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Contribution to the knowledge of the terrestrial isopod fauna of Lithuania

Ingrida Šatkauskienė

Vytautas Magnus University,
K. Donelaičio g. 58,
Kaunas 44248, Lithuania

The present survey provides records on terrestrial isopods from southern and north-western parts of Lithuania. Isopods were sampled manually by checking substrates in eight habitats (several types of forest and anthropogenic environment) between 2014 and 2016. In total, seven species were recorded. The common European species *Trachelipus rathkii* was noted as the most frequent isopod in all studied habitats from southern Lithuania. *Porcellionides pruinosus*, found in the habitat of anthropogenic activity, was recorded for the first time from Lithuania. Based on the data of the present study and previous surveys, the 14 species of terrestrial isopods are recorded in Lithuania and the current state of knowledge about Lithuanian isopod is summarised.

Keywords: woodlice, isopoda, Oniscidae, Lithuania

INTRODUCTION

Isopods (Broly et al., 2013), the tiny creatures that live in old forests or other terrestrial habitats with numerous shelters and feed on plant litter, play an important role in decomposition processes (Zimmer, 2002). Forests cover approximately 33% of the territory of Lithuania, but some of its areas are changed growing numbers of residential houses with adjoining mown lawns that do not provide shelter for the invertebrates discussed. Fortunately, such ecosystems as old woodlands and wetlands are protected and remain inviolable, hence guarantee a living environment for invertebrates. Despite the wide distribution of terrestrial isopods (Schmalfluss 2003; Sfenthourakis, Taiti, 2015), so far the current knowledge on Lithuanian isopod fauna is incomplete. Not only we do not

know the exact list of isopod species, but also how the species are distributed across the regions of Lithuania; we do not know which species can be considered rare or invasive in our country.

In addition, we cannot compare the changes in the communities of isopods during time, because studies in Lithuania, studies into terrestrial isopods started only in 2012. To date, 13 species of terrestrial isopods are known from Lithuania: *Ligidium hypnorum* (Cuvier, 1792) Ligiidae Brandt & Ratzeburg, 1831; *Ligia* Fabricius, 1798, Trichoniscidae Sars, 1899: *Haplophthalmus danicus* Budde Lund 1880; *Hyloniscus riparius* (C. Koch, 1838), *Trichoniscus pusillus* Brandt, 1833. Philosciidae Vandel, 1962: Oniscidae Latreille, 1806: *Oniscus asellus* Linnaeus, 1758; Platyarthridae Verhoeff, 1949: *Platyarthrus hoffmannseggii* Brandt, 1833 Porcellionidae Brandt & Ratzeburg, 1831: *Porcellio scaber* Latreille, 1804, *Porcellio spinicornis* Say, 1818, Cylisticidae Vandel, 1963: *Cylitiscus convexus* (De Geer, 1778); Trachelipodidae Strouhal, 1953: *Trachelipus*

* Corresponding author. Email: ingrida.satkauskiene@vdu.lt

rathkii (Brandt, 1833), *Porcellium conspersum* (Koch, 1841). Armadillidiidae Brandt, 1833: *Armadillidium vulgare* (Latreille, 1804), *Armadillidium pulchellum* (Zenker, 1799) (Kuznetsova, Gongalsky 2012, Vilisics et al., 2012; Tuf et al., 2014, Šatkauskienė, 2017).

The aim of this paper is to summarise the current state of knowledge on Lithuanian isopods based on the data of previous surveys and adding data on the isopods found in southern and north-western parts of Lithuania between 2014 and 2016.

METHODS

Study area and the climate data

Lithuania, the largest of the three Baltic countries, is located at the edge of the East European plain with coordinates of 55°10'10" N latitude and 23°52'52.6" E longitude. Lithuania is glacially flat, except for morainic hills in western uplands and eastern highlands no higher than 300 metres. The terrain is marked by numerous small lakes and swamps, and a mixed-forest

zone covers over 33% of the country (Bukantis et al., 2013).

Lithuania's climate is humid, with moderating effects from the Baltic Sea. January is the coldest month with daytime temperatures usually around -5°C and July is the warmest month with an average temperature of 18°C . The average annual precipitation is 661 mm (Lithuanian Hydrometeorological Service under the Ministry of Environment). Compared to the other localities of Lithuania, more pronounced contrasts of seasonal temperature are characteristic of the southern region. In spring and summer, the average monthly air temperature here is 1.0°C higher than in the western or northern regions of the country. Higher fluctuations of daily temperatures typical in the southern part of the country. These variations are affected by sandy areas, which are warm easily (in summer, sand surfaces can heat up to 50°C) and quickly deliver the accumulated heat (Natural Heritage Foundation 2014). A survey of isopods was conducted in Alytus district ($54^{\circ}23'46''\text{N}$ $24^{\circ}2'29''\text{E}$) in the southern part of Lithuania (Fig. 1).



