Aquatic invertebrates of the pluviotelmata in Sitnianska Lehôtka vicinity (Slovakia)

Jozef Oboňa[1] – Ľubica Pastorková[1] – Soňa Ščerbáková[2] – Peter Manko[1]

Abstract

Pluviotelmata are common but often overlooked small aquatic ecosystems. During one-year research in Sitnianska Lehôtka vicinity (Slovakia), in total 29 sites have been regularly examined in two weeks intervals. Diptera larvae (family Ceratopogonidae, Culicidae, Chironomidae, Limoniidae, Ptychopteridae and Syrphidae) contributed with 75 % to the total number of recorded specimens. They were followed by Coleoptera (10 %), Heteroptera, Ephemeroptera, and Conchostraca. The most common taxa were the mosquito Culex pipiens *Linnaeus, 1758 and Chironomus spp. in the surveyed pluviotelmata. The most important hydroperiodic factors affecting the invertebrate fauna were the total size and length of pluviotelmata, presence (respectively the absence) of shade, and water temperature.*

Keywords

rain pools, puddles, Diptera, important hydroperiodic factors

Introduction

Small rain pools (puddles) or pluviotelmata (Lellák & Kubíček 1992) are small aquatic ecosystems with different physical and chemical properties (Williams 1996, see Fig. 1). They are formed by the with precipitation water and therefore, they are hydrologically unstable. Pluviotelmata are formed in depressions and potholes with an impermeable bottom. Despite the fact that pluviotelmata as temporary waters represent an important part of the country's water balance, they are often underestimated in hydrobiology (Blaustein & Schwartz 2001).

Figure 1. Pluviotelma in Sitnianska Lehôtka.

[1] *Department of Ecology, Faculty of Humanities and Natural Sciences, University of Prešov, 17. novembra 1, SK–081 16 Prešov, Slovakia; e-mails: obonaj@centrum.sk, peter.manko@unipo.sk, lpastorkova@gmail.com*

[2] *Water Research Institute, Nábrežie arm. gen. L. Svobodu 5, SK–812 49 Bratislava 1, Slovakia; scerbakova@vuvh.sk*

Temporal waters are widespread in the world, in all climatic zones and are very diverse. Despite their biological significance, they have been threatened by human activity. Agriculture, forestry, urbanization, environmental pollution, drying and climate change have a significant impact on these ecosystems. In the past, temporary water bodies in Europe appeared much more frequently than at present (Boothby 1997, Sansom 1997, Wood et al. 2003). The cyclic nature of temporary waters creates a different environment for fauna, which does not occur in other habitats, or not in such large communities. From the biological diversity point of view, pluviotelmata have considerable importance (Williams 2006). Compared to persistent streams and lakes, small temporary water bodies, such as rain pools, are to a lesser extent subject to ecology studies (McKay 1996, Williams 2006). They are often overlooked, but their significance of natural resource, despite the assumption, is not limited (Dudgeon et al. 2006). These small and isolated water communities are often an important source of species richness (Scheffer et al. 2006).

Main attention is paid for small periodic pluviotelmata mainly in tropical and subtropical regions. There the life strategies of the invertebrate communities in temporary freshwater habitats were studied by McLachlan & Cantrell (1980) or Brendonck et al. (2002), as well as their species richness and diversity (Spencer et al. 1999, Robertson 2000, Fontanarrosa et al. 2009, Das & Gupta 2010). On the other hand, relatively little attention has been directed toward the study of this subject in Slovakia. Characteristics of periodic pluviotelmata and the species composition of invertebrate communities were studied by Oboňa et al. 2014. Attention was also paid to mosquito reproduction problems (Diptera: Culicidae) in the floodplains of South Slovakia (Jalili & Halgoš 2004) and the continuity of their occurrence related to climatic conditions in South Eastern Slovakia (Bocková & Kočišová 2016). Oboňa et al. (2017) have dealt with the composition of invertebrate fauna in antropotelmata, particularly in fountains, which can serve as a model system for the island biogeography study.

The main idea of this study is to provide the first comprehensive and complete information on the macroinvertebrate fauna of pluviotelmata in the Sitnianska Lehôtka vicinity.

