Arch. Biol. Sci., Belgrade, 65 (2), 795-800, 2013 DOI:10.2298/ABS1302795F

WINTER ACTIVITY OF TERRESTRIAL ISOPODS FROM THERMAL HABITATS IN WESTERN ROMANIA

SÁRA FERENȚI[1 2 3*], DIANA CUPȘA[2], A.-Ș. CICORT-LUCACIU[2] and S.-D. COVACIU-MARCOV[2]

[1] *"Babeș-Bolyai" University, Faculty of Biology and Geology, Department of Biology, Gheorghe Bilașcu (Republicii) str. 44,* 400015 Cluj-Napoca, Romania
[2] *University of Oradea, Faculty of Sciences, Department of Biology, Universității str. 1,* Oradea 410087, Romania
[3] *"Iosif Vulcan" National College, Jean Calvin str. No. 5,* Oradea, Romania

Abstract - Terrestrial isopods from warm shores neighboring the thermal waters from western Romania remain active in the winter. This phenomenon is registered in 35 habitats, affecting 12 species (*Hyloniscus transsilvanicus, H. riparius, Haplophthalmus danicus, Trichoniscus sp., Androniscus roseus, Cylisticus convexus, Protracheoniscus politus, Trachelipus nodulosus, T. rathkii, Porcellio dilatatus, Armadillidium vulgare, A. versicolor*), the most common being *T. nodulosus*. Females with a marsupium were observed in the cold season in the case of some small-sized species that are present in the immediate vicinity of the shores of thermal waters (*A. roseus*, *H. riparius* and *H. transsilvanicus*). The high temperatures of the thermal waters warm the surrounding terrestrial environment, affecting the life cycle of the terrestrial isopods.

Key words: Cold season, isopods` life cycle, thermal water, reproductive period, Romania

INTRODUCTION

Terrestrial isopods hibernate during the winter in temperate areas (Gupta, 1963), a situation also valid in Romania (Radu and Tomescu, 1981, Tomescu et al., 1995). Thus, their life cycle implies the alternation of a hibernation period and a period of activity. However, there are some indirect clues concerning a continuation of activity over winter of terrestrial isopods near the thermal waters from western Romania. And while it is expected that terrestrial isopods hibernate in the cold periods, amphibians have been found that consume them during the winter (Covaciu-Marcov et al., 2006, Bogdan et al., 2012). Recently, active amphibians were recorded during the winter in the thermal waters of western Romania (Covaciu-Marcov et al., 2006, 2010, 2011, Sas et al., 2007, 2012, Bogdan et al., 2011). This observation raises the hypothesis that terrestrial organisms living on the warm shores of the thermal waters, such as terrestrial isopods, also remain active in the winter. The fact that active amphibians from thermal waters consumed terrestrial isopods suggests that these were also active in winter. Consequently, we studied whether terrestrial isopods from the thermal habitats of western Romania remain active in the cold season, in order to observe the possible modifications of their biology and ecology induced by the conditions from these habitats.

MATERIALS AND METHODS

The field study was realized between December and February of two consecutive winters (2010/2011 and 2011/2012). The terrestrial isopods were captured by hand from under different natural (rocks, logs) or

artificial (domestic waste) shelters, as well as from under the grassy vegetation and from the soil surface. The species were determined in the laboratory, according to Radu (1983, 1985), and the current nomenclature (Schmalfuss, 2003). Overall, we investigated 58 thermal habitats from western Romania. Most of them are artificial, but there are also natural ones, such as the thermal lake of 1 Mai Spa and the thermal springs of Călan Spa (Table 1). Thermal canals originating from drill holes or swimming pools represent the artificial habitats, as in the case of winter active amphibians (e.g. Bogdan et al., 2011, Covaciu-Marcov et al., 2006, 2010, 2011, Sas et al., 2012). These canals are linear, with usually abrupt shores, the water level being lower than their margins. Most thermal habitats are surrounded by degraded surfaces, covered only with grassy vegetation. Răbăgani, Bobâlna and Moneasa are the only thermal habitats linked to forests.

