.00	-	-	-		
T. provisorius	P%	-	-	-	-	-	16.66	-	-	-	-	0.60	4.34
	f%	-	-	-	-	-	33.33	-	-	-	-		
H. transsilvanicus	P%	-	12.50	-	6.66	17.24	-	-	-	100	-	7.83	21.73
	f%	-	50.00	-	33.33	66.66	-	-	-	100	-		
H. riparius	P%	-	-	-	6.66	-	33.33	20.00	20.83	-	-	5.42	26.08
	f%	-	-	-	33.33	-	33.33	50.00	100	-	-		
C. convexus	P%	46.66	4.16	-	-	-	-	20.00	16.66	-	-	8.43	26.08
	f%	100	50.00	-	-	-	-	50.00	66.66	-	-		
P. conspersum	P%	-	35.41	-	-	-	-	-	-	-	-	10.24	4.34
	f%	-	50.00	-	-	-	-	-	-	-	-		
P. collicola	P%	6.66	-	-	26.66	-	-	-	-	-	-	3.01	8.69
	f%	50.00	-	-	33.33	-	-	-	-	-	-		

Identification		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	P%	f%
P. politus	P%	-	-	-	26.66	44.82	33.33	-	8.33	-	45.00	18.07	21.73
	f%	-	-	-	33.33	33.33	33.33	-	33.33	-	50.00		
T. difficilis	P%	-	6.25	-	6.66	-	-	-	-	-	-	2.40	8.69
	f%	-	50.00	-	33.33	-	-	-	-	-	-		
T. rathkii	P%	-	-	-	-	-	16.66	40.00	-	-	-	1.80	8.69
	f%	-	-	-	-	-	33.33	50.00	-	-	-		
T. arcuatus	P%	-	4.16	-	-	-	-	-	4.16	-	-	1.80	8.69
	f%	-	50.00	-	-	-	-	-	33.33	-	-		
T. nodulosus	P%	6.66	-	-	-	-	-	-	-	-	-	0.60	4.34
	f%	50.00	-	-	-	-	-	-	-	-	-		
P. scaber	P%	33.33	-	-	-	-	-	-	-	-	-	3.01	4.34
	f%	50.00	-	-	-	-	-	-	-	-	-		
A. vulgare	P%	6.66	2.08	-	-	-	-	-	29.16	-	25.00	8.43	21.73
	f%	50.00	50.00	-	-	-	-	-	33.33	-	100		
A. versicolor	P%	-	4.16	33.33	6.66	6.89	-	-	-	-	-	3.61	26.08
	f%	-	100	50.00	33.33	66.66	-	-	-	-	-		
% individuals		9.03	28.91	1.80	9.03	17.46	3.61	3.01	14.45	0.60	12.04		
No. of species		5	8	2	7	5	4	4	6	1	3		
Shannon diversity		1.26	1.64	0.63	1.74	1.42	1.32	1.33	1.65	0	1.06		

The first place as frequency of occurrence was occupied by three species (*H. riparius*, *C. convexus,* and *A. versicolor*), each with a frequency in samples of 26.08%. The second place was occupied by four species (*L. hypnorum, H. transsilvanicus*, *P. politus,* and *A. vulgare*), each with a frequency of occurrence of 21.73%. The total diversity of the terrestrial isopod assemblages from the road edges was 2.54.

The differences between the terrestrial isopod assemblages from the 10 road sectors were important in terms of the number of species, the percentage abundance, the frequency of occurrence, and the diversity (Table 1).

The highest number of species (8) was registered in the case of sector 2, and the smallest number (only one species) was registered in the case of sector 9. The highest diversity (H=1.74) was recorded in sector 4, and the lowest in sector 9, where only one species was present. According to the Jaccard similarity index, the most different was sector 9, and the most resemblance was registered between sectors 4 and 5 on one side, and sectors 8 and 10 on the other side (Figure 1). According to the Kruskal-Wallis test, the differences between the assemblages from the 10 road sectors were not significant (p=0.083). Nevertheless, analyzing the sectors two by two, differences were significant between sectors 2 and 3 (p=0.007), sectors 2 and 9 (p=0.006), sectors 3 and 4 (p=0.021), sectors 3 and 8 (p=0.035), sectors 4 and 9 (p=0.016) and sectors 8 and 9 (p=0.031).