Fig. 1. Map of the sampling and distribution of terrestrial isopods in Lithuania. Data are based on the records in the literature from 2012 to 2017 and the present study (districts in the southern and north-western regions Lithuania are marked by bold line)

Pine forests and woodlands cover almost half (44%) of Alytus district. Sandy soil and gravel constitute 93.7% of the region soil and are acidic due to intense leaching processes of Ca^{2+} , Mg^{2+} , clay particles, and iron oxides from the deep layer of soils (Mažvila et al., 2004). The north-western part of Lithuania is hilly and the terrain causes high precipitation (700 mm), more pronounced micro-climatic differences, and the formation of small wetlands. In this part of the country, isopods were surveyed in Plokštinė Reserve (PR) (56°1'39"N 21°54'33"E) (Fig. 1) that aims to preserve woods and marsh with ecosystems typical of this region. No forestry, agriculture, or any other type of economic activity is permitted here.

Assessment of habitat features

Six habitats were selected to represent isopod diversity in southern part of Lithuania (Alytus district) and two in north-western Lithuania (Plokštinė Reserve, Plungė district).

The characteristics of the habitats (names of dominant or characteristic plants; exposure; soil characteristics: type of soil and pH; litter properties: thickness, composition, and pH) and their abbreviations are listed below:

Deciduous forest (DDF) (54°23'44.4"N 24°05'11.1"E) – dominated by *Alnus glutinosa* and *Corylus avellane*. The dense canopy layer of growing trees partly keeps the sun from penetrating to the lower layers of the forest. The soil was sandy loam with pH 7.38 ± 0.1 . Litter, formed by leaves of *A. glutinosa* and *C. avellane*, was about 4 cm. Litter pH 6.69 ± 0.2 .

Small deciduous forest (DF) (0.48 ha) (54°23'38"N 24°06'28"E) – light and dry, located beside the road and formed by *Populus tremula*, *Betula pendula*, and scarce *Quercus robur*. The soil was cohesive sand, with pH 6.1 ± 0.5 . Litter, consisting of leaves and fallen bark of *P. tremula*, *Q. robur* was ≈ 2 –2.5 cm and pH 6.7 ± 0.1 .

Broadleaf forest (BLF) (54°23'17"N 24°06'17"E) – *Q. robur*, *Tilia cordata*, *Acer platanoides*, *Ulmus* sp. dominated here. Sandy loam soil dominated here, pH 4.7 ± 0.2 . Litter was formed of the leaves and fallen bark of the mentioned

tree. The thickness of litter was ≈ 2.5 –3 cm and pH 6.45 ± 0.1 .

Anthropogenic habitat (AH) (54°23'38"N 24°06'57"E) – selected around houses: compost, agricultural residues, cellars, and plots of soil with vegetation: *Poa annua*, *Potentilla anserina*, *Chamomilla suaveolens*, *Taraxacum officinale*, *Polygonum aviculare*. The soil was sandy loam with pH 7.05 ± 0.2 . Litter was absent.

Mixed forest with dominating *Pinus silvestris* (MFP) (54°25'22"N 24°03'12"E) – addition to *P. silvestris*, *Quercus robur*, *Betula pendula*, and *C. avellana* grow here. Sandy soil, pH 4.57 ± 0.1 . Litter was formed of pine tree needles, moss (Bryophyta), and leaves of deciduous trees. The thickness of litter was about 2.5–3 cm and pH 6.6 ± 0.16 .

Recovering young mixed forest (RMF) (54°24'43"N 24°04'43"E) – a former clear-cutting forest, now recovered by young *P. silvestris*, in addition to *Picea abies*, and sporadic *B. pendula*. Soil was cohesive sand with pH 6.41 ± 0.1 . Litter was poor (thickness ≈ 1 cm) formed of pine tree needles and coarse birch leaves. Litter pH 5.6 ± 0.2 .

Mixed coniferous forest (MCF) (56°01'38"N 21°54'46"E) – formed of *P. abies*, *P. silvestris*, also *Q. robur*, *C. avellana*, *Sorbus aucuparia*. Sandy loam soil was covered in abundant mosses.

Ruins of abandoned former barracks (RU) (56°01'24"N 21°54'42"E) – located in the territory of a former missile defense base. Ruins (bricks) surrounded by *P. abies*, *Padus avium*, *Urtica dioica*. Sandy loam and black soil dominated here.

Sampling and data analysis

Isopods were sampled directly in habitats, by inspecting natural and artificial shelters in 2 m² randomly chosen fields. The minimum distance between the plots was 15 m. The pH of the soil was measured at each site (except Plokštinė Reserve) monthly. The collected isopods were preserved in 70% ethanol and deposited in the personal collection of the author at the Biology Department of Vytautas Magnus University. Taxonomical identification follows Schmalzfuss (2003).

