

ACTA CARSOLOGICA	34/3	6	650-659	LJUBLJANA 2005
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COBISS:1.02

**FAVNA PRESIHAJOČIH PIVŠKIH JEZER**  
**FAUNA OF THE PIVKA INTERMITTENT LAKES**

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Prejeto/received: 1. 8. 2005

## Izvleček

UDK: 556.538(497.4 Pivka):556.166

### Tanja Pipan: Favna presihajočih Pivških jezer

Prispevek opisuje vodno favno presihajočih Pivških jezer. Zaradi presihajočega značaja jezer so bili na tem območju najdeni zanimivi predstavniki nižjih rakov, predvsem iz skupin škrgonožcev (Anostraca), vodnih bolh (Cladocera) ter ceponožcev (Copepoda). Petelinjsko jezero je edini kraj na svetu, kjer še lahko najdemo endemne rakce vrste *Chirocephalus croaticus*. Vrsti ceponožnih rakov *Diatomus cyaneus* in *Diacyclops charon* sta relativno pogosti vrsti v Evropi, vendar sta Petelinjsko in Veliko Drskovško jezero v Sloveniji trenutno edini znani nahajališči obeh vrst. Vrste so ogrožene zaradi uničevanja njihovih naravnih habitatov.

**Gljučne besede:** vodni nevretenčarji, *Chirocephalus croaticus*, presihajoča Pivška jezera, Slovenija.

## Abstract

UDC: 556.538(497.4 Pivka):556.166

### Tanja Pipan: Fauna of the Pivka intermittent lakes

The present contribution deals with aquatic fauna of the Pivka intermittent lakes. Due to their intermittent character some interesting crustaceans from the groups of fairy shrimps (Anostraca), water fleas (Cladocera) and copepods (Copepoda) are found there. Petelinjsko jezero is the only known location in the world for the endemic species *Chirocephalus croaticus*. Copepod species *Diatomus cyaneus* and *Diacyclops charon* are relatively abundant in Europe, but Petelinjsko jezero and Veliko Drskovško jezero are the only two locations known in Slovenia for both species. All the species are threatened due to destruction of their natural habitats.

**Keywords:** aquatic invertebrates, *Chirocephalus croaticus*, Pivka intermittent lakes, Slovenia.

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## UVOD

Presihajoča jezera so značilnost kraške krajine. Presihajoča jezera oblikujejo ekološko pestre habitate, ki so prepoznavni tako po biodiverzitetnih kot tudi geomorfoloških ter hidroloških značilnostih. Temeljne razlike v razvitosti mozaika habitatnih tipov med različnimi poplavnimi depresijami izhajajo iz vodnega režima oz. iz dolžine obdobja, ko je določen del zalit z vodo. Značilne habitatne tipe predstavljajo polsuha travišča, ki se tekom leta spremenijo v občasne mlake ter jezera (Gaberščik & Urbanc-Berčič 2003). Podzemeljske vode v bližini jamskih ponorov predstavljajo življenjski prostor stigobiontskim vrstam, ki preživijo celoten življenjski cikel v podzemeljskih vodah, kot tudi nekaterim površinskim naključnim vrstam, ki jih voda odplavi v jame.

## INTRODUCTION

Intermittent lakes are a typical phenomenon of karst terrain. Intermittent lakes represent ecologically diverse habitats, with distinct biodiversity, geomorphological and hydrological characteristics. The main differences between types of habitat are caused by the annual cycle of water regime. The various habitat types range from semi-dry meadows to the temporary ponds and lakes (Gaberščik & Urbanc-Berčič 2003). Cave waters offer a habitat to subterranean aquatic animals, stygobionts, as well as to some of the surface species washed in by accident.