Material and methods

Samples were collected in the immediate vicinity of the Sitnianska Lehôtka cadastral area, belonging to village Hontianske Nemce (48°19’24”N 18°57’14”E). Four localities were selected with a characteristic occurrence of rain pools during the spring, summer and autumn periods (in total 29 pluviotelmata). Collecting was carried out every two weeks between the end of April 2017 to the end of September 2017. In case of inappropriate climatic conditions (e.g. drought), samples were not collected. Before each collection the GPS location of each site was recorded, water temperature and dimensions of the water body (length, width, depth) were measured, and presence of dominant substrates, surrounding environment, shadow etc. were recorded. Samples of aquatic invertebrates were sampled with a hydrobiological net (mesh size 0.2 mm) from dominant substrates, similarly to Oboňa et al. (2014). The samples were then preserved in the field by formaldehyde to 4 % final concentration, placed in containers, and transferred to laboratory for processing. In laboratory, the individuals of aquatic invertebrates were identified to the lowest possible taxonomic level using several books and keys for identification of aquatic insects (e.g. Rozkošný 1980, Nilsson 1997, Janecek 1998, Becker et al. 2003, Bitušík & Hamerlík 2014). The temperature was measured in the field with a standard thermometer before each sampling, together with the calculation of the approximate water volume (length * width * depth of the water body) and approximate pluviotelmata area (length * width of the water body) and presence (respectively the absence) of shade.

On the basis of field and taxonomical data, we conducted following analyses and expressed following characteristics of communities: taxonomical diversity (number of taxa present); Shannon index of diversity (*H*); diversity profiles to express the relevance of the diversity comparison between sites; cluster analysis based on hierarchical cluster creation by algorithms UPGMA (unweighted pair-group average) and Bray-Curtis index similarities (differences) of communities; non-metric multidimensional scaling (NMDS) using the Euclidean distance (because of the sampling methodology, we assume that zero data indicates the real absence of taxa on the site), and canonical correspondence analysis (CCA). All of these analyses were done using the PAST software (Hammer et al. 2001). Continuous environmental variables were log-transformed prior to further analyses.

Results

An overview of the taxa recorded in pluviotelmata surveys is shown in list below. Mostly, Diptera larvae (family Ceratopogonidae, Culicidae, Chironomidae, Limoniidae, Ptychopteridae and Syrphidae) were found, which accounted for a total of 75% of the community of recorded specimens. They were followed by Coleoptera (10 %), Heteroptera, Ephemeroptera, and Conchostraca. The most common species in the pluviotelmata was a mosquito *Culex pipiens* Linnaeus, 1758 (40 % of the total number of recorded specimens, followed by unidentified species of the genus *Chironomus* (31 %), and beetle of the genus *Helophorus* (5.1 %). Other taxa were less numerous (< 5%).

List of the taxa recorded in the pluviotelmata in Sitnianska Lehôtka

Conchostraca

Insecta

<u>Coleoptera</u>

- Dytiscidae
  - Dytiscidae indet.
  - *Ilybius* spp.
- Hydrophilidae
  - *Helophorus* spp.
- Gyrinidae
  - *Gyrinus* spp.

Diptera

Ceratopogoniidae

Ceratopogoniidae indet.

Culicidae

Anopheles maculipennis s.l. Meigen, 1818

Culex pipiens Linnaeus, 1758

Chironomidae

Chironomus spp.

Psectrotanypus varius (Fabricius, 1787)

Zavrelimyia sp.

Limoniidae

Limoniidae indet.

Ptychopteridae

Ptychopteridae indet.

Syrphidae

Syrphidae indet.

Ephemeroptera

Baetidae

Cloeon dipterum (Linnaeus, 1761)

Heteroptera

Corixidae

Corixidae indet.

Gerridae

Gerridae indet.

Notonectidae

Notonectidae indet.