The diversity of isopods in the Plokštinė Reserve was assessed by species richness (S), a relative abundance of species, and frequency of occurrence (F, %). Sampling sites in the Alytus region were assessed by species richness (S), a relative abundance of species, frequency of occurrence (F, %), Shannon – Wiener diversity index (H), and Simpson dominance index D (Magurran, 2004).

Analysis of variance (one-way ANOVA), t-tests, and Spearman correlation analyses computed in PAST 2.12 software (Hammer et al., 2001) were used to test the relationships between isopods and habitats at the level of significance equal to 0.05.

The distribution and the number of shared species among habitats were assessed by the Jaccard similarity index and were expressed as a dendrogram constructed with a cluster analysis using the free BioDiversity Pro software (McAleece et al., 1997).

RESULTS

During surveys of isopods in the south and north-western regions of Lithuania, a total of seven species belonging to five families were recorded. *Porcellionides pruinosus* was recorded from Lithuania for the first time. The list of the recorded taxa, along with the new finding localities and remarks on their biology and prevalence in Europe (based on previous researches by different authors), is presented below.

Taxonomy

Family Ligiidae Leach, 1814

Genus *Ligidium* Brandt, 1833

Ligidium hypnorum (Cuvier, 1792)

Material examined

North-western region of Lithuania: 5 ♀ in MCF, 56°01'38"N 21°54'46"E, 11 May 2016, leg. I. Šatkauskienė; Southern region of Lithuania: 4 ♂ in DF1, 54°23'44.4"N 24°05'11.1"E, 18 June 2016, leg. K. Kvašnauskaitė.

Distribution

Widespread species through Europe (Schmalzfuss, 2003), including countries neighbouring Lithuania: Latvia (Spungis, 2008) and Poland (Jędryczkowski, 1981).

Remarks on habitat and ecology in Lithuania

The majority of records of *L. hypnorum* were received from the wet forests in the coastal region of Lithuania (Vilisics et al., 2012). During the current study, *L. hypnorum* was found in ruins surrounded by coniferous (MCF), also in a damp deciduous forest (DF1) dominated by alders (*Alnus* sp.) (Table 1). Based on current and previous studies, it is likely that this species is prevalent in damp habitats in Lithuania (Fig. 1).

Remarks

The genus *Ligidium* is the most species-rich genus within the family Ligiidae; it has 54 species with a Holarctic and Oriental distribution (Schmalzfuss, 2003; Taiti, 2016).

The genus can be diagnosed based on several characters, such as the male pleopod 2 endopod, the male pleopod 1 and 2 exopods, and the uropod, but only the apical tip of male pleopod 2 endopod has the diagnostic value for species delimitation (Vandel, 1965; Li, 2017).

Family Trichoniscidae Sars, 1899

Genus *Hyloniscus* Verhoeff, 1908

Hyloniscus riparius (Koch, 1838)

Material examined

Southern region of Lithuania: 15 ♀, 5 ♂ in DF1, 54°23'44.4"N 24°05'11.1"E, 5 August 2015, leg. K. Kvašnauskaitė; 6 ♀ in MFP, 54°25'22"N 24°03'12"E, 10 August 2015, leg. K. Kvašnauskaitė.

Distribution in Europe

H. riparius is found mostly in Central and Eastern Europe, including countries neighbouring of Lithuania: Poland and Latvia (Jędryczkowski, 1981; Jass, Klausmeier, 2003; Spungis, 2008).

Remarks on habitat and ecology in Lithuania

In the present study, *H. riparius* was the most abundant in litter of alder leaves and under fallen bark in damp deciduous forest (DF1). Less numerous occurrence of the species was

observed in mixed forest (MFP) (Table 1). Previous studies recorded sporadic individuals in urban parks and deciduous forest in the central part of Lithuania (Table 2) (Tuf et al., 2012; Šatkauskienė, 2017).

The largest number of *H. riparius* (N = 98) was captured in August with domination of females (79.6%). It is consistent with Jass and Klausmeier (1996), who reported the increasing occurrence and reproductive activity of *H. riparius* in August–September.

Remarks

Jass and Klausmeier (2003) described habitat preferences for *H. riparius* as ‘wetlands, riparian’. This isopod quickly desiccates due to its exceptionally small size; also, it lacks pseudotracheae on its abdominal pleopods, which perform the function of conserving body moisture in other terrestrial isopods. Thus, it is more strictly confined to moist habitats than some other terrestrial isopod species.

Genus *Trichoniscus* Brandt, 1833

Trichoniscus pusillus Brandt, 1833

Material examined

Southern region of Lithuania: 15♀, in BLF, 54°23′17″N 24°06′17″E, 3 08 2016, leg. K. Kvašnauskaitė

Distribution

T. pusillus is found commonly across Europe (Schmalfuss, 2003).

Remarks on habitat and ecology in Lithuania

Frequency of occurrence of *T. pusillus* was 50% in studied habitats of southern Lithuania, with preference of broadleaf forest (Table 1).