## ECOSYSTEM OF PIVKA LAKES

The exceptional ecosystem of the Pivka intermittent lakes has not only Slovenian but

## EKOSISTEM PIVŠKIH JEZER

Izjemen presihajoči režim kraških Pivških jezer oblikuje ekosistem, ki je prav gotovo poseben tako v slovenskem kot tudi v svetovnem merilu. Zaradi nenehnega spreminjanja vodne gladine Pivška jezera niso pravi jezerski ekosistem, pa tudi močvirje ne. Razvoj in spremembe ekosistema so odvisne od menjave sušnih in mokrih obdobj. Nenehna igra vode oblikuje pravila in razmere, ki postavljajo meje organizmom.

Prav zato mnogo rastlin in živali, ki se pojavljajo v okoliških ekosistemih, na Pivških jezerih ne najdemo. Združba, ki se je v razvoju ekosistema izoblikovala tukaj, je nekaj posebnega. Do sedaj je s tega območja znanih preko 180 vrst rastlin, preko 200 vrst hroščev, preko 100 vrst metuljev, kar je več kot polovica vseh v Sloveniji opaženih vrst metuljev, in preko 120 vrst ptičev. V jezerih živi več kot 18 vrst vodnih živali, predvsem žuželk in drobnih rakcev. Glavni razlog za raznovrstnot favne in flore je poleg ekstenzivne rabe travniških površin na tem območju tudi geografska lega med submediteranskim in celinskim delom Slovenije (Tome 2000).

## VODNI NEVRETEŃARJI PIVŠKIH JEZER

Vodna favna Pivških jezer je bila še pred kratkim praktično nepoznana. Danes vemo, da so Pivška jezera v času visokih voda poseljena z nekaj vrstami tako imenovanih nižjih rakov. Na območju Pivških jezer, vključno z jamami, so bile doslej najdene dve vrsti iz skupine škrgonožcev, tri vrste iz skupine vodnih bolh, devet vrst iz skupine ceponožnih rakov, po ena vrsta rakcev enakonožcev in postranic (Tabela 1) ter predstavniki iz skupine dvoklopnikov.

Med vsemi izredno zanimivimi živalskimi vrstami Pivških jezer izstopajo zlasti štiri, in sicer dve vrsti škrgonožcev in dve vrsti ceponožcev.

also worldwide fame. The Pivka lakes are neither lakes nor a typical wetland. The succession of the ecosystem is continuously disturbed by the water level fluctuations, droughts and floods. The fluctuations of the physical factors are of vital importance for the ecosystem, and present a driving force, although they are at the same time also a limiting factor for the growth, development and reproduction of the organisms.

This is also the reason that many plants and animals that were found in nearby ecosystems are missing from the Pivka intermittent lakes. It is a very diverse and interesting community that lives there. From this region more than 180 plant species are known, more than 200 species of beetles, more than 100 species of butterflies that represent more than half of all known butterfly species from Slovenia, and more than 120 bird species. More than eighteen species of animals were found in the lakes, mostly insects and small crustaceans. The main reason for such diversity of flora and fauna in this region is extensive utilization of the meadows as well as the geographical location of the Pivka basin between the Mediterranean and Continental parts of Slovenia (Tome 2000).

## AQUATIC INVERTEBRATES OF THE PIVKA LAKES

The aquatic invertebrate fauna of Pivka lakes was until recently almost unknown. In spite of the rather non-systematic research, some interesting species of lower crustaceans have been registered there. Pivka lakes together with related caves harbour two species of fairy shrimps, three species of water fleas, nine species of copepods, one species of isopods and amphipods (Table 1) and some taxa of ostracods.

Pivka lakes are truly outstanding for four species, *i.e.*, two species of fairy shrimps and two species of copepods.

Tabela 1: Nižji raki, najdeni na območju Pivških jezer, vključno z jamami (povzeto po Brancelj & Gorjanc 2000).

Table 1: Crustacean species, found in Pivka lakes and in some caves in the Pivka valley (after Brancelj & Gorjanc 2000).