RESULTS

Winter active terrestrial isopods were present in 35 of the 58 investigated thermal habitats (Table 1). Terrestrial isopods populate the areas near water, where the soil does not freeze. The length of the warm shore varies according to the habitat type and the volume or temperature of the thermal water. There are thermal habitats with water temperatures of 70°C, which warm a long length of the canal and a wide surface of the shore. In the habitats in which terrestrial isopods are not active during winter, the shores are without shelters, vegetation, and are often directly exposed to cold air, which causes freezing in close proximity to the water. There are also habitats in which the flow or water temperatures are too low to sufficiently warm the shore.

We identified 12 terrestrial isopod species that were active in winter (*Hyloniscus transsilvanicus, H. riparius, Haplophthalmus danicus, Trichoniscus sp., Androniscus roseus, Cylisticus convexus, Protracheoniscus politus, Trachelipus nodulosus, T. rathkii, Porcellio dilatatus, Armadillidium vulgare, A. versicolor*). The highest number of species was recorded in the larger, relatively natural habitats, which are also the oldest, such as the Călan Spa and Răbăgani (Table 1). We identified 313 terrestrial isopod individuals of which 161 were females, 89 were males and 63 were juveniles. The most common species during the winter in the areas neighboring the thermal waters was *T. nodulosus*. This species was also the most frequent in the habitats (Table 2).

Together with the disappearance of hibernation, some isopod species from certain habitats also present a modification of the reproductive period induced by the thermal regime. Females with marsupium with eggs were identified in February at 1 Mai Spa, Călan Spa and Tărian. The modification of the reproductive period was observed in three species: *A. roseus*, *H. riparius* and *H. transsilvanicus*. This phenomenon was observed in 14 females, of which 10 belonged to the species *H. riparius* (observed at 1 Mai Spa and Tarian), three to *H. transsilvanicus* and one to *A. roseus* (observed at Calan Spa).

DISCUSSION

Regardless of the air temperature, terrestrial isopods remain active throughout the entire winter period. They behave normally, trying to shelter when surprised. *T. nodulosus* frequently hides under domestic waste (cardboard, old rags etc.), which is present near the thermal waters. The finding of isopods that are active during winter confirms the fact that temperature triggers hibernation, as in the case of the amphibians from thermal waters (e.g. Covaciu-Marcov et al., 2006, 2011). The winter-active terrestrial isopods occupy an area of variable width on the shores of the thermal water. Species connected to humid areas, such as *H. riparius* and *H. transsilvanicus* (Radu, 1983, Tomescu et al., 2005), are found close to the water. Species related to drier areas, like *T. nodulosus* and *A. vulgare*, are found at a certain distance from the water, even as far as areas with frozen soil. However, *T. nodulosus*, a xerophilous species (Farkas, 2010) is the most common in the thermal habitats.

Modification of the reproductive period has been observed in three isopod species from three thermal habitats. We encountered *H. riparius* and *H.*

Table 1. The investigated thermal habitats with the identified species (Ht – *H. transsilvanicus*, Hr – *H. riparius*, T sp. – *Trichoniscus* sp., Hd – *H. danicus*., Ar – *A. roseus*, Cc – *C. convexus*, Pp – *P. politus*, Tn – *T. nodulosus*, Tr – *T. rathkii*, Pd – *P. dilatatus*, Avu – *A. vulgare*, Av – *A. versicolor*, * - female with marsupium, SM – Satu-Mare County, SJ – Salaj County, BH – Bihor County, TM – Timis County, HD – Hunedoara County, No – species richness)

