Invertebrate fauna of small temporary rain pools of village Diviacka Nová Ves (Upper Nitra region – Slovakia)

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Abstract
Small rain pools (pluviotelmata) are temporary aquatic ecosystems characterized by large variation in conductivity, oxygen deficiency and slightly acidic to neutral pH. As a result of our investigation of such habitats in the vicinity of Diviacka Nová Ves village in Slovakia, 16 taxa of macroinvertebrates have been recorded. Among them, Diptera larvae of the families Chironomidae and Ceratopogonidae were present in nearly all of the examined pools.

Key words
Pluviotelmata, puddles, macroinvertebrates, Diptera, adaptations, habitat desiccation

Introduction

Rain pools or pluviotelmata (Lellák & Kubíček 1992) are small temporary aquatic habitats formed by rain water in small depressions on the ground (e.g. in clay soils) which experience a recurrent dry phase (Williams & Feltmate 1992; Fischer et al. 2000; Williams 2006). These habitats present a hydrologically unstable ecosystem with variable physical and chemical conditions (Williams 1996). More scientific attention is paid to them in the tropical and subtropical regions, where the rain pools are convenient breeding sites for larvae of epidemiologically important Diptera inhabiting these ecosystems (e.g. Fontanarrosa et al. 2000; Azari-Hamidian 2011). In Europe, however, these common aquatic habitats are largely neglected and only a couple of studies were focused on their biodiversity (e.g. Smoľák 2013). The aim of this study was to describe community composition and environmental characteristics of small rain pools of village Diviacka Nová Ves in Upper Nitra region (Slovakia).

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Material and methods

Qualitative samples of macrozoobenthos were collected in 7 rain pools near the village Diviacka Nová Ves, Upper Nitra region, Slovakia in the summer 2011. Samples of benthic macroinvertebrate communities were taken using D-shaped hand net from the water surface and from sediment. Basic environmental characteristics, such as pH, temperature, oxygen saturation and electrical conductivity (25 °C), were measured in the field using a Multi 3401i (WTW).
Biological material was transported to laboratory, sorted, preserved in 75% ethanol and then identified to the lowest possible taxonomic level using general and specialized keys to identify benthic macroinvertebrates (e.g. Rozkošný 1980; Nilsson 1997; Janecek 1998; Rozkošný & Kniepert 2000; Becker et al 2003). Some larvae of family Ceratopogonidae were reared to adult stages. All adult specimens examined were dissected, mounted on microscope slides in phenol-Canada balsam as described by Wirth & Marston (1968). Material is deposited in Laboratory and Museum of Evolutionary Ecology, University of Prešov, except biting midges (deposited in Department of Invertebrate Zoology and Parasitology, University of Gdańsk) and non-biting midges (deposited in Water Research Institute, Bratislava).

Sampling sites

All sampled pluviotelmata were smaller than 2 m^2 with maximum depth of 10 cm and comprised different habitat types (Tab 1, Figure 1) with habitat distance cca 1 km. Detailed environmental characteristics are given in Tab. 2.

Table 1. Basic features of small rain ponds sampled in Upper Nitra region.

Site	Coordinates (N/E)	Habitat type	Altitude (m)	Max. depth (cm)	Area (m2)	Sediment
K1	48°44‘55.29“/ 18°29‘12.8“	cartway	260	5	1.8	loam
K2	48°44‘55.53“/ 18°29‘14.15“	cartway	262	6	1.3	loam
K3	48°44‘56.28“/ 18°29‘16.29“	cartway	260	7	1.6	loam
K4	48°45‘10.64“/ 18°30‘45.96“	forest	320	4	1.4	loam with leaf litter
K5	48°45‘31.96“/ 18°31‘7.87“	forest	290	7	2	loam with leaf litter
K6	48°45‘31.23“/ 18°31‘12,26“	forest way	330	7	1.7	loam with leaf litter
K7	48°45‘33.22“/ 18°30‘39.95“	ecotone (meadow – forest)	297	10	1.2	loam with plant roots

Figure 1. Photography of studied rain pools (on the left K6, on the right K7).

RESULTS

Characteristics of rain pool environment

Studied rain pools showed large variation in conductivity and low oxygen content (Tab. 2). Conductivity of rain pools in forest area was lower (95218 µS.cm^{-1}) than in open area sites – cartways (502–1131 µS.cm^{-1}). Values of pH showed less variability in forest (7.12–7.27) than in cartways (5.16–7.76).

Table 2. Environmental characteristics of small rain ponds sampled in Upper Nitra.

