

PAST INDUSTRY VS. NATURE: WHICH ONE INFLUENCES MORE THE TERRESTRIAL ISOPOD ASSEMBLAGES FROM A TOWN IN WESTERN ROMANIA?

HERLE Alexandra Ioana, COVACIU-MARCOV Severus-Daniel, FERENȚI Sára

Abstract. Despite the strong industrialization and the complex urban development, in Ștei town from western Romania there is a diverse terrestrial isopod fauna, consisting of more species than in other towns from the region. In Ștei, we have identified 16 terrestrial isopod species, the most common being *Hyloniscus riparius*, *Porcellio scaber* and *Trachelipus nodulosus*. The isopod fauna from Ștei does not present zoogeographic or ecological surprises, being formed of common species, which are native in the country and well distributed in the natural areas of western Romania. Species linked to natural wetlands were present even in the ruins of some abandoned buildings situated in severely affected areas in the past. They colonized probably these habitats after the cessation of the anthropogenic damage, coming from the neighbouring natural wetlands. The composition of the terrestrial isopod fauna from Ștei is a consequence of the town position in a depression area between mountains, wetlands and forests. For the terrestrial isopods, the existence of the natural habitats neighbouring Ștei is more important than the strong industrialization of the past.

Keywords: terrestrial isopods, small town, industrialization, wetlands, species, diversity.

Rezumat. Industria din trecut sau natura: cine influențează mai mult comunitățile de izopode terestre dintr-un oraș mic din vestul României? În ciuda industrializării puternice și a dezvoltării urbane complexe, în orașul Ștei din vestul României există o faună diversă de izopode terestre, conținând mai multe specii decât în alte orașe din regiune. În Ștei am identificat 16 specii de izopode terestre, cele mai comune fiind *Hyloniscus riparius*, *Porcellio scaber* și *Trachelipus nodulosus*. Fauna de izopode din Ștei nu prezintă surprize zoogeografice sau ecologice, fiind formată din specii comune, care sunt native în țară și bine răspândite în zonele naturale în vestul României. Speciile legate de zone umede au fost prezente inclusiv în ruinele unor clădiri puternic afectate antropice în trecut. Aceste specii au colonizat probabil aceste habitate după încetarea activității antropice, venind din zonele umede naturale din apropiere. Compoziția faunei de izopode terestre din Ștei este o consecință a poziției orașului într-o zonă depresionară, fiind înconjurat de munți, zone umede și păduri. Pentru izopodele terestre existența habitatelor naturale învecinate orașului Ștei este mai importantă decât industrializarea puternică din trecut.

Cuvinte cheie: izopode terestre, oraș mic, industrializare, zone umede, specii, diversitate.

INTRODUCTION

A recent research indicates that urbanization influences only negatively or neutrally the species abundance and richness (see in: SAARI et al., 2016). The town, Ștei, has recently obtained this statute, as a result of the industrialization from 1950s, when it became a development centre for the uranium mining of the region (e.g. FILIMON et al., 2012; PRASCA & OLĂU, 2013). The very quick development, subordinated to a single industrial branch, generated a very diverse urban settlement (FILIMON et al., 2012; PRASCA & OLĂU, 2013), grafted over an old agricultural rural zone (PRASCA & OLĂU, 2013). In the locality, beside the old buildings, there are block resident areas of different ages, industrial zones, etc. (FILIMON et al., 2012; PRASCA & OLĂU, 2013). In the last 25 years, the town went into a decline, the industry being almost totally closed, and the population decreased (FILIMON et al., 2012). In this context, we have proposed to study how much the biodiversity of this town was influenced by these changes on a small time scale, choosing terrestrial isopods, a useful group in this kind of studies. Terrestrial isopods are detritivorous (RADU, 1983), being important in the indication of heavy metal pollution; they are considered bioindicators (e.g. DALLINGER et al., 1992; DROBNE, 1997; PAOLETTI & HASSALL, 1999; MAZZEI et al., 2014; NANNONI et al., 2015). In western Romania, there are two studies upon isopods from towns (BODIN et al., 2013; FERENȚI et al., 2015), the first one being from the vicinity of Ștei (BODIN et al., 2013). Also, there is information on isopods from natural habitats of the region (TOMESCU et al., 2008; IANC & FERENȚI, 2014). We hypothesized that the quick development of the town modified the native terrestrial isopod assemblages. We also supposed that the block resident areas would have low species richness, as well as the entire town, compared to the natural areas or other towns.