Locality	Habitat type	*Ht*	*Hr*	*Tsp*	*Hd*	*Ar*	*Cc*	*Pp*	*Tn*	*Tr*	*Pd*	*Avu*	*Av*	**No**
1 Mai Spa (BH)	Stream from the thermal lake		X*	X					X					3
Moneasa (AR)	Thermal stream	X												1
Răbăgani (BH)	Thermal lake	X	X					X	X			X		5
Săcuieni I (BH)	Inundate grassy area	X				X							X	**3**
Călan – small basin (HD)	Old abandoned swimming pools	X	X				X		X					4
Călan – roman spoon (HD)			X										X	2
Acâș (SM)	Thermal canals									X		X		2
Beltiug (SM)									X					1
Mihăieni (SM)									X					1
Boghiș (SJ)			X			X					X		X	**4**
Chiraleu (BH)									X					1
Chislaz (BH)									X					1
Ciocaia (BH)									X			X		2
Livada (BH)													X	**1**
Mădăras (BH)									X			X		2
Roșiori (BH)									X			X		2
Rosiori / Tamaseu (BH)												X		1
Săcuieni II (BH)			X						X					2
Săcuieni III (BH)			X											1
Sânnicolau de Munte (BH)									X					1
Tărian (BH)			X*				X		X			X		4
Socodor (AR)												X		1
Zerind (AR)									X					1
Băile Călacea (TM)									X					1
Beba Veche (TM)									X			X		2
Cărpiniș (TM)									X			X		2
Ciacova (TM)			X											1
Lovrin (TM)				X	X		X		X					4
Sandra (TM)							X							1
Sânmihaiu German (TM)									X	X		X		3
Teremia Mare (TM)									X					1
Bobâlna (HD)		X				X			X				X	**4**
Călan - large basin(HD)		X	X		X		X			X			X	**6**
Călan – canal (HD)		X*				X*				X				3
Răpolțel (HD)		X				X							X	**3**
Total no. of localities		8	10	2	2	5	5	1	21	4	1	11	7	

transsilvanicus females with marsupium at the beginning of February, in conditions in which *H. riparius* reproduces between May and July (Tomescu et al., 2002) and *H. transsilvanicus* between May and August (Tomescu, 1976). However, it cannot be stated that isopods have a continuous reproduction, as do some frogs from the thermal waters (Covaciu-Marcov et al., 2006), or that an additional or an early reproduction occurs, as we did not monitor these populations throughout the whole year. In the case of

Table 2. The number of the individuals (No.), relative abundance (A %) and frequency (f %) of the species

Species	No.	A %	f %
H. riparius	48	15.34	23.33
H. transsilvanicus	35	11.18	20.00
Trichoniscus sp.	9	2.87	6.66
A. roseus	31	9.90	16.67
H. danicus	4	1.27	6.66
C. convexus	21	6.70	13.33
P. politus	6	1.91	3.33
T. rathkii	24	7.66	10.00
T. nodulosus	88	28.12	70.00
P. dilatatus	2	0.63	3.33
A. vulgare	20	6.39	40.00
A. versicolor	25	7.98	20.00

an Amphipod species from Iceland, the influence of thermal water determined the start of the breeding season, bringing it 2-3 months forward (Ingólfsson et al., 2007). This could be the situation in terrestrial isopods from the northwestern Romania's thermal habitats, which breed approximately 3 months earlier than normally. Isopods from temperate areas have a seasonal reproduction, displayed during the summer in a relatively short interval (e.g. Tomescu, 1972, Tomescu et al., 1992). However, there are species that have a continuous reproduction in tropical areas (Dangerfield and Telford, 1990). In the case of terrestrial isopod species, temperature is considered to be a factor determining the periodicity of reproduction (McQueen, 1976), warmer conditions determining earlier breeding (Hornung and Warburg, 1993). Reproduction is energetically costly for terrestrial isopod females; the presence of the marsupium reduces the females' mobility and exposes them to predators (Lardies et al., 2004). However, to remain active during winter is a reproductive advantage as some predators are absent and food is sufficient. Because terrestrial isopods are detritivores (Hassall et al., 1987), they can normally feed during the winter, thus remaining active does not disadvantage them.