Table 1 shows the presence of individual taxa during the collection period. Species *C. pipiens* was present in the samples throughout the year as well as the genus *Chironomus* (with the exception of the first month). At the beginning of the sampling season (April to June), beetles and Diptera from families Syrphidae and Ptychopteridae were often found in pluviotelmata. Middle of the season (July) preferred taxa from ordo Heteroptera, family Gerridae and ordo Ephemeroptera, species *C. dipterum.* At the end of the season (August, September) Diptera larvae from families Culicidae (species *A. maculipennis*), Chironomidae (*P. varius* and *Zavrelimyia* sp.), Ceratopogonidae and Limoniidae prevailed.

Table 1. Occurrence of individual taxa in pluviotelmata during all collection months.

	Anopheles maculipennis	Cerotopogoniidae	*Cloeon dipterum*	Corixidae	*Culex pipiens*	Dytiscidae	Gerridae	*Gyrinus* spp.	*Helophorus* spp.	*Chironomus* spp.	*Ilybius* spp.	Limoniidae	Notonectidae	*Psectrotanypus varius*	Ptychopteridae	Syrphidae	*Zavrelimyia* sp.
April					x	x	x	x							x	x	
Jun			x	x	x	x	x	x	x	x	x		x				
July			x		x		x			x							
August	x	x			x					x				x			
September	x				x					x		x					x

The largest number of taxa was recorded at site 13 (6 taxa) and site 21 (6 taxa) (see Fig. 2). Less than 5 taxa were present in other locations. Only two taxa were recorded at about 60 % of the sites surveyed.

The taxonomic diversity referred by the Shannon Index (*H*) was generally low, the highest value (1.447) was reached at site no. 13, followed by sites No. 22 ($H = 1.334$), 21, and 20 (Fig. 2). Given the small number of individuals in the samples, relatively large confidence intervals were observed in the calculation of the diversity index.

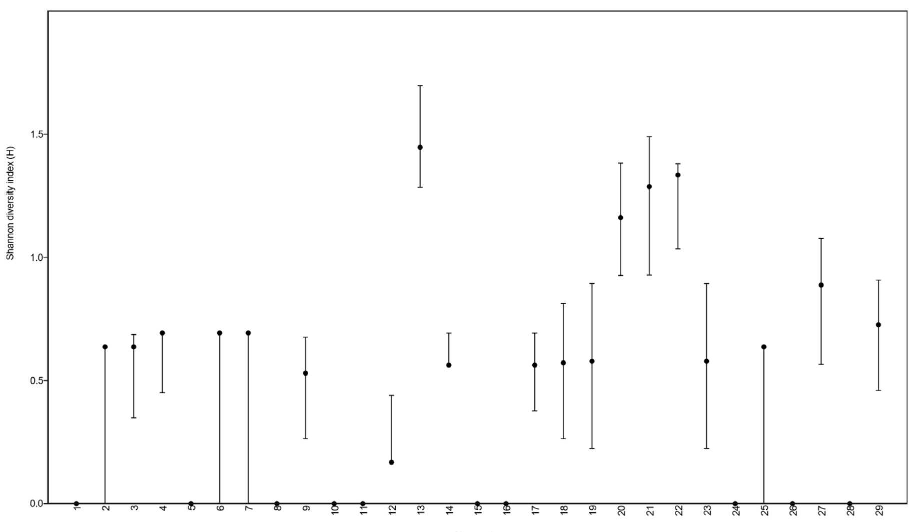

Figure 2. Shannon diversity index (*H*) values with the estimated approximate confidence interval.

By analysing the profiles of diversity (Fig. 2) excluding samples with a single taxa and value *H*=0, it was found that comparisons of the taxonomic diversity of individual pluviotelmata are problematic due to the distinctly different diversity profiles of individual sites.