MATERIAL AND METHODS

The research upon the terrestrial isopod fauna from Ștei took place in the year 2015. We realized two field trips on May 14 and July 4. We collected 34 samples from 27 collecting points from Ștei. The isopods were collected directly with hand under different shelters. The time spent for each sample was approximately 20 minutes, like in other studies (FERENȚI et al., 2015). In only one case, in a forested area, we used the litter sieve. Isopods were preserved in tubes with alcohol and determined in the laboratory at stereomicroscope, using the keys (e.g. RADU 1983, 1985; FARKAS & VILISICS, 2013; TOMESCU et al., 2015).

Ștei town is situated in the southern part of Bihor County in western Romania, in Beiuș Depression, along the Crișul Negru River (MÂNDRUȚ, 2006). Even if it is surrounded by mountains (MÂNDRUȚ, 2006), the town is situated in a relatively flat area, in the south of the depression. In the east, the town is surrounded by generally abandoned and ruined industrial zones, but also by small watercourses, the park of a hospital and a forest crossed by a stream, on which a small pond was furnished. The terrestrial isopods were collected from diverse areas: wetlands, forest, urban parks, residential block areas, abandoned or used buildings, ruins, abandoned industrial zones, etc. (Table 1). After the species identification, we calculated the percentage abundance and the frequency of occurrence. The data were analysed both by collecting points and habitat types. For species diversity we used Shannon - Wiever index (SHANNON & WIEVER, 1949). The similarity between the terrestrial isopod assemblages between the investigated habitats and the significance of these differences was calculated using the Past.3x software (HAMMER et al., 2001).

RESULTS

In Ștei, we identified 16 terrestrial isopod species (*Ligidium hypnorum*, *Trichoniscus* sp., *Hyloniscus riparius*, *H. transilvanicus*, *Haplophthalmus danicus*, *Cylisticus convexus*, *Porcellium collicola*, *Protracheoniscus politus*, *Trachelipus nodulosus*, *T. rathkii*, *T. arcuatus*, *Porcellionides pruinosus*, *Porcellio spinicornis*, *P. scaber*, *Armadillidium vulgare*, *A. versicolor*). Totally, we collected 204 individuals. Of these 42 were males, 155 females and seven juveniles. The species from the *Trichoniscus* genus could not be identified, because we collected only one female. The species with the highest percentage abundance in Ștei was *H. riparius*, followed by *P. scaber* and then by *T. nodulosus* (Table 1). The same species occupy the top in the case of frequency of occurrence too, *T. nodulosus* being on the second place. There were also species with very low percentage abundance (*Trichoniscus* sp., *H. transilvanicus*, *P. spinicornis*). The species spectrum is different between the collecting points, the number of species / collecting point being low (Table 1).

Table 1. The terrestrial isopod species identified in Ștei town (Lh – *L. hypnorum*, Trich – *Trichoniscus* sp., Hr – *H. riparius*, Ht – *H. transilvanicus*, Hd – *H. danicus*, Cc – *C. convexus*, Pc – *P. collicola*, Ppo – *P. politus*, Tn – *T. nodulosus*, Tr – *T. rathkii*, Ta – *T. arcuatus*, Ppr – *P. pruinosus*, Psp – *P. spinicornis*, Psc – *P. scaber*, Avu – *A. vulgare*, Ave – *A. versicolor*, Ns – species number, P% - percentage abundance, f% - frequency of occurrence).