Remarks

T. pusillus is similar to *Hyloniscus riparius*. Distinguishing characters of *T. pusillus* are their eyes composed of three ocelli (Oldham, 2011) and antenna with four or five flagellar segments; meanwhile *H. riparius* have eyes with one ocellus and the antenna of six segments (Schultz, 1965).

Family Oniscidae Latreille, 1806

Genus *Oniscus* Linnaeus, 1758

Oniscus asellus Linnaeus, 1758

Material examined

Southern region of Lithuania: 1♂, 6♀ in DF1: 54°23′44.4″N 24°05′11.1″E, 12 July 2014; Northwest Lithuania region: 4♀ in MCF: 56°01′38″N 21°54′46″E, 23 May 2015, leg. I. Šatkauskienė.

Distribution

O. asellus Linnaeus, 1758 comes from Western Europe, from the Atlantic area (Vandel, 1962) and widespread in Northern and Western Europe (Schmalfuss, 2003). In the north and east of its range, *O. asellus* is considered synanthropic (Bilton, 1994).

Remarks on habitat and ecology in Lithuania

Occasional individuals of *O. asellus* were recorded in southern Lithuania during current study (Table 1). Low frequency is possibly related to dry sandy soil dominating in southern Lithuania, since *O. asellus* does not thrive in dry habitats (Dias et al., 2012). Furthermore, soil pH in sampling sites was 6.7–7.4, whereas *O. asellus* tolerates lower pH, with a preference for 5.1 (Straalen, Verhoeff, 1997). *O. asellus* was found in urban parks and natural habitats of previous studies (Tuf et al., 2014; Vilisics et al., 2012; Šatkauskienė et al., 2016).

Remarks

The family Oniscidae, together with Porcellionidae and Armadillidiidae, are found in drier areas with increased morphological specialisation (Wright, Ting, 2006) and different ability to tolerate dry conditions. *O. asellus* as epigeal clinger species (Schmalfuss, 1984) is the least terrestrial in comparison with *Porcellio scaber* and *Armadillidium vulgare* and thus the most susceptible to desiccation (Dias et al., 2012).

Family Porcellionidae Brandt, 1831

Genus *Porcellio* Latreille, 1804

Porcellio scaber Latreille, 1804

Material examined

Southern region of Lithuania: 1♀ in AH: 54°23′38″N 24°06′57″E, leg. I. Šatkauskienė 10 July 2015. North-western region of Lithuania: 2♀ in MCF: 56°01′38″N 21°54′46″E, 11 May 2016, leg. I. Šatkauskienė.

Distribution

A European species introduced in many parts of the world (Schmalfuss, 2003). Prevalence of this species accompanied by human habitation is recorded in Poland and the Baltic countries (Jedryzckowski, 1981; Spungis, 2008).

Remarks on habitat and ecology in Lithuania

Single specimens of *Porcellio scaber* were found in anthropogenic site (Alytus district) and in mixed coniferous forest (Plungė district) (Table 1). The largest number of captured isopods was reported from coastal habitats (Vilisics et al., 2012).

Remarks

The first record of *P. scaber* in Lithuania was made by Vilisics (Vilisics et al., 2012). The complete list of the widely studied species *P. scaber* is available in Schmalfuss (2003).

Genus *Porcellionides* Miers, 1877

Porcellionides pruinosus (Brandt, 1833)

Material examined

Southern region of Lithuania: 22♀, 5♂ in AH, 54°23'38"N 24°06'57"E, 14 July 2014 leg. K. Kvašnauskaitė; 3♀ 17 July 2016 leg. I. Šatkauskienė.

Distribution

P. pruinosus is considered to be the most widely distributed species of terrestrial isopods extensively carried elsewhere by humans (Vandel, 1962; Garthwaite, Sassaman, 1985).

Remarks on habitat and ecology in Lithuania

In the current study, it was the first time that *P. pruinosus* was found in Lithuania.

P. pruinosus was found only in a settlement, dwelt under the bricks of the buildings, in cellars, and manure. The highest number of these isopods (total 343) were collected in July. *T. rathkii* and *P. scaber* were found in association with *P. pruinosus*, but the domination of the latter species was obvious.

Remarks

Extensive polymorphism in *P. pruinosus*, with numerous subspecies recognised throughout the world, was described by Vandel (1962). However, subspecific taxa were based solely on

morphological criteria, and their biological validity has been questioned repeatedly (Lefebvre and Marcadé, 2005).

Family Trachelipodidae Strouhal, 1953

Genus *Trachelipus* Budde-Lund, 1908

Trachelipus rathkii (Brandt, 1833)

Material examined

Southern region of Lithuania: 50♀, 11♂ in MFP, 54°25'22"N 24°03'12"E, 12 July 2014 leg. K. Kvašnauskaitė; north-western region of Lithuania: 1♂, 16♀ in MCF, 56°01'38"N 21°54'46"E, 23 May 2015, leg. I. Šatkauskienė.

