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IZVORNI ZNANSTVENI ČLANCI **ORIGINAL SCIENTIFIC PAPERS**

DIVERSITY OF WATER BEETLES (Hydradephaga, Coleoptera) IN TEMPORARY PONDS OF LONJSKO POLJE NATURE PARK, CROATIA

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The objectives of this study were to determine the fauna of Hydradephaga and to relate their assemblages in temporary ponds of Lonjsko Polje with respect to water permanence (hydroperiod) and shading of ponds by surrounding vegetation. A field survey was conducted in six different ponds in Lonjsko Polje Nature Park from May to December 2004. Aquatic coleoptera were collected using the semiquantitative method of sweeping with a D-frame pond net. Altogether, 341 specimens belonging to 29 species of Hydradephaga were collected. The highest species richness was recorded for the Trebež pond, with 15 species of Hydradephaga recorded exclusively in this pond. None of the species were found in common in all the investigated ponds. It is observed that water beetles prefer more permanent ponds with a longer hydroperiod and open, less shaded habitats.

Aquatic coleoptera, Hydradephaga, Lonjsko Polje, temporary ponds, hydroperiod, aquatic habitat, wetlands

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Svrha ovog rada jest utvrditi raznolikost faune Hydradephaga u privremenim lokvama na Lonjskom polju i usporediti sastav i brojnost njihovih zajednica u odnosu na hidroperiod i zasjenjenost svake lokve okolnom vegetacijom. Istraživanje je provedeno od svibnja do prosinca 2004. na šest različitih privremenih lokava na području Parka prirode Lonjsko polje. Uzorci su uzimani semikvantitativnom metodom poteza D-mrežicom. Uzorkovana je ukupno 341 jedinka i utvrđeno je 29 vrsta Hydradephaga. Najveći broj vrsta zabilježen je na lokvi Trebež, a 15 vrsta bilo je prisutno isključivo na toj lokvi. Niti jedna vrsta nije zajednička svim lokvama. Utvrđeno je da vodeni kornjaši na istraživanom području preferiraju trajnije lokve s duljim hidroperiodom te otvorena i nezasjenjena staništa.

Vodeni kornjaši, Hydradephaga, Lonjsko polje, privremene lokve, hidroperiod, vodena staništa, poplavno područje

Introduction

Aquatic beetles (Coleoptera, Insecta) are secondarily adapted for life in aquatic habitats and they constitute one of the main groups of aquatic macroinvertebrates. Temporary and permanent standing waters represent the most important habitats for this group of insects. Today, these fragile ecosystems are under threat due to intensive anthropogenic influences (draining, waste waters, etc.), (Čelik et al., 2005; Valladares et al., 2002; Schneider-Jacoby & Ern, 1993). Lonjsko Polje is one of the largest naturally flooded plains in Europe with a variety of aquatic habitats. It is included in the Ramsar List of Wetlands of International Importance. To reach a high biodiversity of water beetles it is necessary to preserve and to combine several different types of wetlands in different environments and in all stages of succession, which has a great conservation value (Lundkvist et al., 2000; Ambrožić et al., 2005). Water beetles are good bioindicators of habitat quality and changes in freshwater ponds (Fairchild et al., 2000), and certain species have special ecological requirements (Valladares et al., 2002). The relation between water beetle assemblages and habitat features (e.g. water chemistry, hydroperiod, shading, size of water bodies, site age, habitat homogeneity, acidity, salinity, macrophytes and plant structure, distance from more permanent ponds) have been much studied all over Europe and Canada (De Szalay & Resh, 2000; Fairchild et al., 2000; Lundkvist et al., 2000), while no such study has ever been performed for the Lonjsko Polje area. Faunal research into water beetles in Croatia was conducted by Novak (1952) within the research into the beetle fauna in Dalmatia and the surrounding islands, while research into the Hydradephagan fauna of the northern Adriatic islands (Krk, Rab, Pag, Cres, Lošinj, Unije) was performed by Franciscolo (1972; 1978). All known data about water beetles in

Croatia, published before 1971, are collected in the Catalogues faunae Jugoslaviae (Guéorguiev, 1971). Recently, water beetle fauna have been investigated on the wider area of Kopački Rit Nature Park (Merdić et al., 2005).

The objective of this research was to determine water beetle fauna in six temporary ponds in Lonjsko Polje Nature Park and to relate assemblage structure and abundance of Hydradephaga with respect to water permanence (hydroperiod) and shading of ponds. By these means we could evaluate these ponds as different types of habitats for water beetles and how these environmental characteristics influence beetle assemblages.