Sampling points	Lh	Trich	Hr	Ht	Hd	Cc	Pc	Ppo	Tn	Tr	Ta	Ppr	Psp	Psc	Avu	Ave	Ns
Beltway, wet area	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X	2
Debris, market	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	X	3
Abandoned sports hall interior	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	1
Abandoned sports hall exterior	-	-	X	-	-	-	X	-	-	-	X	-	-	-	-	-	3
Debris parking sports hall	-	-	X	-	-	-	-	-	X	-	-	-	X	-	X	-	4
Railway station pond store	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	2
New block resident zone downtown	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	1
Stream beltway industrial area	-	-	X	-	X	X	-	-	X	-	-	-	-	-	-	-	4
Debris old houses main road	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	2
Old block residents downtown I	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	1
Old block residents downtown II	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	2
Old block residents downtown III	-	-	-	-	-	-	-	-	-	X	X	-	-	X	-	-	3
Railway district ruins beltway	-	-	-	-	-	X	-	-	-	-	-	X	-	-	X	-	3
Railway station pond	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	X	3
Heating station new block residents	-	-	X	-	X	-	-	-	-	-	-	-	-	X	-	-	3
New block resident area bus station	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	1
Stream forest pond	X	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	3
Northern old block residential zone	-	-	X	-	-	-	-	-	X	-	-	-	-	X	-	-	3
Railway station repository	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	1
The Crisul Baitei river bank, near blocks	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	X	3
Northern old block residential zone - small park	-	-	X	-	X	-	-	-	-	-	-	-	-	X	-	-	3
Beltway debris industrial area	-	-	X	-	-	X	X	-	X	-	-	-	-	-	X	-	5
Forest to the pond	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	1
Northern old block residential zone garages	-	-	X	-	X	-	-	-	-	-	-	-	-	X	-	-	3
Debris hospital	-	-	X	-	X	-	-	-	-	-	-	-	-	-	X	-	3
Railway station	-	-	X	-	X	-	-	-	-	-	-	-	-	X	X	-	4
Repositories to the railway station	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	X	3
P %	2.94	0.49	30.88	0.49	8.33	6.37	1.96	1.96	14.71	0.98	4.41	0.98	0.49	15.69	5.39	3.92	
f %	2.94	2.94	47.06	2.94	17.65	14.71	5.88	2.94	35.29	5.88	8.82	2.94	2.94	32.35	14.71	17.65	

The diversity of the terrestrial isopod assemblages from Ștei town was $H=2.16$. The diversity differed according to the habitats, the highest being in wetlands (Table 2). The highest species richness and individual number was registered in ruins with debris and wetlands. Of the 16 species, seven were identified in only one habitat type (Table 2). *H. riparius* was found in seven of the eight habitat types (Table 2). In the case of the similarity between the habitat types (Fig. 1), the closest assemblages were found on the one hand between small urban green areas (park and railway station, which also has a small park) and on the other hand between constructed areas (old and new buildings). The most distinguished from the rest of the habitats is the forest, where only one species was present. The differences between the assemblages from different habitat types are significant (Anova: $p<0.05$).

DISCUSSIONS

The study hypotheses were verified only partially. The terrestrial isopod fauna from Ștei town does not seem to be diminished by the quick development and strong industrialization of the town. Both by species richness and diversity, Ștei is situated at the top between the western Romanian towns, where this group was studied (BODIN et al., 2013; FERENȚI et al., 2015). Even in Beiuș, a larger and older town without mining industry (FILIMON et al., 2011) only 15 species were identified (BODIN et al., 2013). The resemblance between the fauna from Ștei and Beiuș towns (BODIN et al., 2013) is a consequence of the small distance between them (only 16 km) and their location in the same geographic unit, namely Beiuș depression (MÂNDRUȚ, 2006). The difference is even greater compared with Salonta town, where only 11 species were present (FERENȚI et al., 2015). These differences are not determined directly by the town but by its surrounding areas. Thus, Salonta is situated in a flat plain without forests (FERENȚI et al., 2015), but Ștei is situated in a well forested zone, being in contact with forests. Some of the species identified in Ștei are sylvan species (*P. politus*) or wetland species characteristic to high altitudes (*L. hypnorum*, *H. transilvanicus*) (see in: TOMESCU et al., 2011).

Table 2. The percentage abundance of the terrestrial isopods from Ștei in different habitat types (Lh – *L. hypnorum*, Trich – *Trichoniscussp.*, Hr – *H. riparius*, Ht – *H. transilvanicus*, Hd – *H. danicus*, Cc – *C. convexus*, Pc – *P. collicola*, Ppo – *P. politus*, Tn – *T. nodulosus*, Tr – *T. rathkii*, Ta – *T. arcuatus*, Ppr – *P. pruinosis*, Psp – *P. spinicornis*, Psc – *P. scaber*, Avu – *A. vulgare*, Ave – *A. versicolor*, Ns – species number, P% - percentage abundance, f% - frequency of occurrence, H – Shannon-Wiever diversity).