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### **ANOSTRACA – ŠKRGONOŽCI (FAIRY SHRIMPS)**

*Branchypus schafferi* Fischer de Waldheim, 1834

*Chirocephalus croaticus* (Steuer, 1899)

### **CLADOCERA – VODNE BOLHE (WATER FLEAS)**

*Biapertura affinis* (Leydig, 1860)

*Daphnia obtusa* Kurz, 1875

*Moina brachiata* (Jurine, 1820)

### **COPEPODA – CEPONOŽCI (COPEPODS)**

Calanoida:

*Arctodiaptomus laticeps* (Sars, 1863)

*Diaptomus cyaneus* Gurney, 1909

Cyclopoida:

*Acanthocyclops robustus* (Sars, 1863)

*Acanthocyclops vernalis* (Fischer, 1853)

*Cyclops abyssorum divulsus* (Lindberg, 1955)

*Diacyclops charon* (Kiefer, 1931)

*Eucyclops serrulatus* (Fischer, 1851)

*Megacyclops viridis* (Jurine, 1820)

*Paracyclops fimbriatus* (Fischer, 1853)

### **OSTRACODA – DVOKLOPNIKI (OSTRACODS)**

Dve vrsti, ne določeni (Two species – not identified)

### **ISOPODA – ENAKONOŽCI (ISOPODS)**

*Asellus aquaticus* cf. *cavernicolus*

### **AMPHIPODA – POSTRANICE (AMPHIPODS)**

*Gammarus* cf. *fossarum*

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### **ŠKRGONOŽCI (Anostraca)**

Predstavniki skupine škrgonožcev so v Sloveniji zastopani s štirimi vrstami in vsaka je znana le iz ene oz. dveh lokalitet (Sket 2003).

### **FAIRY SHRIMPS (Anostraca)**

Fairy shrimps are represented in Slovenia by four species. Each species has been found in one or two localities only (Sket 2003). Three species

Tri vrste živijo v sladkih vodah (*Chirocephalus croaticus*, *C. diaphanus*, *Branchypus schafferi*), ena pa v somornici (*Artemia* aggr. *salina*). Predstavniki sladkovodnih vrst živijo v lužah in mlakah, ki občasno presahnejo. V tem času preživijo njihova trajna jajca, iz katerih se v ugodnih pogojih razvije ličinka navplij, ki se hitro preobrazi v odraslo žival. Solinski rakci živijo v bazenih, tudi slanih jezerih in lagunah ob morju, kjer je koncentracija soli povišana.

Vrste so ogrožene predvsem zaradi onesnaževanja in uničevanja njihovih naravnih habitatov ter vnašanja rib v njihovo okolje. V stoječih vodah, kjer živijo ribe, te vrste namreč ne preživijo. Po drugi strani pa te vrste potrebujejo za svoj normalen razvoj določeno obdobje, ko so jajca, sicer zaščitena s trdnim ovojem, izpostavljena suši in nizkim temperaturam. Tako okolje pa nudijo prav presihajoče mlake in jezera.

V Petelinjskem jezeru živi 12-15 mm dolg rakec z znanstvenim imenom *Chirocephalus croaticus* (Slika 1) ali kraški škrgonožec. Rakec je bil najprej opisan iz mlak v spodnjem toku reke Neretve na Hrvaškem, vendar ga tam niso več našli. Kasneje so ga našli še v dveh manjših mlakah ob Cerkniškem jezeru. Ker so ti dve mlaki zasuli, so s tem uničili tudi rakce. Petelinjsko jezero je sedaj edini kraj na svetu, kjer še lahko najdemo te majhne, a zelo zanimive rakce (Brancelj & Gorjanc 1999). Zanimivo je zlasti to, da se v Petelinjskem jezeru vrsta nahaja ob ugodnih razmerah masovno. Populacija je zaenkrat zelo vitalna, vendar je potencialno ogrožena predvsem zaradi morebitnih mehanskih posegov v okolje ali onesnaževanja, vključno z gnojenjem travnikov. Po najnovejših terenskih podatkih, ki jih je zbral Slavko Polak (Notrajnski muzej Postojna), se rakci *C. croaticus* masovno pojavljajo tudi v lužicah v Jeredovcih.