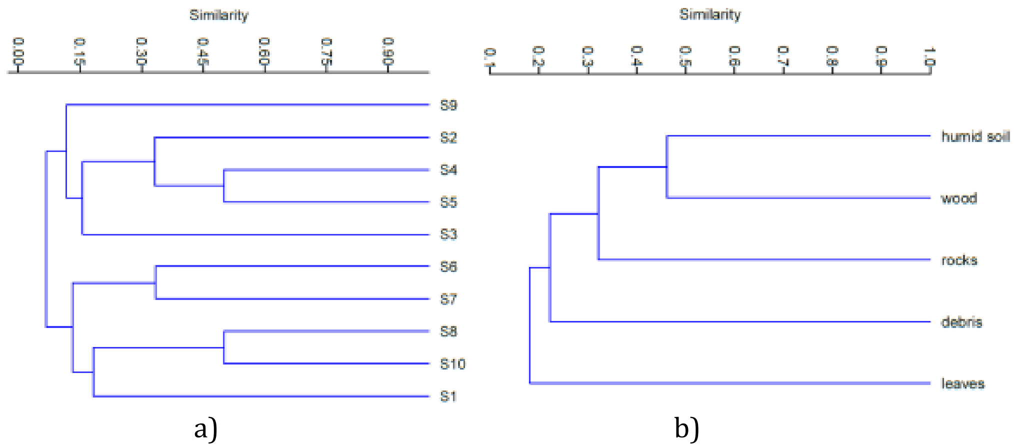

Figure 1. Similarity of terrestrial isopod assemblages (according to the Jaccard index) between the studied sectors (a) and shelter types (b)

In the case of shelters, in the forest litter, we identified 7 terrestrial isopod species, the most abundant and frequent being *P. politus* (Table 2).

Table 2. Percentage abundance (P%), frequency of occurrence (f%), species richness, and Shannon diversity index of terrestrial isopods identified in different shelters and sides of the road.

		Shelters					Roadside	
		Leaf litter	Humid soil	Stones	Debris	Logs	Upper side	Lower side
L. hypnorum	P%	8.10	22.61	-	-	8.33	17.32	5.12
	f%	50.00	33.33	-	-	33.33	28.57	11.11
L. germanicum	P%	-	13.09	-	-	-	3.93	15.38
	f%	-	33.33	-	-	-	7.14	11.11
L. intermedium	P%	13.51	-	-	-	-	3.93	-
	f%	25.00	-	-	-	-	7.14	-
Trichoniscus sp.	P%	-	1.19	-	-	-	-	2.56
	f%	-	16.66	-	-	-	-	11.11
T. provisorius	P%	2.70	-	-	-	-	0.78	-
	f%	25.00	-	-	-	-	7.14	-
H. transsilvanicus	P%	10.81	9.52	-	12.50	-	9.44	2.56
	f%	50.00	33.33	-	50.00	-	28.57	11.11
H. riparius	P%	2.70	2.38	30.76	-	8.33	5.51	5.12
	f%	25.00	16.66	37.50	-	33.33	28.57	22.22
C. convexus	P%	-	2.38	15.38	50.00	25.00	7.87	10.25
	f%	-	16.66	25.00	50.00	66.66	21.42	33.33
P. conspersum	P%	-	20.23	-	-	-	13.38	-
	f%	-	16.66	-	-	-	7.14	-
P. collicola	P%	10.81	-	-	12.50	-	3.93	-
	f%	25.00	-	-	50.00	-	14.28	-
P. politus	P%	51.35	13.09	-	-	-	16.53	23.07
	f%	75.00	33.33	-	-	-	28.57	11.11
T. difficilis	P%	-	3.57	-	-	4.16	-	10.25
	f%	-	16.66	-	-	33.33	-	22.22
T. rathkii	P%	-	-	23.07	-	-	-	7.69
	f%	-	-	25.00	-	-	-	22.22
T. arcuatus	P%	-	2.38	-	-	4.16	2.36	-
	f%	-	16.66	-	-	33.33	14.28	-
T. nodulosus	P%	-	-	-	12.50	-	0.78	-
	f%	-	-	-	50.00	-	7.14	-