Distribution

T. rathkii are widespread through most of Europe (Schmalfuss, 2003; Kuznetsova, Gongalsky, 2012).

Remarks on habitat and ecology in Lithuania

Exhibiting unspecific habitat requirements (Jass, Klausmeier, 1996), *T. rathkii*, was the most frequent species with occurrence in all habitats during the present study. These isopods showed preference to mixed deciduous forest and were less numerous in recovering young forest and broadleaf forest (Table 1). Based on precursor records, habitats of *T. rathkii* ranged from urban habitats (Vilisics, Hornung, 2009; Tuf et al., 2014; Šatkauskienė et al., 2016) to dune pine forest (Vilisics et al., 2007) and mixed deciduous forest (Šatkauskienė, 2017). During the warm season in Lithuania, females dominated in the studied populations (Šatkauskienė et al., 2016), in agreement with McQueen (1976) and Hornung et al. (2015).

Remarks

The centre of the geographic distribution of the genus *Trachelipus* is south-eastern Europe. These species are common in central Europe, and one has been introduced to North America (Schmidt, 1997). Finding additional species *Trachelipus difficilis* Radu, 1950 and *Trachelipus nodulosus* is believable in Lithuania since they are distributed in neighbouring Poland and Belarus (Schmidt, 1997; Schmalfuss, 2003).

Table 1. The number of species, individuals, the relative abundance (in parentheses), and the frequency of occurrence (F) of isopods in sampling sites. Values of diversity indices for the sampling sites in Alytus district

Species	MFP	DF	RMF	DDF	AH	BLF	MCF	RU	F %
<i>L. hypnorum</i>				4 (0.92)			9 (29.03)	15 (62.5)	37.5
<i>O. asellus</i>	1 (0.27)			3 (0.69)		1 (2.22)	3 (9.67)		50.0
<i>P. pruinus</i>					763 (98.2)				12.5
<i>P. scaber</i>					1 (0.13)		2 (6.45)		25.0
<i>T. rathkii</i>	325 (88.07)	32 (71.1)	5 (83.3)	83 (19.03)	13 (1.67)	5 (11.6)	17 (54.8)	9 (37.5)	100
<i>H. riparius</i>	18 (4.87)	1 (2.22)	1 (16.6)	335 (76.8)		2 (4.65)			62.5
<i>T. pusillus</i>	25 (6.77)	12 (26.6)		18 (4.12)			35 (81.39)		50.0
N	369	45	6	436	777	43	31	24	
S	4	3	2	5	3	4	4	2	
D	0.78	0.56	0.66	0.60	0.96	0.67			
H	0.47	0.68	0.45	0.73	0.09	0.65			

MFP = mixed forest with dominant *Pinus silvestris*; DF = deciduous forest on roadside; RMF = recovering young mixed forest; DDF = damp deciduous forest; AH = anthropogenic habitat; BLF = broadleaf forest, MCF (PR) = mixed coniferous forest in Plokštinė Reserve; RU (PR) = ruins of building in Plokštinė Reserve; N = total number; S = species richness; D = Simpson index; H = Shannon-Wiener index.

Overall, seven isopod species belonging to seven genera and five families were recorded during this study (Table 1): *Ligidium hypnorum*, *Oniscus asellus*, *Porcellionides pruinus*, *Porcellio scaber*, *Trachelipus rathkii*, *Hyloniscus riparius*, *Trichoniscus pusillus*. All seven species were recorded in the studied habitats of southern Lithuania. Four species – *T. rathkii*, *P. scaber*, *O. asellus*, and *L. hypnorum* – were identified in Plokštinė Reserve (western Lithuania).

It was the first record of *Porcellionides pruinus* for Lithuanian isopod fauna.

The maximum number of species (5) and 436 individuals of isopods were found in damp deciduous forest (DF, DDF) and only two species and six individuals were recorded in recovering mixed forest (RMF). Mixed forest (MFP), broadleaf forest (BLF), and mixed

coniferous forest (MCF) were represented by four species (Table 1).

T. rathkii was the most frequent (100%) in the studied habitats, followed by *H. riparius* (62.5%) and then *O. asellus* (50%) and *T. pusillus* (50%), with similar occurrence. *P. pruinus* was found only in anthropogenic habitats (Table 1).

T. rathkii and *H. riparius* demonstrated affinity to more appropriate habitats, even though their distribution was observed in the majority of the studied habitats. *T. rathkii* prevailed (88.07%) in mixed deciduous forest, and *H. riparius* (76.8%) dominated in a damp deciduous forest (DDF) (Table 1).

The correlation between soil pH and the abundance/species richness of isopods was not statistically significant ($R_{pH/N} = 0.438$ $p = 0.396$; $R_{pH/S} = 0.076$; $p = 1$). Also, litter pH

was found to influence the abundance of isopods only weakly ($R_{pH/N} = 0.9$, $p = 0.037$).