Prve osebkve vrste *C. croaticus* opazimo v mlakah ter lužah šele pozno spomladi, ko je temperatura vode 6-8 °C. Običajno vztrajajo do izsušitve mlak, ko so temperaturne in kisikove

live in freshwater habitats (*Chirocephalus croaticus*, *C. diaphanus*, *Branchypus schafferi*) and one is found in salt pans on the Slovenian coast (*Artemia* aggr. *salina*). Freshwater species populated temporary pools and puddles. *A. salina* is common in temporary saline lakes with a higher salinity than freshwater lakes. Fairy shrimps are developed from resting eggs that survive unfavourable environmental conditions. Nauplii larvae developed from eggs are fast metamorphosed to adult animals.

All species are endangered by decline and pollution of their habitats and also because of the introduction of fish by man into their natural environment. In karstic lakes inhabited by fish fairy shrimps cannot survive. They live in temporary wetlands where there are no predatory fish. Nevertheless, for their development they need special conditions. Resting eggs or so-called thick-shelled "winter" eggs remain in the mud at the base of the pool and dry out with the pool. The eggs will hatch in the spring when the pools refill. Though the resting period usually varies between 6 to 10 months, such conditions are necessary for the development. One can find them in temporary pools and lakes that regularly dry out during summer.

Petelinjsko jezero is populated by the endemic species of karstic fairy shrimp *Chirocephalus croaticus* (Figure 1). The usual length of adults is 12-15 mm. Its type locality is a small lake in Southern Croatia, where it was considered as endemic. Later it was found in two small pools near the intermittent lake Cerkniško jezero in south-central Slovenia. At the present moment there is no information on the status of the population from the type locality and probably it was destroyed. A small population of the same species near the intermittent lake Cerkniško jezero was destroyed a few years ago because pools were filled with debris. Petelinjsko jezero in SW Slovenia is the only known location for *C. croaticus* in Slovenia and in the whole world. The population that was found in this intermittent lake is vital and appears each year (Brancelj & Gorjanc 1999). It

razmere že precej kritične (temperatura preko 20 °C, koncentracija kisika pod 30 %) (Simčič & Brancelj 2000). Iz jajc, ki jih samice prejšnje generacije odložijo na podlago, se izležejo ličinke navpliji. V relativno kratkem času, ki traja približno 14 dni, samci odrastejo, kmalu zatem pa tudi samice. Samci takoj oplodijo samice, ki začno kmalu zatem odlagati jajca. Samice tvorijo dva tipa jajc: t.im. »poletna« jajca s tankim ovojem ter »zimsko« jajca z debelejšim ovojem. Tip jajc, ki jih samica proizvaja, je odvisen od števila samcev v populaciji. V primeru njihovega manjšega števila samica proizvaja poletna jajca, katerih razvoj je hitrejši, kar pomeni, da se generacija zamenja še istega leta. Življenjska doba škrgonožcev vrste *C. croaticus* traja približno mesec dni. Uspešen razvoj v tako kratkem času, ko se posamezen osebek razvije iz jajca in konča svoj življenjski cikel z lastno proizvodnjo jajc, jim omogoča visoka stopnja metabolizma, ki je odvisna predvsem od temperature (Simčič & Brancelj 2000).

is threatend by the destruction of natural habitats and by pollution, including fertilization of meadows. According to the latest data collected by Slavko Polak (Notranjski muzej Postojna) *C. croaticus* appears in large numbers also in the lake Jeredovce.

Animals developed from resting eggs appear in pools and lakes in late spring. At that time the temperature of the water is between 6-8 °C and they persist in the same habitat till the habitats dry up. The temperature rises to above 20 °C and the value of dissolved oxygen is below 30% (Simčič & Brancelj 2000). Fairy shrimps usually hatch as nauplius. Females can produce two types of eggs, thin-shelled "summer" eggs and thick-shelled "winter" eggs. The type of egg produced is determined by the number of males in the community; summer eggs will be produced if there is a shortage of males in the population. Summer eggs hatch rapidly; the young form while still inside the brood sac. The young from these eggs will populate the pool during the same season they are laid. The young will develop in a series of instars. Development is often rapid in the spring, but can be slowed by unusually low temperatures. The speed of development usually reflects the amount of time water will remain in the pool, the water temperature or the arrival of predators in the pool. Fairy shrimps can complete their life cycle in 14 days. This allows for rapid reproduction (Simčič & Brancelj 2000).