	Lh	Tri	Hr	Ht	Hd	Cc	Pc	Ppo	Tn	Tr	Ta	Ppr	Psp	Psc	Avu	Ave	P%	Ns	H
Wetlands	12.50	2.08	31.25	2.08	12.50	2.08	-	-	25.00	-	-	-	-	-	-	12.50	23.53	8	1.73
Debris, ruins	-	-	41.07	-	-	17.86	1.79	-	10.71	-	-	3.57	1.79	8.93	12.50	1.79	27.45	9	1.72
New buildings	-	-	33.33	-	4.76	9.52	14.29	-	9.52	-	4.76	-	-	23.81	-	-	10.29	7	1.72
Old buildings	-	-	21.62	-	8.11	-	-	-	18.92	5.41	21.62	-	-	24.32	-	-	18.14	6	1.68
Repositories	-	-	28.57	-	-	-	-	-	42.86	-	-	-	-	14.29	-	14.29	3.43	4	1.28
Parks	-	-	9.09	-	27.27	-	-	-	-	-	-	-	-	63.64	-	-	5.39	3	0.86
Forest	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	1.96	1	0
Railway station	-	-	35.00	-	20.00	-	-	-	-	-	-	-	-	25.00	20.00	-	9.80	4	1.36
f%	12.5	12.5	87.5	12.5	62.5	37.5	25	12.5	62.5	12.5	25	12.5	12.5	75	25	37.5			

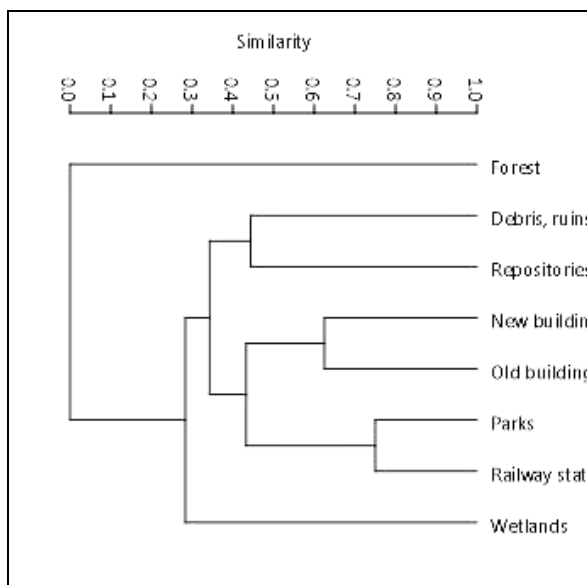


Figure 1. The similarity of terrestrial isopods assemblages between habitat types (Jaccard index).

The terrestrial isopod species from Ștei are well represented in Romania, generally native and characteristic for the region and habitats they were identified in (e.g. RADU, 1983, 1985; TOMESCU et al., 2011, 2015). Also, in other zones, the species identified in urban areas were widespread (VILISICS et al., 2012). The terrestrial isopod fauna from Ștei resembles the one from its vicinity, like Pădurea Craiului Mountains (IANC & FERENȚI, 2014). Thus, the relatively rich and diverse terrestrial isopod fauna from Ștei is mainly the consequence of the existence of some natural habitats from the vicinity of the town. The industrialization from the past did not manage to eliminate the species linked to natural areas from the locality, they being eventually eliminated from some constructed area during the constructions. After abandoning the industrial zones, the terrestrial isopods from the natural areas re-occupied those zones, including the most anthropogenically affected ones. Thus, the species linked to natural wetlands, like *P. collicola* are present in

the ruins of the abandoned sports hall. At some hundreds of meters distance of it there is a stream, *P. collicola* being a wetland species (e.g. FERENȚI et al., 2013).