Materials and methods

Study area and investigated ponds

For this study, six temporary ponds were selected, located on three different stations in Nature Park Lonjsko Polje, which is one of the largest marshlands in Europe (Figure 1). Investigated ponds varied in size (at each sampling date pond

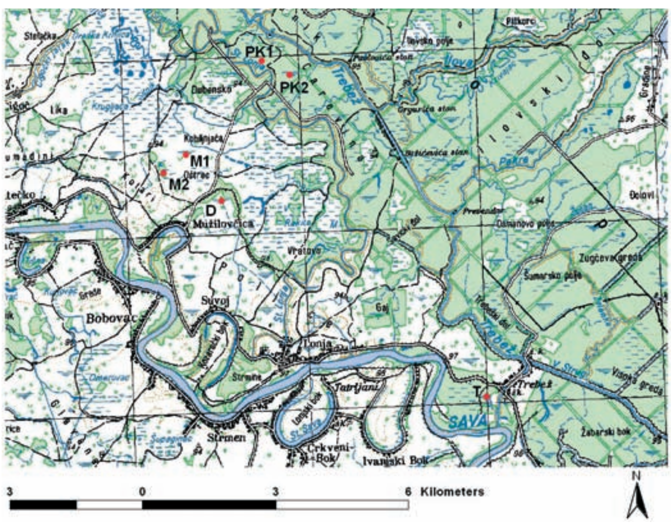

Figure 1. Map of study site with six ponds in Lonjsko Polje Nature Park, Croatia (ponds PK1 and PK2 at the Pavlinov kljun station (N 45° 23’ 58,9” E 016° 41’ 31,3”); M1, M2 and M3 at the Mužilovčica station (N 45° 23’ 42,8” E 016° 41 09,5”) and pond T at the Trebež station (N 45° 21’ 25,6” E 016° 46’ 13,6”)).

Table 1. Hydroperiod of investigated ponds (+ - sampling dates in each pond).

Date Pond	**3.5.**	**13.5.**	**24.5.**	**4.6.**	**16.6.**	**2.7.**	**15.7.**	**25.8.**	**22.10.**	**16.12.**
Ponds										
M1	+	+	+	+						
M2	+	+	+							
M3	+									
PK1	flooded	flooded	+	+	+	+			+	frozen
PK2	flooded	flooded	+	+		+	+		+	frozen
T				+	+	+	+		+	frozen

dimensions were measured: length, width and max. depth), shading by surrounding vegetation, presence of groundwater and water permanence (hydroperiod) influenced mainly by flooding dynamics of the Sava (Table 1). According to density of surrounding vegetation the ponds were classified into three categories: open pond, pond with low density of neighbouring trees and pond shaded by trees.

At the Mužilovčic station three ponds were sampled. Ponds M1 and M2 are located in mixed forest of common oak and black alder, therefore their surface is almost completely shaded. The bottoms of these ponds are covered by dead, partly decomposed leaves and they represent ponds in wooded environments. These two ponds are supplied by precipitation and by groundwater. Pond M3 is situated close to ponds M1 and M2, but is only partly shaded and supplied only by meteoric water. The bottom is muddy, without leaves.

The Pavlinov kljun station is a periodically flooded plain, but during dry periods when it is not in contact with the main body of water, temporary ponds PK1 and PK2 are formed. A small part of PK1 pond is shaded by trees, while PK2 pond is completely open. The bottoms of both ponds are muddy, without leaves and they are supplied by meteoric water.

At the Trebež station only one pond (T) was sampled; it was open although situated near a forest.

Beetle sampling and data analyses

Field work was carried out from May to December 2004. with ten sampling dates. Aquatic coleoptera were collected using semiquantitative method of sweeping with a D-frame pond net (80-µm mesh). Captures were made from the middle of the pond towards the shore through the entire water column. The length of each sweeping transect was measured every sampling date. A total of 108 samples were collected. Beetles were preserved in 75 % ethanol and later identified with specialised keys: Freude et al. (1971), Nilsson (1996), Tachet et al. (2000), Guignot (1947), Drost et al. (1992), Reiter (1908-1912).

The Sörensen (S_s) and Bray-Curtis (Sbc) indices were used to test faunal similarities in Hydradephaga species composition and their abundance between ponds (Krebs, 1989).