Shannon-Wiener index had the highest value ($H = 0.73$) in damp deciduous forest and was at its lowest ($H = 0.09$) in the anthropogenic habitat dominated by *P. pruinosa* ($D = 0.96$).

The diversity of isopods was similar (one-way ANOVA, $df = 5$ $F = 0.711$ $p = 0.618$) in the surveyed habitats.

The cluster analysis based on Jaccard similarity index indicated similarities between the compositions of isopod species recorded in habitats. The mixed and broadleaf forests revealed the highest similarity between isopod communities (>90%). The anthropogenic habitat stood out clearly from other habitats and showed the lowest (0.17%) similarity in species composition (Fig. 2).

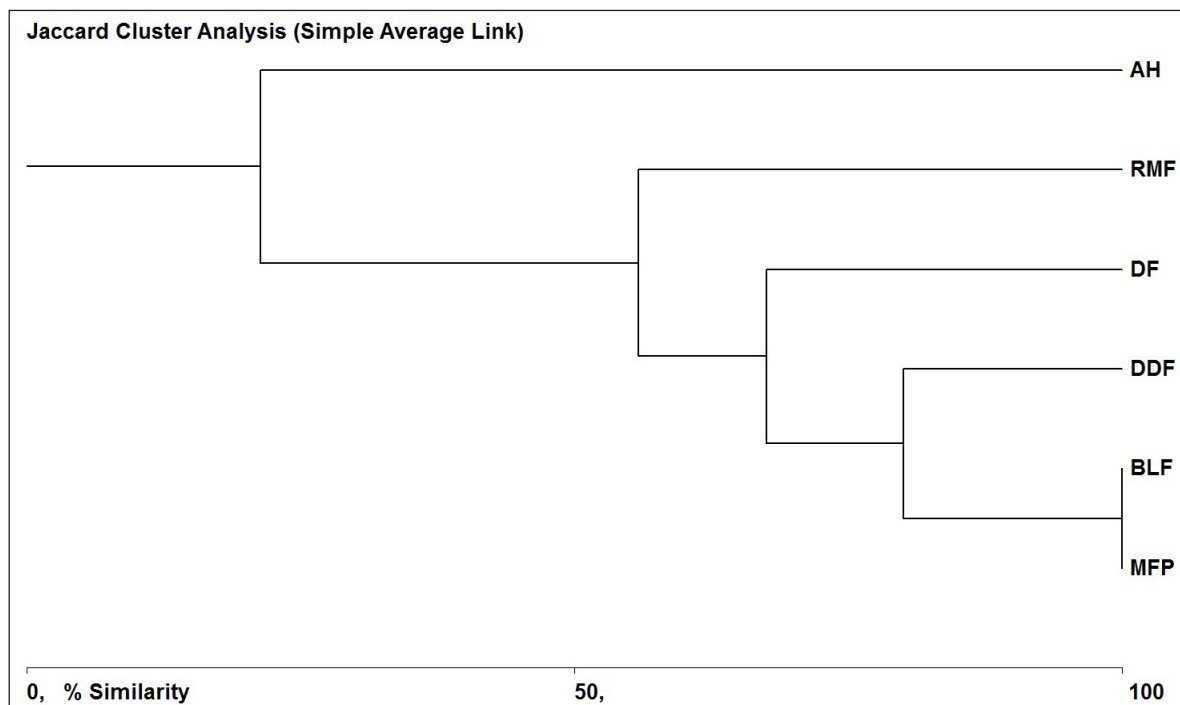


Fig. 2. Dendrogram constructed by the data on similarity (Jaccard index) of isopods community between habitats in Alytus region, Lithuania (AH = Anthropogenic habitat RMF = Recovering young mixed forest; DF = Deciduous Forest on roadside; DDF = Damp deciduous forest; BLF = Broadleaf Forest; MFP = Mixed Forest with dominant *Pinus silvestris*)

DISCUSSION

Distribution and richness of species in habitats

According to the present study, seven species of terrestrial isopods are widespread in Europe (Schmalzfuss, 2003). *T. rathkii* as habitat generalist (Hornung et al., 2007; Hornung et al., 2015) is most frequent, with occurrence in all the studied habitats. Although *H. riparius* was found in most habitats, being sensitive to desiccation (Jass, Klausmeier, 2003) gave a clear preference (76.8%) to damp deciduous forest.

The relation between soil/litter properties and isopod communities was determined as weak ($p > 0.05$) during the present study.

On the other hand, soil/litter – together with other environmental factors such as moisture, plant community, and microhabitats – often incorporates into a collective set and acts together creating a more or less suitable background for isopod communities, as in the case of damp deciduous forest (DDF), in which highest diversity ($H = 0.73$) and five species were recorded (Table 1). Well-developed

litter of alder leaves as energy-efficient food for isopods (Loureiro et al., 2006), moisture, and shadows of the canopy formed suitable habitat for isopods.