The terrestrial isopods that reproduce in winter belong to small-sized species connected to moist areas. Being present close to the water, they are little influenced by air temperature. Therefore, they are most susceptible to the appearance of modifications in the reproduction biology. Two of the three habitats with isopods that reproduce during winter are natural and old habitats (1 Mai Spa and Călan Spa). In these habitats, continuous reproduction has also been recorded in amphibians (e.g. Covaciu-Marcov et al., 2006, Sas et al., 2010).

The low number of isopod species from most thermal habitats is probably a consequence of anthropogenic disturbance. Near the majority of the thermal canals, there are only degraded terrains. The species connected to moist areas appear only in less affected habitats where there are wet areas with vegetation on the shores. Other species, such as *P. politus*, are rare in the thermal habitats, because the habitats that correspond to them are also rare. This is a sylvan species (Tomescu et al., 2011), and was encountered only at Răbăgani, a habitat surrounded by an oak forest.

Beside the ecological aspects, our results have a faunistic importance. To our best knowledge, until now *A. roseus* was known in western Romania only from four localities (Radu, 1983, Ferenti et al., 2012a), now being encountered in another five. The species' presence in non-thermal habitats (Ferenti et al., 2012a) can indicate that they have a wider distribution range in western Romania. However, the relatively high frequency of *A. roseus* in thermal habitats can indicate a link between them. It is possible that this endogenous species (Radu, 1983) is advantaged by the warm soil near the thermal water. *P. dilatatus* was mentioned in the past in only one locality from the country (Radu, 1985). It seems that the species is connected to warmer, artificial areas, being previously observed in the botanic garden of Cluj-Napoca (Radu, 1985). Although it has been encountered in colder areas (Spuņgis, 2008), it appears to be a rare presence in the Pannonian Basin (Vilisics and Hornung, 2010). The presence of *H. transsilvanicus* at only 103 m altitude at Săcuieni seems unusual, as this species has been considered in the past to be characteristic for hills and mountains in Romania (Tomes-

cu et al., 2011). However, *H. transsilvanicus* was found on the plains of Hungary (Kontschán, 2003, Vilisics and Hornung, 2010), and recently identified in northwestern Romania, in Carei Plain (Ferentti et al., 2012b). However, the presence of this species at Săcuieni, south of the Carei Plain, suggests that the low altitude populations have a larger distribution range in northwestern Romania. The presence of *H. transsilvanicus* in the lower areas of northwestern Romania and the neighboring sectors of Hungary is possible due to the existence of marshes, where other mountainous species also appear at low altitudes (Covaciu-Marcov et al., 2008, 2009).

Acknowledgments - We wish to express our gratitude to Professor Dr. Nicolae Tomescu for his support in determining the isopod species and his valuable comments on this manuscript. Our study was realized with the support of the Freies Europa Weltanschauung Foundation, which we wish to thank. As Caretaker of several Protected Natural Areas from Romania, the Freies Europa Weltanschauung Foundation supports activities dedicated to investigating the biodiversity of Romania.

REFERENCES

Bogdan, H.V., Covaciu-Marcov, S.D., Antal, C., Cicort-Lucaciu, A.S. and *I. Sas* (2011). New cases of winter-active amphibians in the thermal waters of Banat, Romania. *Arch. Biol. Sci. Belgrade* **63**, 4, 1219-1224.

Bogdan, H. V., Covaciu-Marcov, S.-D., Cupsa, D., Cicort-Lucaciu, A.-S. and *I. Sas* (2012). Food composition of a *Pelophylax ridibundus* (Amphibia) population from a thermal habitat in Banat region (Southwestern Romania). *Acta Zool. Bulgar.* **64**, 3, 253-262.

Covaciu-Marcov, S.-D., Sas, I. and *A.-S. Cicort-Lucaciu* (2006). *Amfibienii apelor termale din vestul României*. Ed. Universităţii din Oradea, 1-160. [in Romanian].

Covaciu-Marcov, S.-D., Cicort-Lucaciu, A.-S., Ferenţi, S. and *A. David* (2008). The distribution of lowland *Zootoca vivipara* populations in North-Western Romania. *North-West. J. Zool.* **4,** 1, 72-78.