Results and discussion

Fauna of Hydradephaga

In the period from May to December 2004, 341 adults were collected and 29 species of Hydradephaga were identified. With 334 specimens captured and classified into 16 genera and 25 species, Dytiscidae has the highest species richness and abundance followed by the family Haliplidae with 6 specimens, 2 genera and 3 species and finally the family Noteridae with only one specimen belonging to species *Noterus crassicornis.*

Among valuable faunal data are records of species with distributions restricted to Eastern Europe like *Bidessus nasutus* (Franciscolo, 1979) and *Hyphydrus anatolicus* (Franciscolo, 1979; Móra at al. 2004). Móra at al. (2004) highlighted a record of *Hyphydrus anatolicus* as an important faunal data for the Jászság area in Hungary. This is the first published data on records of the species *Hydroporus striola* in Croatia.

A systematic list of Hydradephaga species has been made according to Freude et al. (1971), Drost et al. (1992) and Nilsson (2003) (Table 2). Hydradephaga fauna in the ponds of Lonjsko Polje is more similar to the water beetle fauna of Kopački Rit Nature Park, which is also a marshland, than to the water beetle fauna in the ponds of the northern Adriatic islands (Franciscolo, 1972; 1978; Merdić et al., 2005).

Hydradephaga assemblage structure in ponds

Differences were observed in species composition and abundance of Hydradephaga in the ponds. The highest species richness (75.86 % of all species)

Table 2. Systematic list of Hydradephaga species present in investigated ponds of Lonjsko Polje.

Family: **HALIPLIDAE**

Peltodytes Régimbart, 1978

- *Peltodytes caesus* (Duftschmid, 1805)

Haliplus Latreille, 1802

Haliplinus Gignot, 1939

- *Haliplus ruficollis* (Degeer, 1774)
- *Haliplus heydeni* (Wehncke, 1875)

Family: **NOTERIDAE**

Noterus Clairville, 1806

- *Noterus crassicornis* (O.F. Müller, 1776)

Family: **DYTISCIDAE**

Subfamily**: Hydroporinae**

Hyphydrus Illiger, 1807

- *Hyphydrus anatolicus* (Guignot, 1957)

Hydroglyphus Motschulsky, 1853 (*Guignotus* Houlbert, 1934)

- *Hydroglyphus geminus* (Fabricius, 1792)

Bidessus Sharp, 1882

- *Bidessus nasutus* Sharp, 1887

Hygrotus Stephens, 1828

- *Hygrotus decoratus* (Gyllenhal, 1810)
- *Hygrotus inaequalis* (Fabricius, 1777)

Coelambus Thomson, 1860

- *Hygrotus impressopunctatus* (Schaller, 1783)

Suphrodytes Gozis, 1914

- *Suphrodytes dorsalis* (Fabricius, 1787)

***Hydroporus* (s. str.)** Clairville, 1806

- *Hydroporus angustatus* (Sturm, 1835)
- *Hydroporus tristis* (Paykull, 1798)
- *Hydroporus striola* (Gyllenhal, 1827)
- *Hydroporus palustris* (Linnaeus, 1761)
- *Hydroporus planus* (Fabricius, 1781)
- *Hydroporus rufifrons* (Duftschmid, 1805)

Porhydrus Guignot, 1945

- *Porhydrus lineatus* (Fabricius, 1775)

Graptodytes Seidlitz, 1887

- *Graptodytes bilineatus* (Sturm, 1835)
- *Graptodytes granularis* (Linnaeus, 1767)

Subfamily: **Laccophilinae**

Laccophilus Leach, 1817

- *Laccophilus minutus* (Linnaeus, 1758)

Subfamily: **Colymbetinae**

***Liopterus* Dejean, 1833**

- *Liopterus haemorrhoidalis* (Fabricius, 1787)

Agabus Leach, 1817

- *Agabus bipustulatus* (Linnaeus, 1767)
- *Agabus undulatus* (Schrank, 1776)

Rhantus Dejean, 1833

- *Rhantus bistriatus* (Bergsträsser, 1778)
- *Rhantus latitans* (Sharp, 1882)

Family: **Dytiscinae**

Hydaticus Leach, 1817

- *Hydaticus transversalis* (Pontoppidan, 1763)

Acilius Leach, 1817

- *Acilius sulcatus* (Linnaeus, 1758)

Dytiscus Linnaeus, 1758

- *Dytiscus marginalis* (Linnaeus, 1758) as well as the highest abundance (84.75 % of all specimens) were recorded for pond T at the Trebež station. Of the 29 identified species of Hydradephaga, 15 species were recorded exclusively in this pond, three species exclusively in pond M1 at the Mužilovčica station, two in ponds PK1 and PK2 at the Pavlinov kljun station and only one species exclusively in pond M2 (at the Mužilovčica station). Similar results were found in Ambrožić et al. (2005) where they recorded 17 species out of 28 only at one location. There were no Hydradephaga specimens captured in pond M3 at the Mužilovčica station, but this was not surprising due to its extremely short hydroperiod. For this reason we excluded pond M3 from further result analyses.