		Shelters					Roadside	
		Leaf litter	Humid soil	Stones	Debris	Logs	Upper side	Lower side
P. scaber	P%	-	-	-	-	20.83	3.93	-
	f%	-	-	-	-	33.33	7.14	-
A. vulgare	P%	-	5.95	7.69	12.50	29.16	7.08	12.82
	f%	-	33.33	12.50	50.00	33.33	21.42	22.22
A. versicolor	P%	-	3.57	23.07	-	-	3.14	5.12
	f%	-	50.00	37.50	-	-	28.57	22.22
% individuals		22.28	50.60	7.83	4.81	14.45	76.50	23.49
No. of species		7	12	5	5	7	15	11
Shannon diversity index		1.49	2.14	1.52	1.38	1.71	2.42	2.19

The assemblage diversity in the forest litter was reduced, reaching a value of only 1.49. In humid soil, we identified 12 species, the most abundant being *L. hypnorum*; in the case of frequency of occurrence, several species registered a high value (Table 2). In this type of shelter, we registered the highest species number and diversity (H=2.14). Under stones, we identified only 5 species, the diversity of the assemblages being 1.52. The same number of species was identified under debris, but the species diversity was the lowest, reaching a value of only 1.38. Under logs, we identified 7 terrestrial isopod species, with a diversity of 1.71. According to the Jaccard index, the assemblages from wet soil and under logs seem the most similar and the most different from forest litter (Figure 1).

According to the Kruskal-Wallis test, the differences between the assemblages from different types of shelters were significant (p=0.025). The Mann-Whitney test shows significant differences between the assemblages from wet soil and stones (p=0.011), between wet soil and debris (p=0.003), and between wet soil and logs (p=0.044). The differences between the assemblages on the two roadsides were significant, according to the Kruskal-Wallis test (p=0.012) and the Mann-Whitney test (p=0.013). The Principal Component Analysis showed that *H. transsilvanicus*, *L. hypnorum*, and *P. conspersum* had an affinity for the upper side of the road, and *L. germanicum* and *P. politus* for the lower part of the road (Figure 2).

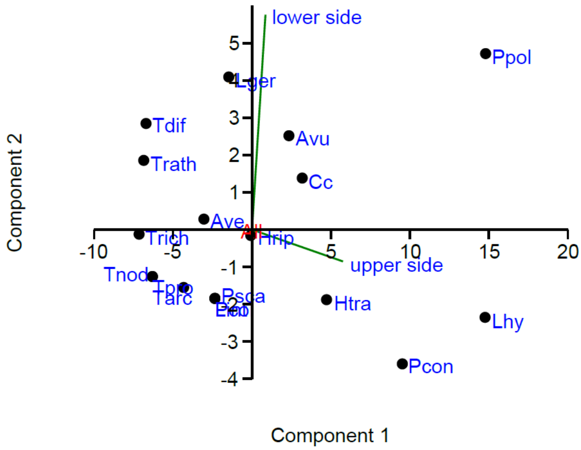

Figure 2. Principal component analysis between terrestrial isopod species and sides of the road (Lhy–*L. hypnorum*, Lger-*L. germanicum*, Lint-*L. intermedium*, Tpro–*T. provisorius*, Htra-*H. transsilvanicus*, Hrip-*H. riparius*, Cc-*C. convexus*, Pcon-*P. conspersum*, Pcol-*P. collicola*, Ppol-*P. politus*, Tdif-*T. difficilis*, Trath-*T. rathkii*, Tarc-*T. arcuatus*, Tnod-*T. nodulosus*, Psca-*P. scaber*, Avu-*A. vulgare*, Ave-*A. versicolor*)

Regarding shelters, *P. conspersum* presented an affinity for wet soil, *T. nodulosus* for debris, and more species for leaf litter (Figure 3). In the sectors, the affinity of *P. scaber* and *T. nodulosus* for sector 1 was very clear (Figure 3).