Slika 1: Endemit Petelinjskega jezera *Chirocephalus croaticus* (Foto: S. Polak).

Figure 1: *Chirocephalus croaticus*, endemic for Petelinjsko jezero (Photo: S. Polak).

**VODNE BOLHE (Cladocera)**

Vodne bolhe so relativno bogata skupina drobnih rakcev, katerih areali so večinoma obsežni. Možnosti za razširjanje in s tem za ponovno naseljevanje lokalno iztrebljenih populacij so dokaj velike. Predstavniki skupine vodnih bolh so prebivalci predvsem celinskih vod. Doslej je bilo na ozemlju Slovenije najdenih 51 vrst vodnih bolh; dve sta znani iz morja, dve sta endemni stigobiontski vrsti (Brancelj 1996). Vodne bolhe se ponekod pojavljajo zelo množično, zato so predvsem v jezerih poleti skupaj s ceponožnimi raki pomemben dejavnik pri kroženju snovi.

Najpogostejši način razmnoževanja pri vodnih bolhah je z neoplojenimi jajci (t.i. deviškorojna jajca) oz. partenogenezo. Iz njih se razvijejo samice, ki ležejo prav tako neoplojena jajca. Samci se iz neoplojenih jajc razvijejo le takrat, ko je ogrožen obstoj populacije zaradi neugodnih pogojev v okolju. Odrasli samci nato oplodijo samice, ki ležejo jajca, zaščitena s trdnim ovojem. Taka trpežna oz. trajna jajca, obdana s posebnim ovojem, imenujemo ephippium ali sedelce. Vodnim bolham omogočajo preživetje v neugodnih razmerah, obenem pa služijo za razširjanje vrste na druga območja.

Na Pivških jezerih so bile do sedaj ugotovljene tri vrste vodnih bolh: *Daphnia obtusa*, *Biapertura affinis* in *Moina brachiata* (Brancelj & Gorjanc 2000). Čeprav ptiči trajna jajca uspešno prenašajo in se areal razširjenosti različnih vrst vodnih bolh širi, se vrstni sestav vodnih bolh z območja Pivških jezer ne prekriva s tistim iz podobnega habitata na Cerknškem jezeru. Na Pivških jezerih so bile najdene tri planktonske vrste, posamični primerki vrste *B. affinis* celo iz jamskega habitata. Čeprav so številni taksoni vodnih bolh ogroženi zaradi eutrofizacije ali strupenih snovi v okolju, pa so vse tri ugotovljene vrste iz Pivških jezer splošno razširjene in niso uvrščene na rdeči seznam ogroženih živalskih vrst v Sloveniji (Sket & Brancelj 1992).

**WATER FLEAS (Cladocera)**

Water fleas are small crustaceans, covered with a very thin shell and are found in huge numbers in the lakes, where they are a valuable food supply for many creatures. Cladocera are mostly freshwater inhabitants. Up to now 51 species of water fleas have been found to occur in the territory of Slovenia; two of them are marine species and two are endemic stygobionts (Brancelj 1996). Water fleas reproduce rapidly and have, particularly in lakes together with copepods, an important role in the energy flow and matter cycling.

In water fleas there are several generations per year. They are developed from eggs which are not fertilised by males (so-called parthenogenetic eggs). From eggs new young water fleas are developed, the majority being females. Each female produces several tens of such eggs during the summer. In the autumn, more and more males develop from non-fertilised eggs. They start to mate with females, and eggs produced by females get fertilised and their shells become harder. Before they are released, the female undergoes moult and part of the old carapace changes into a special envelope for additional protection of the fertilised egg. The whole structure is called the ephippium and is resistant to low and high temperatures and loss of water, and it provides additional mechanical resistance.