Since a typical forest isopod community consists of 3–7 species (Farkas et al., 1999), the diversity of isopods found in damp forest can be assumed as average rich.

The lowest species richness and only a few specimens (Table 1) were observed in recovering forest (RMF). Young pines and birches, with a scarce canopy, do not form a shadow and litter, and, as a consequence, do not create a suitable environment for isopods.

An anthropogenic environment with an abundance of shelters and food sources are often suitable for synanthropic isopods. In this study, a settlement was the first and only place of finding *P. pruinus*. Prevalence (98.19%) of anthropophilic *P. pruinus* (Radu, 1985) in such a place (Table 1) can be assigned to the available manure-like food source (Cawley, 1996) or, possibly, adaptation of this species to higher temperatures (Römbke et al., 2011) characteristic of southern Lithuania. In any case, the distribution of *P. pruinus* in Lithuania remains unclear and needs further studies.

Similar communities consisting of *T. rathkii*, *H. riparius*, and *T. pusillus* were found in mixed (MFP) and broadleaf forest (BLF). However, the rich cover of moss in MFP, ensuring a more suitable living space for isopods (Božanić et al., 2013) probably determined the highest abundance of isopods in this habitat in comparison with BLF.

Relatively low diversity of isopods in Plokštinė Reserve (Table 1) was most likely due to brief inspection of the habitats and to prevailing coniferous (Table 1).

In general, the average richness of species (2–5) was determined in habitats of southern Lithuania, comparing with 11 species that were recorded in one mixed deciduous forest in the Kaunas region (Šatkauskienė, 2017). It could be related to the rather complicated environment for isopods in southern Lithuania. Pine forests, dominant in this region, generate

low-quality litter resulting in restricted litter shelter (Loureiro et al., 2006), so probably limiting the diversity of isopods in such an environment. In addition, it is likely that the prevalence of sandy soil in most areas of Alytus district creates less favorable soil conditions for isopods: sand is characterised by low water-holding capacities and as low in all essential nutrients, which are significant factors for isopods and myriapods (Kula, Lazork, 2017).

Review of the isopod fauna in Lithuania

This section aims to overview the available knowledge on isopods in Lithuania, including records of the present study. The previous faunistic studies (Kuznetsova, Gongalsky, 2012; Vilisics et al., 2012; Tuf et al., 2014; Šatkauskienė et al., 2016; Šatkauskienė, 2017) resulted in 13 isopod species. The first record of *Porcellionides pruinus* during the present study extended the list of species of Lithuanian isopods to 14 (Table 2).

All recorded Lithuanian isopod species are common in Europe (Schmalfuss, 2003).

O. asellus, *P. scaber*, and *T. rathkii* are widely distributed in Lithuania, with occurrences in a wide range of habitat types (Fig. 1, Table 2).

P. scaber, often regarded as an urban environment specialist (Magura et al., 2008), demonstrated a preference for natural dry habitats in Lithuania. Most records of this woodlouse were obtained from the coast of the Baltic Sea (Vilisics et al., 2012), while these isopods were less numerous in city parks in the central part of the country (Tuf et al., 2014; Šatkauskienė et al., 2016). A similar distribution of this species in dry coastal dune meadows and pine forests in Latvia were recorded as well (Spungis, 2008).

Cylistiscus convexus and *P. pruinus* occur in a wide range of natural and human-affected areas in Europe (Vandel, 1962; Garthwaite, Sassaman, 1985; Schmalfuss, 2003; Vilisics, Horning, 2009); however, only two records were received from two localities in Lithuania (Table 2). Since the occurrence of these isopods is sporadic in neighbouring countries (Jedryzckiowski, 1981; Spungis, 2008), its distribution is

Table 2. Updated list of terrestrial isopod species recorded in Lithuania (based on previous research and the present survey)

No.	Family/species	Kuznetsova et al. 2012	Vilisis et al. 2012	Tuf et al. 2014	Šatkauskienė et al. 2015	Šatkauskienė 2017	Present study	Total of individuals
Ligiidae Brandt & Ratzeburg, 1831								
1	<i>Ligidium hypnorum</i> (Cuvier, 1792)		320	75		1	28	424
Trichoniscidae Sars, 1899								
2	<i>Haplophthalmus danicus</i> Budde Lund 1880			4		5		9
3	<i>Hyloniscus riparius</i> (C. Koch, 1838)			5		1	357	363
4	<i>Trichoniscus pusillus</i> Brandt, 1833			17		15	90	122
Platyarthridae Vandel, 1946								
5	<i>Platyarthrus hoffmannseggii</i> Brandt, 1833					5		5
Oniscidae Latreille, 1806								
6	<i>Oniscus asellus</i> Linnaeus, 1758	+	17	10	1	20	8	56
Porcellionidae Brandt & Ratzeburg, 1831								
7	<i>Porcellio scaber</i> Latreille, 1804	+	269	14	24	6	3	316
8	<i>Porcellio spinicornis</i> Say, 1818	+		2				2
9	<i>Porcellium conspersum</i> (C. Koch, 1841)		50	4				54
10	* <i>Porcellionides pruinosus</i> (Brandt, 1833)						763	763
Trachelipodidae Strouhal, 1953								
11	<i>Trachelipus rathkii</i> (Brandt, 1833)	+	1942	68	988	48	489	3535
Cylitiscidae								
12	<i>Cylitiscus convexus</i> (De Geer, 1778)		1					1
Armadillidiidae								
13	<i>Armadillidium vulgare</i> (Latreille, 1804)			2		5		7
14	<i>Armadillidium pulchellum</i> (Zenker, 1799)	+		5		20		25