The cluster analysis has divided pluviotelmata based on their taxonomic similarity into several groups (Fig. 3). The most different were sites 17 (group I.); 15 and 16 (gr. II.); 7 and 26 (gr. III.). Another two groups of sites are larger (gr. IV of sites 9, 12, 20, 21, 5, 14, 2, 13, and 22; gr. V of sites 10, 28, 24, 19, 23, 11, 3, 8, 27, 18, 29, 25, 1, 4, and 6). Site 17 (gr. I) is the most different one, containing only few taxa: mosquitoes – *Culex* (Diptera), *Chironomus* spp. (Diptera), Gyrinidae (Coleoptera) and *Cloeon dipterum* (Ephemeroptera). It is likely that the presence of *C. dipterum* significantly separated this site from the others. The site 7 was occupied by the dipteran family Culicidae (*Anopheles*) and the dipteran subfamily Tanypodinae while the site 26 by mosquitoes (*Culex*), *Chironomus* spp., and *Helophorus* spp. (Coleoptera).

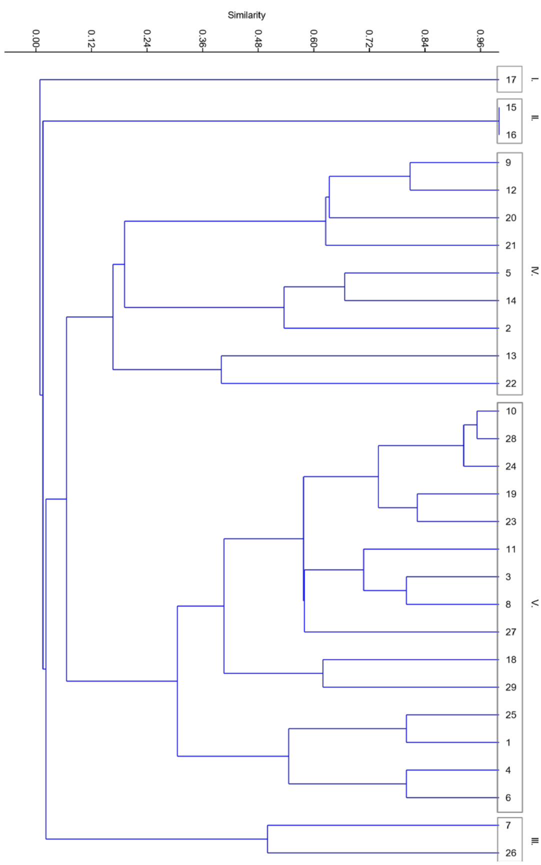

Figure 3. Cluster analysis based on the similarity of the taxonomical composition of pluviotelmata (Bray - Curtis index of similarity).

Non-metrical multidimensional scaling (NMDS) using the Euclidean distance, the model of which is due to the low stress factor, the Sheppard chart, and the high percentage of the variability explained by the first two axes, (Fig. 4) indicates that the taxonomic composition of invertebrate fauna in pluviotelmata are mainly affected by variables related to the size of the pluviotelma (Coordinate 1 - first dimension), but also by shading (Coordinate 2 - second dimension). The sampling sites 9, 12, 20, and 21 are distinctly different from others and were most likely affected by temperature. Sites 1, 4, 6 as well as 7, 15, 16, 25 and 26 by their location near the shading vector demonstrates the importance of this variable in the communities composition. Similar results were obtained by canonical correspondence analysis (Figure 5), according to which the beetles of the genus *Ilybius* and *Gyrinus*, as well as those of the species *C. dipterum*, were the most affected by temperature. An important factor, according to this analysis, is also the dry period, which most affected the abundance of the larvae of the Tanypodinae subfamily. The dimensions of the studied pluviotelmata were important in the representation of *C. pipiens*, Limoniidae and Ostracoda. Of particular importance in explaining the composition of the studied communities was the location of the sampling sites, as indicated by the significant length of the variable site, which means the placement of the groups of sampling sites in the four remote areas.