In total, three planktonic species of water fleas have been found in Pivka lakes: *Daphnia obtusa*, *Moina brachiata* and *Biapertura affinis*, the last one also from cave waters (Brancelj & Gorjanc 2000). Although birds successfully transmit resting eggs and different species of cladocerans can be found in wide region, it is interesting that species composition from the intermittent lake Cerknško jezero (about 30 km from Petelinjsko jezero) do not overlap with the species composition from Petelinjsko jezero (and other Pivka lakes). Like most crustaceans, water fleas are sensitive to poisonous substances in the environment. All three species found

## CEPONOŽCI (Copepoda)

Predstavniki ceponožnih rakcev so v Sloveniji zastopani s 107 vrstami in podvrstami, od katerih jih je skoraj polovica stigobiontov (Pipan 2005), torej poseljujejo različne podzemeljske vode. Pogosto imajo manjše areale in so že s tem bolj ogrožene. Poleg tega ima veliko število vrst ali podvrst iz te skupine v Sloveniji tipska nahajališča. Predvsem tam, kjer se pojavljajo množično, so pomemben člen v prehranjevalnih verigah. Vrste so ogrožene zaradi onesnaževanja vod.

Ceponožci, katerih telesna velikost se giblje med 0,2 in 2 mm, se praviloma razmnožujejo spolno, iz oplojenih jajčec. Za oploditev, ko samčev spermatofor pride v stik s samičino oploditveno odprtino, je potrebna ena ali več kopulacij. Oplojena jajčeca se običajno takoj izločijo v jajčno vrečko. Samica ima glede na pripadnost skupini eno ali dve jajčni vrečki, izjemoma se oplojena jaca brez predhodnje nošnje takoj sprostijo na podlago. Iz jajc se razvijejo ličinke navpliji, ki se preko navplijevih stadijev preobrazijo v kopepoditne stadije in odraslo žival. Razvoj je odvisen od temperature, zaloga hrane ter drugih okoljskih dejavnikov. Stigobiontske vrste imajo razvoj običajno počasnejši kot površinske vrste ter daljšo življenjsko dobo.

Ceponožni raki so na Pivških jezerih zastopani s sedmimi vrstami, ki spadajo v skupino Cyclopoida (Slika 2), ter dvema (*Arctodiaptomus laticeps*, *Diaptomus cyaneus*), ki spadata v skupino Calanoida. Vrsta *A. laticeps* je bila ugotovljena tudi na Cerknškem jezeru (Brancelj 2003), ki predstavlja s Petelinjskim jezerom najnižje ležeče nahajališče vrste v Evropi. V skupini Cyclopoida, katere predstavniki poseljujejo različne tipe neonesnaženih stalnih ali občasnih voda, si pozornost zasluži vrsta *Diacyclops charon*. *D. charon* je stigobiont, prvič opisan po primerkih iz Postojnske jame. Njegov areal razširjenosti sega do Tržaškega krasa na zahodu in do Like na vzhodu. V jamah Notranjskega in Primorskega krasa je relativno

in the Pivka lakes are generally distributed and locally abundant, so they are not included to the Red List of Endangered Species of Slovenia (Sket & Brancelj 1992).

## COPEPODS (Copepoda)

By the end of 2000 107 species and subspecies of free-living copepods had been found across the territory of Slovenia, of which almost half were subterranean species, stygobionts (Pipan 2005), limited to aquatic cave habitats. Many of these species are limited exclusively to the Slovene territory and/or have a type locality in Slovenia. Ecologically they are important links in the food chain. Copepods, particularly their subterranean species, are endangered by water pollution.

The usual length of adults is between 0.2 and 2 mm. Most copepods develop from fertilised eggs. Fertilisation consists in the attachment of the spermatophore by the male to the copulatory pore of the female. After copulation, sperm is stored in the female seminal receptacle; the eggs are fertilised and usually extruded into egg sacs. The female has one or two egg sacs, depending on the copepods group; egg sacs have never been found among some stygobiotic species of the harpacticoids and cyclopoids. In some cases eggs are, after fertilisation, immediately released onto the substratum. Free-living copepods go through six naupliar and six copepodite stages. The rate of development is strongly affected by temperature, food supply and other environmental conditions. Groundwater copepods develop slowly, consequently interstitial and stygobiotic species have longer life spans than surface relatives.