Site	Water temperature (°C)	Conductivity 25°C (µS.cm-1)	pH	O2 saturation (%)	O2 (mg/ l-1)
K1	22.3	1131	5.16	60.40	5.15
K2	20.2	502	7.76	47.1	4.18
K3	21.6	608	7.31	34.2	2.88
K4	22.3	218	7.12	51.8	4.37
K5	20.4	124	7.12	39.7	3.59
K6	21.2	95	7.27	48.8	4.31
K7	20.8	358	7.44	45.2	3.99

Taxonomic composition

Altogether 16 invertebrate taxa (cca 200 individuals), consisting of Nematoda, Cladocera, Copepoda, Oligochaeta, Conchostraca and Insecta (Diptera, Coleoptera and Odonata) were found in studied small rain pools (see list of taxa). Diptera was the most abundant group of insects; represent 96.6% of all samples. Larvae of the families Ceratopogonidae and Chironomidae were presented in almost every rain pool, Tabanidae and Culicidae in 2 pools and other Diptera families (Muscidae, Limonidae, Psychodidae, Stratiomyidae, Syrphidae, Tipulidae) as well as Coleoptera and Odonata were rare (in one pool) (see Tab. 3)

List of taxa in pluviotelmata:

Oligochaeta

Cladocera

Copepoda

Conchostraca

Insecta

- Diptera
  - Ceratopogonidae
    - *Culicoides stigma* (Meigen, 1818)
  - Culicidae
    - *Culex pipiens* Linnaeus, 1758
  - Chironomidae
    - *Chironomus* spp.
  - Limoniidae
    - cf. *Erioptera*
  - Muscidae
    - Muscidae indet.
  - Psychodidae
    - *Pneumia* sp.
  - Stratiomyidae
    - *Stratiomys chamaeleon* (Linnaeus, 1758)
  - Syrphidae
    - Eristalini
  - Tabanidae
    - *Heptatoma pellucens* (Fabricius, 1776)
  - Tipulidae
    - *Tipula* (*Acutipula*) sp.
- Coleoptera
  - Dytiscidae
    - *Ilybius fuliginosus* (Fabricius, 1792)
- Odonata
  - Libellulidae
    - *Libellula depressa* (Linnaeus, 1758)

Table 3. Presence (+) of insect taxa at sampling sites.

Taxa	K1	K2	K3	K4	K5	K6	K7
C. stigma	+	+	+		+	+	+
C. pipiens			+	+			
Chironomus spp.	+	+	+		+		+
cf. Erioptera	+			+			
Muscidae indet.							+
Pneumia sp.		+					
S. chamaeleon			+				
Eristalini	+						
H. pellucens		+					+
Tipula (Acutipula) sp.	+						
L. depressa						+	
I. fuliginosus	+						

Discussion

Studied rain pools showed large variation in conductivity and low oxygen content. In general almost all telmata (e.g. dendrotelmata, antrotelmata, fytotelmata) have similar environmental characteristics (e.g. Oboňa & Svitok 2012, 2013; Smoľák et al. 2014,). Also, the desiccation of habitat is frequent and imposes a potential catastrophic event on aquatic fauna. McLachlan and Ladle (2001) studied survival strategies of Diptera larvae in tropical rain pools and found that the duration of the pool was important environmental filter for several species. They found Diptera with short life cycles and ability to survive the dry period, such as Chironomidae and Ceratopogonidae, were the first macroinvertebrate colonizers of rain pools. The traits mentioned above give them an advantage against other groups in very small pools prone to desiccation. These families dominated in our study sites. Other immature stages of dipterans or even dragonflies found during our research have longer life spans and therefore it is questionable whether they can complete their life cycle in these habitats or not. However, some species which were found in rain pools in the present study are able to survive the dry period hidden in the wet sediment, e.g. Stratiomidae or Tipulidae (Rozkošný & Kniepert 2000; Jong et al. 2008) but other taxa, e.g. Culicidae, probable cannot (Becker et al. 2003). The latter group colonized temporary rain pools only rarely.

Not only desiccation of habitat but also oxygen deficiency and other variables represent strong environmental filters for colonization of these habitats (Nilsson & Svensson 1994; Williams 2006). Consequently, organisms that successfully colonize this variable environment are usually adapted to atmospheric oxygen breathing and/or are able to escape during unfavorable periods (e.g. adult Coleoptera). Larvae of Chironominae subfamily (e.g. *Chironomus* genus) are able to survive in the environment with very low content of dissolved oxygen, even to the point of occasional anoxia due to presence of haemoglobin with a „high affinity" for oxygen (Cranston 1995).

Some Diptera larvae from pluviotelmata may constitute epidemiological important species. Adult females of family Culicidae are vectors of various diseases agents (Kramář 1958; Becker et al. 2003), likewise the females of genus *Culicoides* (Ceratopogonidae) (Mellor et al. 2000) and family Tabanidae (Baldacchino et al. 2014). This is an important issue in the period of climate change and global warming because pluviotelmata in Europe can be colonized by non-native invasive species spreading from tropical and subtropical regions (Knudsen et al. 1996; Schaffner et al. 2009). Therefore it is necessary to focus more closely on these habitats when searching for vector insect species.

Small temporary rain pools are relatively simple ecosystems which could serve as ideal model systems for studies of colonization dynamics, island biogeography and other ecological problems. They definitely deserve more attention than they recently had.

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