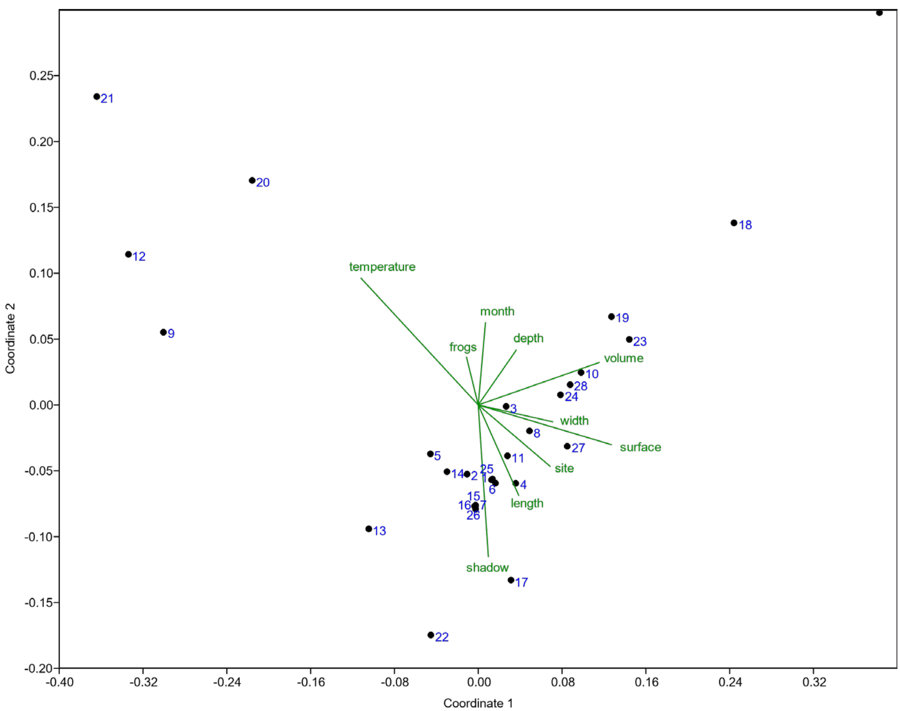

Figure 4. Graphical output of NMDS using a Euclidean distance (Stress factor: 0.05188, R^2 for the axis x: 0.915, and for the axis y: 0.659; the Sheppard graph output

inside; temperature = water temperature at sampling, frogs = presence of frogs in the pluviotelma, month = month in which sample was taken, volume = approx. pluviotelma volume, width = width of the pluviotelma, surface = approx. pluviotelma surface, length = length of the pluviotelma, site = localisation of the pluviotelma in one of the four localities, shadow = degree of shading).