Covaciu-Marcov, S.-D., Sas, I., Cicort-Lucaciu, A.-Ş., Kovács, É.-H. and *C. Pintea* (2009). Herpetofauna of the Natural Reserves from Carei Plain: zoogeographical significance, ecology, statute and conservation. *Carpath. J. Earth Env.* **4,** 1, 69-80.

Covaciu-Marcov, S.-D., Sas, I., Antal, C., Cicort-Lucaciu, A.-S. and *M. Buncan* (2010). We cannot hibernate again: new amphibian populations active during winter in the thermal habitats from Western Romania. *Biharean Biol.* **4,** 2, 153-159.

Covaciu-Marcov, S.-D., Rosioru, C. and *I. Sas* (2011). Hot winters: new thermal habitats with frogs active in winter in north-western Romania. *North-West. J. Zool.* **7,** 1, 81-86.

Dangerfield, J.M. and *S.R. Telford* (1990). Breeding phenology, variation in reproductive effort and offspring size in a tropical population of the woodlouse *Porcellionides pruinosus*. *Oecologia* **82,** 251-258.

Farkas, S. (2010). Magyarország szárazföldiászkarákfaunája (Isopoda: Oniscidea): *Trachelipus nodulosus* (C. L. Koch, 1838). *Natura Somogyiensis* **17**, 123-132 [in Hungarian].

Ferenti, S., Cupsa, D. and *S.-D. Covaciu-Marcov* (2012a). Terrestrial isopod assemblages from four habitats from Crasna Hills, North-Western Romania. *Oltenia. Studii si Comunicari. Stiintele Naturii* **28**, 2, 45-48.

Ferenţi, S., Cupsa, D. and *S.-D. Covaciu-Marcov* (2012b). Ecological and zoogeographical significance of terrestrial isopods from the Carei Plain Natural Reserve (Romania). *Arch. Biol. Sci., Belgrade* **64,** 3, 1029-1036.

Gupta, M. (1963). Seasonal variation in the humidity reaction of woodlice, *Oniscus asellus* L. and *Porcellio scaber* Latr. (Crustacea: Isopoda). *Proc. Natn. Inst. Sci. India* **29**, 203-206.

Hassall, M., Turner, J. and *M. Rands* (1987). Effects of terrestrial isopods on the decomposition of woodland leaf litter. *Oecologia* **72**, 597-604.

Hornung, E. and *M. R. Warburg* (1993). Breeding patterns in the oniscid isopod, *Porcellio ficulneus* Verh., at high temperature and and under different photophases. *Invertebr. Reprod. Dev.* **23**, 2-3, 151-158.

Ingólfsson, A., Ólafsson, Ó. P. and *D. Morritt* (2007). Reproduction and life-cycle of the beachflea (*Orchestia gammarellus* (Pallas)(Crustacea: Amphipoda) at thermal and non-thermal sites in the intertidal of Iceland: how important is temperature? *Mar. Biol.* **150,** 1333-1343.

Kontschán, J. (2003). Néhány ritkaászkarák (Crustacea: Isopoda: Oniscidea) újabb előfordulási adatai Magyarországról. *Folia Historico Naturalia Musei Matraensis* **27,** 43-48.

Lardies, M. A., Cotoras, I. S. and *F. Bozinovic* (2004). The energetics of reproduction and parental care in the terrestrial isopod *Porcellio laevis*. *J. Insect Physiol.* **50,** 1127-1135.

McQueen, D. J. (1976). The influence of climatic factors on the demography of the terrestrial isopod *Tracheoniscus rathkii* Brandt. *Can. J. Zoolog.* **54**, 12, 2185-2199.

Radu, V.G. (1983). *Fauna R. S. R. Crustacea. vol. IV, Fascicola 13 Ordinul Isopoda, Subordinul Oniscoidea, Oniscoidee inferioare.* Ed. Academiei R. S. R. Bucharest. 1-168. [in Romanian].