None of the species were found in all five ponds (Table 3), while 10 species were recorded just once during the sampling period. *Hydroporus* is the only genus common to all the investigated ponds and species of this genus constitute the main part of Hydradephaga fauna at the Mužilovčica station (70-80 %). Species *Hydroporus striola*, *H. rufifrons* and *H. tristis* were present only at the Mužilovčica station, while *H. angustatus* and *H. planus* as well as in the Mužilovčica also occurred in the Trebež samples, but with rather small abundance (1.38 % of all specimens). *Hydroporus angustatus* is present in forested ponds, as is *H. striola,* also frequent in shaded ponds, as well as in eutrophic temporary standing waters supplied by a lot of decomposing plant material and organic matter, such as M1 and M2 ponds (Drost et al., 1992; Freude et al., 1971). The species *Hydroporus palustris* occurred in all three localities and it is the second most abundant species in pond T (21% of all specimens). It is generally widespread, very common and the most abundant of all *Hydroporus* species, with a preference for eutrophic permanent water bodies (Drost et al., 1992; Freude et al., 1971).

Degree of water permanence (hydroperiod) is one of the main parameters influencing water beetle species richness and composition (Fairchild et al., 2003; Lundkvist et al., 2000; Rundle et al., 2002; Valladares et al., 2002). The highest species richness and abundance were recorded for pond T, with the longest hydroperiod of all the investigated ponds and therefore representing the most stable environment for water beetles. Rundle et al. (2002) pointed out that this relationship could be driven by two factors: more permanent habitats are longer available for colonisation, and fewer species are able to tolerate fluctuations of hydroperiod conditions, such as those on M1, M2, PK1 and PK2 ponds.

Table 3. Abundance of Hydradephaga species in investigated ponds.

POND	T	M1	M2	PK1	PK2
Species					
• *Hydroporus striola*	0	4	0	0	0
• *Hydroporus tristis*	0	1	1	0	0
• *Hydroporus rufifrons*	0	1	0	0	0
• *Hydroporus angustatus*	1	3	1	0	0
• *Hydroporus planus*	3	3	2	0	0
• *Hydroporus palustris*	61	4	0	1	0
• *Suphrodytes dorsalis*	6	0	0	0	0
• *Porhydrus lineatus*	1	0	0	0	0
• *Bidessus nasutus*	4	0	0	0	0
• *Hydroglyphus geminus*	76	0	0	1	19
• *Hyphydrus anatolicus*	19	0	0	0	0
• *Hygrotus decoratus*	7	0	0	0	0
• *Hygrotus inaequalis*	2	0	0	0	0
• *Hygrotus impressopunctatus*	50	2	0	0	0
• *Graptodytes granularis*	0	0	1	0	0
• *Graptodytes bilineatus*	0	0	0	0	1
• *Rhantus latitans*	6	0	0	0	0
• *Rhantus bistriatus*	1	0	0	0	0
• *Agabus undulatus*	4	0	0	0	0
• *Agabus bipustulatus*	0	3	0	0	0
• *Liopteruss haemorrhoidalis*	13	2	0	0	0
• *Laccophilus minutus*	25	0	0	0	1
• *Hydaticus transversalis*	2	0	0	0	0
• *Acilius sulcatus*	1	0	0	0	0
• *Dytiscus marginalis*	1	0	0	0	0
• *Noterus crassicornis*	0	0	0	0	1
• *Haliplus ruficollis*	3	0	0	0	0
• *Haliplus heydeni*	2	0	0	0	0
• *Peltodytes caesus*	1	0	0	0	0
Σ specimens of Hydradephaga	**289**	**23**	**5**	**2**	**22**
Total number of species	**23**	**9**	**4**	**2**	**4**

Small overlap in species composition between ponds implied that temporary ponds, as habitats for water beetles, are as interesting as permanent water bodies and it is necessary to apply conservation programmes to different types of water habitats to preserve high biodiversity of water beetles.