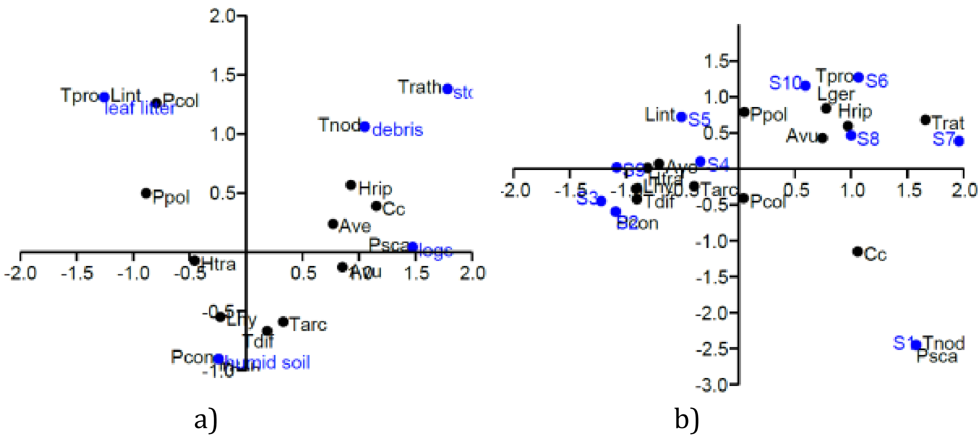

Figure 3. Correspondence analysis between terrestrial isopod species and shelters (a)/ studied sectors (b) (for species abbreviations see Figure 2)

Discussion

The terrestrial isopod species with the highest percentage abundance on the edges of the road between Negrești Oaș and Luna Șes are native species, characteristic of wet areas and forests. This is the case of the species from the *Ligidium, Hyloniscus,* and *Porcellium* genera or the case of *T. difficilis* and *T. arcuatus*, which, according to the literature, are related to such habitats (e.g., Radu 1983, 1985, Tomescu *et al.* 2011, 2012, 2015, Giurginca 2022). Through this composition, the isopod assemblages that populate the road verges resemble the ones from natural areas situated in this region of Romania (Ferenți *et al.* 2012, 2013a,b, Ianc & Ferenți 2014, Ferenți & Covaciu-Marcov 2015). Unlike these, both in the case of terrestrial isopods (Vona-Túri *et al.* 2017, 2019) and other invertebrates (Knapp *et al.* 2013), road verges are populated by generalist and invasive species.

Unlike roads, railways, especially abandoned ones, shelter more diverse isopod assemblages dominated by native species, which include even rare and endemic species (Pop *et al.* 2021a,b). Thus, the degree of disturbance in the assemblages is determined by the type of transportation network and its use, but also probably by the amplitude of the impact it generates. This is proved by this secondary road with little traffic surrounded by the forests from Oaș Mountains, which had a rich terrestrial isopod fauna. Therefore, the presence of natural areas surrounding the road had important effects in maintaining the natural assemblages that are in balance with the region, just like in the case of small towns surrounded by natural habitats (Herle *et al.* 2016). The number of terrestrial isopod species present on the road edges is close to the one registered in the natural areas of Western Romania (Ferenți *et al.* 2013a,b, Ianc & Ferenți 2014, Ferenți & Covaciu-Marcov 2015) or other regions in the country (Tomescu *et al.* 2011). In this study we even recorded two more species than in another study realized in more localities in the Oaș Mountains (Ferenți *et al.* 2013b).

Porcellium conspersum is a species well represented near the road from Oaș Mountains. In other parts of its distribution range it is usually connected with old and humid natural forests (Soesbergen 1999, Berg *et al.* 2012). It was also identified in the wet soil situated at the base of alders (Berg *et al.* 2012), just like in the vicinity of the road between Negrești Oaș and Luna Șes. Even in Romania, *P. conspersum* was considered a species typical for coniferous and deciduous forests (Tomescu *et al.* 2012). In the Oaș Mountains region, *P. conspersum* has been identified previously at low altitudes but in a smaller number of individuals (Ferenți *et al.* 2012, 2013b). In this study, however, *P. conspersum* registered a much higher percentage abundance than *P. collicola*, which is usually the better-represented species (Ferenți *et al.* 2013b) or the only one present from the genus (Ferenți *et al.* 2013a, Ferenți & Covaciu-Marcov 2015). The higher abundance of *P. conspersum* is probably a consequence of the higher altitude reached by the studied road, compared with the locations previously studied in the region (Ferenți *et al.* 2012, 2013b). This is also proved by the fact that *P. conspersum* was abundant in an area with high altitude from the southern Făgăraș Mountains (Ferenți & Covaciu-Marcov 2016).