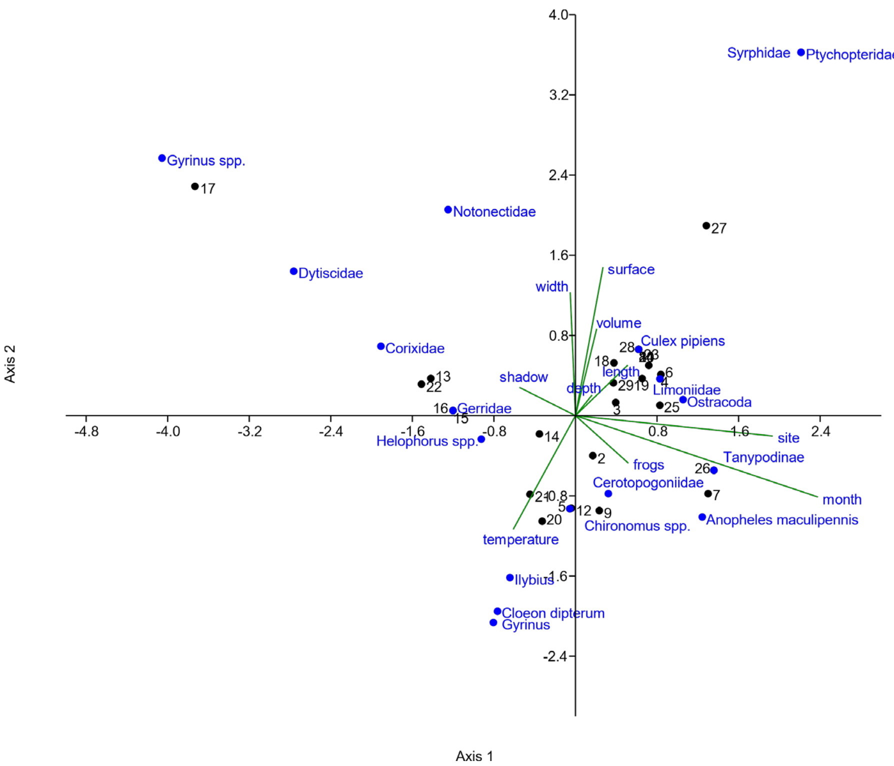

Figure 5. Graphical output (triplot) of the CCA (temperature = water temperature at sampling, frogs = presence of frogs in the pluviotelma, month = month in which sample was taken, volume = approx. pluviotelma volume, width = width of the pluviotelma, surface = approx. pluviotelma surface, length = length of the pluviotelma, site = localisation of the pluviotelma in one of the four localities, shadow = degree of shading).

Discussion

Similarly to this research, Fischer et al. (2000) recorded a number of invertebrates in the pluviotelmata in Buenos Aires (the presence of up to 46 insect taxa). Oboňa et al. (2014) studied pluviotelmata in Upper Nitra and confirmed the occurrence of 16 taxa. While in Buenos Aires beetles were the most numerous representatives, in our research and in Oboňa et al. (2014) Diptera were the most abundant. The mosquito *C. pipiens* was the most common species in investigated pluviotelmata in Sitnianska

Lehôtka. Also, in Buenos Aires (Fischer et al. 2000), the highest incidence of *Culex* mosquitoes, representing up to 76 % of the total species richness of the recorded insects was reported. Regarding the trophic categories, the predominant group was the detritus-feeding (detritophagous) type, represented predominantly by the Culicidae family. On the other hand, predators represented by the Coleoptera and Heteroptera taxa prevailed in December and January in Buenos Aires (Fischer et al. 2000). Based on our results, we conclude that *C. pipiens* mosquitoes were present throughout the year, while predators (Coleoptera, Heteroptera, Tanypodinae larvae) were present in samples usually in a later period. Williams (1987) classifies taxa from pluviotelmata according to the seasonal occurrence of organisms and not according to the taxonomic classification and created several groups. In the group no. 1, there are included taxa occurring in these aquatic habitats during the entire inflow phase. Recorded taxa belonging to this group could be mosquitoes (*C. pipiens*) and genus *Chironomus*. Group no. 2 represents the active forms of species which complete their life cycle about 4-6 weeks before the biotope dries out. This group includes aquatic larvae of Coleoptera, Heteroptera, and *Anopheles* mosquitoes. In the group no. 3 are included taxa that occur in spring, 2-5 weeks after the pool is formed. Their life cycle usually lasts only about 5 weeks. In this study, Coleoptera were also present at the beginning of the season and Diptera larvae from families Syrphidae and Ptychopteridae belong to this group. In the group no. 4, there are included taxa that occur approximately 10 weeks after filling of the depression with water or 3-4 weeks before it dries. From this group, we recorded taxa which occurred mainly in the middle of the season, and also end-of-season taxa (August to end of September). This includes especially the Diptera larvae: *A. maculipennis* mosquitoes, *P. varius*, *Zavrelimyia* sp., and Limoniidae larvae.

Many of temporal water bodies have also negative aspects. Especially in tropical and subtropical regions, they often serve as habitats for larval stages of vectors of various diseases. This fact could be also supported by this research, while several taxa of pluvial moths are epidemiologically significant. Adult females of the mosquitoes (e.g. *Culex* and *Anopheles*) (Kramář 1958, Becker et al. 2003) and Ceratopogonidae (Mellor et al. 2000) are vectors of many disease-causing agents.

Pluviotelmata communities in the surveyed area were influenced mostly by the length and width of the pluviotelmata, the presence of shade, and associated temperature. In previously published papers (Williams & Felmate 2002, Williams 2005, Schneider 1999), the most important variable was the hydroperiodic factor. In our results the size of the pool (expressed as length, width and depth) are related to the hydroperiod - the larger the pool - the longer the water will keep. However, considering only water puddles (e.g. we omit the hydroperiod, Schneider 1999, Bazzanti et al. 1996, 1997) other important factors can be community parameters, composition and temporal succession. Our research confirmed temperature as an important environmental factor which is in accordance with study Fischer et al. (2000)

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