According to the data known up to now there are nine copepod species found in the Pivka lakes, from which seven belong to a group of Cyclopoida (Figure 2) and two are from a group of Calanoida (*Arctodiaptomus laticeps*, *Diaptomus cyaneus*). Species *A. laticeps* was discovered also in Cerknishko jezero (Brancelj 2003).



pogosta vrsta, vendar zaradi onesnaženosti podtalnice tudi ogrožena.



## ZAKLJUČKI

Poznavanje favne Pivških jezer je zelo nepopolno, kljub temu pa je bilo doslej ugotovljenih 18 vrst in podvrst nižjih rakov (Entomostraca) s tega območja (Brancelj & Gorjanc 2000). Med raki, najdenimi na območju Pivških jezer, je vrsta *C. croaticus* endemit, tri vrste (*C. croaticus*, *B. schafferi*, *D. cyaneus*) pa imajo tukaj edino znano nahajališče v Sloveniji. Čeprav sta vrsti iz skupine škrgonožcev (*B. schafferi*) in ceponožcev (*D. cyaneus*) relativno pogosti vrsti v Evropi, pa sta Petelinjsko in Veliko Drskovško jezero v Sloveniji trenutno edini znani nahajališči obeh vrst.

Skupina, ki je na Pivških jezerih zastopana z največjim številom vrst, so ceponožni raki. Po sestavi je favna značilna za manjša in plitvejša vodna telesa, čeprav je bil najden predstavnik iz rodu *Cyclops*, ki je eden najbolj značilnih planktonskih rodov, v večjih jezerih. Predstavniki skupin Cyclopoida in Calanoida so v zooplanktonu sladkovodnih jezer pogosto najštevilčnejši, kljub temu da sta abundanca in

Both lakes (Petelinjsko jezero and Cerknjsko jezero) are among the southernmost sites for this species in Europe. The most outstanding in the group of Cyclopoida is the stygobiontic species *Diacyclops charon*, first discovered in Postojnska jama. The range of species extends from north Italy to Lika in Croatia on the east. The species is relatively frequent in the caves of Notranjska and Primorska region, but is threatened due to its exposure to contaminants from the surface.

Slika 2: Samica ceponožnega raka iz skupine Cyclopoida iz Petelinjskega jezera (Foto: S. Polak).

Figure 2: Female of the cyclopoid copepod from Petelinjsko jezero (Photo: S. Polak).

## CONCLUSIONS

Until now the fauna of the Pivka lakes has been very little investigated and is more or less unknown, but 18 species and subspecies of freshwater lower crustacean (Entomostraca) have been found from this region (Brancelj & Gorjanc 2000). Among the crustaceans found from the Pivka lakes is one species *C. croaticus* endemic, and three species (*C. croaticus*, *B. schafferi*, *D. cyaneus*) have there the only known locality in Slovenia. Species from the group of fairy shrimps (*B. schafferi*) and copepods (*D. cyaneus*) are relatively frequent species in Europe, but Petelinjsko jezero or Veliko Drskovško jezero are the only two localities in Slovenia where these species were ever found.

The most abundant group registered at Pivka lakes was Copepoda. Such relatively rich species composition characterises, however, smaller, shallower water bodies. Nevertheless, species from genus *Cyclops*, characteristic of larger, permanent lakes, was also present. Cyclopoida and Calanoida are two major zooplankton groups in freshwater lakes, and often coexist. However, their abundance and species diversity generally differs (Ternje-Bukvič *et al.* 2001). On average, the number of cyclopoid species

diverziteta med skupinama različni (Ternjej-Bukvič *et al.* 2001). Po številu ciklopoidne vrste običajno presegajo kalanoidne vrste za faktor dva. Tak vzorec je značilen za jezera v osrednji Evropi in je posledica geomorfologije jezerske kotanje, stopnje produktivnosti ter pritiska ple-nilskih vrst. V splošnem vrstno razmerje kala-noidov proti ciklopoidom z evτροφikacijo upada (Ternjej-Bukvič *et al.* 2001).