Even if *T. provisorius* was not mentioned in the past in Romania (Radu 1983), not being indicated even in the most recent monograph on terrestrial isopods in the country (Giurginca *et al.* 2022), there is a recent record of the species in Carei town (Pal *et al.* 2019). The identification of this species in the vicinity of the road from Oaș Mountains represents its second record in Romania. However, those two distribution records are situated in the same region (North-Western Romania), just approximately 100 km from each other. Thus, at least in North-Western Romania, the species seems well represented. Moreover, it was also mentioned in the neighbouring areas in Hungary (Vilisics *et al.* 2008, Gregory *et al.* 2009). Nevertheless, the fact that it was identified only now in a region where there are many studies on isopods (Ferenți *et al.* 2012, 2013a,b, Ianc & Ferenți 2014, Ferenți & Covaciu-Marcov 2015), confirms the fact that it is a species difficult to observe, although native in the region (Pal *et al.* 2019). Even if it is considered a species largely distributed in Europe, it was only recently mentioned in other regions, too, like Slovenia (Vittori *et al.* 2023). In other cases, *T. provisorius* was identified in karst areas, at the base of sinkholes (Vilisics *et al.* 2011), unlike Oaș Mountains, which are volcanic mountains (Pătrașcu 1993, Jurje *et al.* 2014, Kovacs *et al.* 2017).

Trachelipus nodulosus was extremely rare on the road edges in Oaș Mountains (only 1 individual). In western Romania, it is a common species (Ferenți & Covaciu-Marcov 2015, Tomescu *et al.* 2015, Pop *et al.* 2021b), even in mountain regions (Ianc & Ferenți 2014), and in some cases, it is the most abundant species (e.g. Ferenți *et al.* 2015, Laza *et al.* 2017). This rarity is probably a consequence of two facts. First, the region surrounding the road is covered almost completely by wide and natural forests, which are not favorable habitats for this species related to open areas (e.g. Tomescu *et al.* 2015), or even urbanized ones (e.g. Ferenți *et al.* 2015, Laza *et al.* 2017). Second, the road was asphalted only recently, therefore, the opening cut by the road in the forest was insufficient for this species to migrate along the road, in terms of both space and time. Moreover, the single individual was encountered in sector 1, a sector which is situated on the outskirts of Negrești Oaș town, as the species was frequently encountered under rubble in other towns (Herle *et al.* 2016). Not only *T. nodulosus* but also *P. scaber*, another synanthropic and generalist species (Radu 1985), had an affinity for sector 1, which is situated at the limit of the town. The large surface of the natural areas in the vicinity of the road is emphasized even by the low diversity of species of the isopod assemblages found under debris. Moreover, the area shelters species linked to natural areas and endemic ones. Thus, *L. intermedium*, *H. trassilvanicus*, and *T. difficilis* are Carpathian endemic species (Radu 1983, 1985, Schmalfuss 2003, Tomescu *et al.* 2015, Giurginca 2022), also present in other cases in natural forested habitats in Romania (Pop *et al.* 2019).

The terrestrial isopod fauna linked to forests and natural areas obviously was not modified by the road, as it is predominant in the assemblages from the vicinity of the road. As animals with low mobility, terrestrial isopods were only slightly affected by the presence of the road in this case, even though, in the past, they were found killed both on roads (Ciolan *et al.* 2017, Popovici & Ile 2018, Sucea *et al.* 2023, Cupșa *et al.* 2024) and on railroads (Pop *et al.* 2023). Unlike terrestrial isopods, the negative direct impact of roads on other invertebrate groups is much higher (e.g. Baxter-Gilbert *et al.* 2015). In the Oaș Mountains, a narrow and relatively short road that crosses a natural, high-biodiversity area failed in shifting the native terrestrial isopod assemblages. Thus, in the case of this group, local roads from natural areas do not affect much the local assemblages from the vicinity of the roadside, they being resilient enough. Still, this fact must not be viewed out of context because these types of roads have numerous other negative effects, killing a large number of other invertebrates (e.g. Baxter-Gilbert *et al.* 2015).

Apparently, the scientific literature presents a notable gap of knowledge referring to the importance of transport networks as corridors for insects (Villemey *et al.* 2018). Even if our study does not focus on insects but on other arthropods, it contributes to the increase of knowledge in this direction. At the same time, our study is a particular case, in which the road did not succeed in shifting the native assemblages due to the large surface of natural areas from the vicinity of the road. Thus, generalist, non-native, and synanthropic species did not use the road as a movement corridor and, therefore, did not colonize the neighboring areas due to the fact that the road is enclosed by a sanitary corridor made up of natural habitats. Unlike this, other types of roads, like highways, have been certified as corridors for terrestrial isopods (Vona-Túri *et al.* 2017). The same situation was reported on a secondary railroad, in the vicinity of a city (Pop *et al.* 2021b). At least for the soil fauna from the area of the studied road, this equilibrium has been maintained, supporting ecosystem functioning.

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