Ponds M1 and M2 at the Mužilovčica station are situated in a forest and are therefore very shaded, which could be one possible explanation for the small number of sampled water beetle specimens in these ponds. The highest abundance of Hydradephaga was recorded in pond T, which is completely open. Habitats less shaded by surrounding vegetation have a positive influence on colonization because they are more exposed and more easily detected by water beetles from the air, and generally the number of species is higher in open surroundings (Lundkvist et al., 2000). On the other hand, assemblage structure and abundance of Hydradephaga varied between ponds T and PK2 even though they are both open, due to some other environmental factors that have an influence on the species composition and abundance of Hydradephaga.

Constructed dendrograms illustrating the similarities between the Hydradephaga assemblages of investigated ponds according to Sörensen (S_s) and Bray-Curtis (Sbc) indices revealed two clusters (Figure 2 and 3). Ponds classified into the same group were similar in degree of shading. The first group consists of shaded ponds M1 and M2 surrounded by woods from the Mužilovčica station, while the second group consists of open and less shaded ponds and ponds with a low density of neighbouring trees from Pavlinov kljun and Trebež station, although these ponds are much further away from each other.

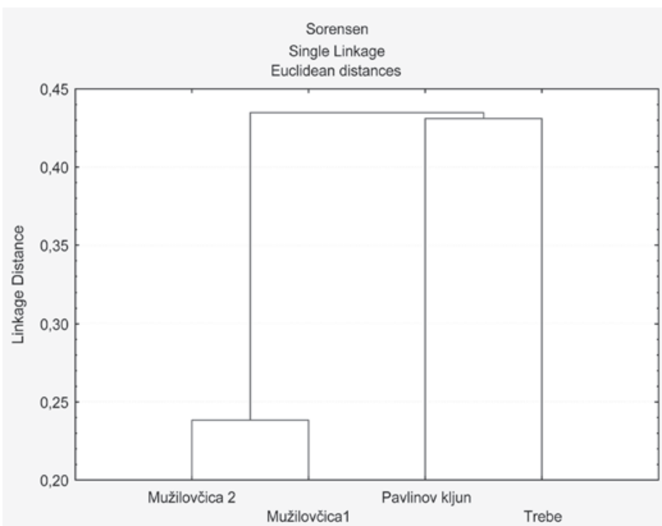

Figure 2. Sörensen index of similarity for qualitative data of investigated ponds.

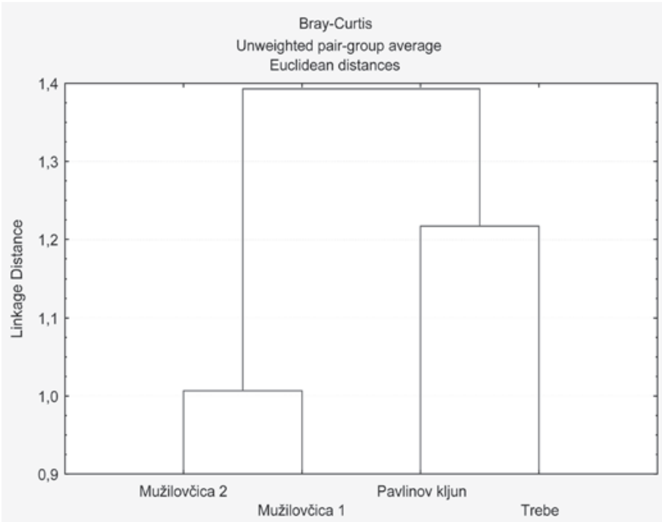

Figure 3. Bray-Curtis index of similarity for quantitative data of investigated ponds.

Conclusions

According to results of species richness and abundance, it is observed that water beetles prefer more permanent ponds with longer hydroperiods, for such pools constitute a more stable environment.

With respect to the degree of shading by surrounding vegetation, they prefer open, less shaded habitats. Although shaded ponds contain fewer species, the water beetle assemblages of such habitats are the characteristic supporting species that are absent in open habitats.

Great differences in species composition in the investigated temporary ponds imply their great value as habitats for different water beetle species and hence important for their biodiversity.

A longer sampling period, of several years, is necessary to investigate factors influencing the assemblage structure of water beetles because their communities are unstable and the turnover of fauna between years is high, especially in temporary wetlands.

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