Radu, V.G. (1985). *Fauna R. S. R.. Crustacea. vol. IV, Fascicola 14 Ordinul Isopoda, Subordinul Oniscoidea, Crinochaeta.* Ed. Academiei R. S. R. Bucharest. 1-158. [in Romanian].

Radu, V.G. and *N. Tomescu* (1981). Cercetări ecologice cantitative asupra unor populaţii de izopode terestre. *Nymphaea, Folia Naturae Bihariae* **8-9,** 433-438. [in Romanian].

Sas, I., Covaciu-Marcov, S.-D. and *A.-S. Cicort-Lucaciu* (2007). New thermal water habitats with non-hibernating *Pelophylax ridibundus* populations from north-western Romania. *Analele Universităţii din Craiova, Biologie* **12,** 229-235.

Sas, I., Antal, C. and *S.-D. Covaciu-Marcov* (2010). Tropics patch in the Holarctic: A new case of wintertime breeding of a *Pelophylax ridibundus* population in north-western Romania. *North-West. J. Zool.* **6,** 1, 128-133.

Sas, I., Rosioru, C. and *S.-D. Covaciu-Marcov* (2012). Note on eight new thermal habitats with winter-active amphibians in Western Romania. *North-West. J. Zool.* **8**, 2, 382-385.

Schmalfuss, H. (2003). World catalogue of terrestrial isopods (Isopoda: Oniscidea). *Stuttgarter Beitr. Naturk. Serie A* **654,** 1-341.

Spuņgis, V. (2008). Fauna, Distribution, Habitat Preference and Abundance of Woodlice (Oniscidea) in Latvia. *Latvijas Entomologs* **45,** 25-37.

Tomescu, N. (1972). Reproduction and ontogenetic development of *Protracheoniscus politus* – C. L. Koch. *Rev. Roum. de Biol., Zool.* **17**, 1, 31-39.

Tomescu, N. (1976). Reproduction et developpement ontogenetique post-embryionnaire chez *Hyloniscus transsylvanicus* Verh. 1901 (Crustacea, Isopoda). *Studia Univ. Babes-Bolyai, Biologia* **21,** 44-48.

Tomescu, N., Accola, S. and *C. Berciu* (1992). Reproduction of terrestrial isopods of Cheile Turzii Natural Reservation (Romania). *Studia Univ. Babeş-Bolyai, Biologia* **37**, 2, 39-45.

Tomescu, N., Accola, S. and *C. Paşca* (1995). Ecology of the populations of terrestrial Isopods (Crustacea Isopoda) in Cheile Turzii. *Studia Univ. Babeş-Bolyai*, *Biologia* **40**, 1-2, 78-94.

Tomescu, N., Dolniţchi-Olariu, L., Mureşan, D. and *V. Popa* (2002). Reproduction and distribution of congener terrestrial isopod species (Crustacea Isopoda) in the Dorna Depresion and the adjacent areas. In: *In memoriam "Professor Dr. Doc. Vasile Gh. Radu" corresponding member of Romanian Academy of Sciences.* (eds. Tomescu, N. and Popa, V.), 11-19. Ed. Cluj Universitary Press.

Tomescu, N., Mureşan, D., Olaru, L. and *R. Hotea* (2005). Terrestrial isopod communities (Crustacea Isopoda) in riverside coppices and meadows of mountainous, hilly and depression areas. *Studia Univ. Babeş-Bolyai, Biologia* **50**, 2, 19-24.

Tomescu, N., Ferenti, S., Teodor, L.A., Covaciu-Marcov, S.-D., Cicort-Lucaciu, A.-S. and *F.N. Sucea* (2011). Terrestrial isopods (Isopoda: Oniscoidea) from Jiului Gorge National Park, Romania. *North-West. J. Zool.* **7**, 2, 277-285.

Vilisics, F. and *E. Hornung* (2010). Újabb adatok Magyarország szárazföldiászkarákfaunájához (Crustacea, Isopoda, Oniscidea). *Állattani Közlemények* **95**, 1, 87-120. [in Hungarian].