Endemna vrsta in druge najdene redke vrste na Pivških jezerih ter še dokaj neraziskano področje, ki prav gotovo skriva veliko, morda tudi za znanost novih vrst, je dovolj močan argument za nadaljnja raziskovanja biodiverzitet ter trajno zaščito območja Pivških jezer.

in Central European lakes exceeds the number of calanoids by a factor of two. This pattern is related to lake morphology, productivity and predator pressure. It is generally believed that the ratio of calanoids – cyclopoids frequently declines with eutrophication (Ternjej-Bukvič *et al.* 2001).

Endemic species and other rare species from Pivka lakes, as well as insufficient knowledge about the distribution of taxa which inhabit Pivka lakes with potential new species that are still undiscovered or not described are very interesting ecological entities for future studies and the protection of the Pivka intermittent lakes.

## LITERATURA - REFERENCES

- Brancelj, A., 1996: Vodne bolhe (Crustacea: Cladocera) v celinskih vodah.- In: Narava Slovenije, stanje in perspektive. Društvo ekologov Slovenije, 238-241, Ljubljana.
- Brancelj, A. & N. Gorjanc, 1999: On teh presence of *Chirocephalus croaticus* (Steuer, 1899) in an intermittent lake in SW Slovenia.- *Hydrobiologia*, 412, 25-34, Den Haag.
- Brancelj, A. & N. Gorjanc, 2000: Vodni nevretenčarji in jamska favna.- In: Inventarizacija favne, flore in vegetacije Pivških jezer. Končno poročilo, Tome, D. (ed.), Nacionalni inštitut za biologijo, 16-19, Ljubljana.
- Brancelj, A., 2003: Škrgonožci, vodne bolhe ter ceponožci.- In: Jezero, ki izginja. Monografija o Cerknškem jezeru, Gaberščik, A. (ed.), Društvo ekologov Slovenije, 131-137, Ljubljana.
- Gaberščik, A. & O. Urbanc-Berčič, 2003: Ekosistem, ki ga ustvarja igra vode.- In: Jezero, ki izginja. Monografija o Cerknškem jezeru, Gaberščik, A. (ed.), Društvo ekologov Slovenije, 51-57, Ljubljana.
- Pipan, T., 2005: Epikarst - A Promising habitat. Copepod fauna, its diversity and ecology: A case study from Slovenia (Europe).- ZRC Publishing, Karst Research Institute ZRC SAZU, 101 pp, Ljubljana.
- Simičič, T. & A. Brancelj, 2000: Energy exploitation in *Chirocephalus croaticus* (Steuer, 1899) (Crustacea: Anostraca): survival strategy in an intermittent lake.- *Hydrobiologia*, 437, 187-163, Den Haag.
- Sket, B., 2003: Raki: Crustacea.- In: Živalstvo Slovenije, Sket, B., M. Gogala, V. Kuštor (eds.), Tehniška založba Slovenije, 188-224, Ljubljana.
- Sket, B. & A. Brancelj, 1992: Rdeči seznam ogroženih sladkovodnih nižjih rakov (Entomostraca: Anostraca, Cladocera, Copepoda, Ostracoda) v Sloveniji.- *Varstvo narave*, 17, 165-172, Ljubljana.
- Ternjej-Bukvič, I., M. Kerovec, Z. Mihaljevič, V. Tavčar, M. Mrakovčič & P. Mustafić, 2001: Copepod communities in karstic mediterranean lakes along the eastern Adriatic coast.- *Hydrobiologia*, 453/454, 325-333, Den Haag.
- Tome, D., 2000: Inventarizacija favne, flore in vegetacije Pivških jezer. Končno poročilo.- Nacionalni inštitut za biologijo, 36 pp, Ljubljana.