Even if many terrestrial isopod species from Ștei town are specific to natural zones, in the locality there are also other species linked to artificial habitats, like *T. nodulosus*, *P. scaber* and *A. vulgare*. These species were frequently reported in urban areas (e.g. VILISICS & HORNUNG, 2009; FERENȚI et al., 2015). However, unlike Salonta (FERENȚI et al., 2015), the non-native species are fewer. However, some of these synanthropic species were also reported in western Romania in natural and semi-natural habitats (e.g. FERENȚI et al., 2012; FERENȚI & COVACIU-MARCOV, 2015). Thus, even if Ștei developed strongly in the last decades (e.g. FILIMON et al., 2012), the non-native isopods did not arrive there or their establishment in the town was very difficult.

The best represented genus from Ștei is *Trachelipus*. This genus has numerous species in Romania, the three species from Ștei being common in the country (TOMESCU et al., 2015). In the case of *Trichoniscus*, there is a possibility that the unidentified female would belong to *T. carpathicus*, a species which was recently identified in Pădurea Craiului Mountains from the region (IANC & FERENȚI, 2014), or in other zones in western Romania (FERENȚI & COVACIU-MARCOV, 2015). Also, in other cases, from the genus *Trichoniscus* only females were captured, which could not be determined (e.g. BODIN et al., 2013; FERENȚI & COVACIU-MARCOV, 2016). Totally, the isopod species from Ștei town are the expected ones, without any zoogeographic or ecological surprises.

The highest diversity was registered in wetlands, habitats which repeatedly proved to be important for isopods including western Romania (e.g. FERENȚI & COVACIU-MARCOV, 2015; FERENȚI et al., 2013, 2015). The highest species richness and individual number was registered in ruins with debris, followed by wetlands, just like in other towns (FERENȚI et al., 2015). As wetlands are situated near ruins, wetland species are frequently collected from the ruins. The presence of a single species in the forest is a consequence of the sampling with the litter sieve. With this method we managed to capture only *P. politus*, a sylvan species (see in: TOMESCU et al., 2011). Generally, the forest shelters a higher number of species. Thus, wetland species (*H. transsilvanicus*, *L. hypnorum*) identified near streams, were also present in the forest, because that stream crosses the forest.

However, one of the hypotheses was partially verified. Thus, in the block residential areas less species were present, being usually synanthropic, frequent in localities (e.g. JEĐRYCZKOWSKI, 1981; FERENȚI et al., 2015). The presence of these species indicates the anthropogenic pressure affecting of a region, their advance in natural zones being also in other cases considered a result of anthropization (FERENȚI & COVACIU-MARCOV, 2016). The block residential areas have proven to be difficult for terrestrial isopods (VILISICS & HORNUNG, 2009). Also, in the case of new parks there are less species than in old parks (JEĐRYCZKOWSKI, 1981). In Ștei, the parks have a low species richness and diversity, like in other towns (FERENȚI et al., 2015).

For terrestrial isopods from Ștei the most important fact is the town location in a zone with many natural habitats, forests, wetlands, etc. Their presence has determined the composition of the present isopod fauna more than the past industrialization. Thus, for terrestrial isopods maintaining the natural zones near the anthropogenically affected ones is important. Also, in other cases the maintenance of the habitat heterogeneity was considered vital for the diversity and distribution of isopods (PURSE et al., 2012). As long as the regress of the industry from Ștei continues, the isopod fauna will regain new zones and will be organized closer to its initial aspect, these animals colonizing even abandoned and then rehabilitated mining zones (e.g. TAJOVSKÝ, 2001; PURGER et al., 2007). Thus, isopods succeed to survive in urban industrial zones too and colonize towns after the cessation of the industry pressure. Actually, Ștei town can be considered an experiment on the evolution of an urban industrialized locality grafted over a semi-natural rural zone, which after some decades of functioning seems to be back at the square. At least for terrestrial isopods this fact does not seem too difficult.

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Herle Alexandra Ioana

Ștei, Petrileni str., bl. 18, ap. 6, Bihor County, Romania.

Covaciu-Marcov Severus-Daniel

University of Oradea, Faculty of Sciences, Department of Biology; 1, Universităţii, Oradea 410087, Romania.

Ferenți Sára

University of Oradea, Faculty of Sciences, Department of Biology; 1, Universităţii, Oradea 410087, Romania.
Iosif Vulcan National College, Jean Calvin str., 3, Oradea, Romania.

E-mail: ferenti.sara@gmail.com

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