* – new records for the fauna of Lithuania

possibly similar in Lithuania as well, but more detailed studies are needed for confirmation of the statement.

Although widespread in Europe, myrmecophilous *Platyarthrus hoffmannseggii* (Forró, Farkas, 1998; Schmalzfuss, 2003) was found only in Kaunas district until now. (Table 2; Fig. 1). However, this single site of occurrence is most likely an inaccuracy due to pitfall trapping used in previous studies. Small underground isopods usually do not fall in pitfall traps (Ianc, Ferenti, 2014); meanwhile, about half of the data from

previous studies (Vilisis et al., 2012; Tuf et al., 2014; Šatkauskienė et al., 2016) were based on pitfall traps.

Till now, most data on isopods are available from central (Kaunas region) (Tuf et al., 2014; Šatkauskienė et al., 2016; Šatkauskienė, 2017) and south-western Lithuania (Kuznetsova and Gongalsky, 2012; Tuf et al., 2014; and present study), with records of eleven and eight species, respectively. The highest species richness recorded in Kaunas district was probably influenced by direct sampling and checking of

litter in old mixed deciduous forest, generating an optimal habitat for the majority of isopods (Šatkauskienė, 2017).

The western part of the country, the main coast of the Baltic Sea, is represented by six common species of isopods, which are capable to adapt to the coastal environments harsh for isopods (Vilisics et al., 2012).

In summary, 14 species of isopods are recorded in the fauna of Lithuania but the presence of still another few species is plausible since about 20 isopod species are recorded in neighboring Latvia (Spungis, 2008). Most regions of Lithuania remain unexplored and knowledge on the isopod fauna is still incomplete. Since richness of isopods is highly correlated with geographical and landscape complexity, and environmental heterogeneity (e.g., Mediterranean) (Sfenthourakis, Taiti, 2015), we probably could not expect very high species richness due to the flat terrain and rugged climate of Lithuania. However, the forested area covers approximately 33% of the territory (19% of mature old forests) (Lithuanian Statistical Yearbook of Forestry 2015), it provides a suitable environment for isopods and suggests finding more isopod species during further investigations.

CONCLUSIONS

Seven species of terrestrial isopods were found in habitats of the southern and north-western regions of Lithuania. As a habitat generalist, *Trahalipus rathkii* was the most frequent, with occurrences in all the studied habitats. *Porcellionides pruinosus* was recorded for the first time for the Lithuanian isopod fauna.

Summarising of available data on isopods in Lithuania, including the records of the present study and the previous faunistic studies (Kuznetsova, Gongalsky, 2012; Vilisics et al., 2012; Tuf et al., 2014; Šatkauskienė et al., 2016; Šatkauskienė, 2017), 14 isopods species are recorded in Lithuania.

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Ingrida Šatkauskienė

INDĖLIS Į LIETUVOS SAUSUMOS LYGIAKOJŲ VĖŽIAGYVIŲ PAŽINIMĄ

Santrauka

Straipsnyje pateikiamos sausumos lygiakojų vėžiagyvių rūšys, rastos 2014–2016 metais Pietų ir Šiaurės vakarų Lietuvos vietovėse. Vėžiagyviai surinkti tiesiogiai rankomis apžiūrint slėptuves ir substratą aštuoniuose (skirtingi miško tipo biotopai ir antropogeninės veiklos zonos biotopas) biotopuose. Iš viso rastos ir identifikuotos septynios sausumos lygiakojų vėžiagyvių rūšys. Europoje įprastinė ir dažna *Trachelipus rathkii* rūšis buvo randama visuose tirtuose biotopuose. Antropogeninės veiklos zonos biotope rasta nauja Lietuvai rūšis *Porcellionides pruinosus*. Remiantis gautais rezultatais ir ankstesnių autorių tyrimais, Lietuvoje šiuo metu nustatyta 14 sausumos lygiakojų vėžiagyvių rūšių.

Raktažodžiai: vėžiagyviai, lygiakojai, vėdarėliai, Lietuva