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NAJSTARIJI ŽIVUĆI FOSILI U LONJSKOM POLJU

Najstarijom živućom vrstom na Zemlji smatra se jedan od predstavnika skupine Notostraca, *Triops cancriformis*, budući da je *Triops* na ovom planetu od devona, od prije 350 milijuna godina. Na temelju fosilnih nalaza starih više od 200 000 godina, iz geološkoga razdoblja ordovicija, može se utvrditi da se vrste skupine Notostraca od tada morfološki nisu bitnije mijenjale. To znači da rakovi te skupine danas izgledaju vrlo slično kao što su izgledali u razdoblju kada su Zemljom hodali dinosauri.

Tijelo rakova te skupine izgrađeno je od ovalne leđne ljuske, na kojoj se nalaze dva sastavljena oka smještena jedno blizu drugog, poviše kojih je smješteno jednostavno građeno nauplijevo oko. Sastavljene oči su sjedilačke, bez očne stapke i smještene su na leđnoj površini glave, dok je nauplijevo oko položeno dublje unutar glave. Na svakoj polovici ljuske mogu se primijetiti i leđne žlijezde, koje su utisnute u ljusku a imaju osmoregulatornu ulogu. Leđna ljuska prekriva prednji dio tijela, dok stražnji dio tijela s nitastim nastavcima viri ispod ljuske.

Močvarni leđnoljuskaši žive u malim, najčešće povremenim lokvama koje nastaju zadržavanjem vode na površini tla nakon obilnih proljetnih kiša. Takve lokve mogu nastati u prirodnim depresijama poplavnih polja i pašnjaka ili u poplavnim šumama, te u udubljenjima uz ceste i putove. Na takvim staništima leđnoljuskaši pužu uz dno ili plivaju u stupcu vode. Takve lokve najčešće su bez riba, kao značajnih predatora ove skupine rakova. Kako sredinom ljeta, zbog visokih temperatura i smanjene količine oborina, lokve potpuno presuše, močvarni leđnoljuskaši su razvili specifičan način preživljavanja. Tijekom 24 sata, nakon punjenja lokava kišnicom, izuzetno velikom brzinom dolazi do rehidracije i izlijeganja jaja, koja su tijekom sušnoga razdoblja godine u površinskom sloju sedimenta. Iz jaja će se u svega nekoliko sati izleći ličinke - naupliji, koji su filtratori u stupcu vode. Rakovi se brzo presvlače, prolazeći kroz nekoliko nauplijskih stadija, uključujući i stadij metanauplija, te konačno do juvenilnog stadija, koji migrira prema dnu lokve, rujući ondje kako bi došli do hrane. U toj fazi razvoja rakovi imaju opći oblik koji će zadržati tijekom cijeloga života. Udvostručujući svakog dana svoju veličinu, tri dana stare jedinke već su duge 2 centimetra.

Rast i razvoj vrlo su brzi, pa spolnu zrelost postižu već nekoliko tjedana nakon izlijeganja. Za dva tjedna

THE OLDEST LIVING FOSSILS IN LONJSKO POLJE

A representative of the order Notostraca, *Triops cancriformis*, the tadpole shrimp, is considered the oldest living species on Earth, for *Triops* has been on the planet since the Devon, 350 million years ago. On the basis of fossil finds more than 200,000 years old, from the geological period of the Ordovician, it can be determined that species of the order Notostraca have not essentially changed in morphological terms since that period. This means that crustaceans of this period look very similar to the way they looked in the period when the dinosaurs were walking the earth.

The body of crustaceans of the species is built of an oval dorsal shell on which there are paired compound eyes located close to each other, above which is placed a simply built nauplius or median eye. The composed eyes are placed flat, without stalks, and located on the dorsal area of the head, while the median eye is placed deeper inside the head. On each half of the shell, dorsal glands can be perceived, impressed into the shell, having an osmoregulatory role. The dorsal shell covers the front part of the body, while the rear part of the body with its threadlike appendages pokes out from under the shell.

Marsh crustaceans live in small, often temporary pools that are created by water remaining on the ground after abundant spring rains. Such pools can be created in natural depressions of floodplains and pastureland or in riparian forests, as well as in concavities alongside roads and paths. In such habitats, the crustaceans crawl along the bottom or swim in the water column. Such pools mostly have no fish, important predators of this order of crustaceans. Since in mid-summer, because of the high temperatures and the reduction of the amount of rainfall, the pools dry up completely, the marsh crustaceans have developed a particular way of surviving. During the 24 hours after the pool is filled with rainwater, there is an enormously rapid rehydration and egg deposition, eggs that during the dry period stay in the surface layer of the sediment. In just a few hours the nauplius or larval form will emerge from the egg, filtering the water column. The crustaceans quickly moult, passing through a number of nauplian phases, including that of the metanauplius, and finally arrive at the juvenile stage, which migrates towards the bottom of the pool, burrowing there in order to find food. In this phase of development the crustaceans have the general form that they will retain throughout their lifetime. They double in size every day, and three day old individuals are already 2 cm long.

Growth and development are extremely fast, and

mogu doseći veličinu odrasle jedinke od oko 4 centimetra. Razvoj jedinka je najčešće partenogenetski, tj. nove jedinke razvijaju se iz neoplođenih spolnih stanica. Populacije s mužjacima vrlo su rijetke. Postizanjem spolne zrelosti, ženke, čije tijelo je još u razvoju, započinju polagati jaja, stvarajući pritom ljetna jaja s tankom ljuskom ili jaja s ljepljivom ljuskom, koja mogu preživjeti zamrzavanje i isušivanje. Ženke dnevno polože jedno «leglo», koje čini jednu ispražnjenu vrećicu, smještenu s trbušne strane tijela životinja, nastavljajući s punjenjem vrećice i polaganjem jaja sve do smrti, koja nastupa 2 do 4 tjedna nakon izlijeganja.

Ženke vrste *Lepidurus apus* obično polažu jaja na biljke koje rastu u lokvi, dok ženke vrste *Triops cancriformis* zatrpavaju jaja u gornje slojeve sedimenta. Pritom mogu odložiti nekoliko stotina jaja. S isušivanjem lokve, jaja ovih životinja dehidriraju i ostaju u stadiju mirovanja sve do sljedećega obilnijeg kišnog razdoblja, najčešće do sljedećega proljeća. Međutim, u ekstremnim uvjetima suše jaja mogu «čekati» u sedimentu i više od desetljeća. Jaja će se izleći u svega nekoliko dana nakon što su bila pod vodom, no jedan dio jaja se neće izleći. To je djelotvoran način održavanja populacije tijekom nepredvidivih fluktuacija okolišnih čimbenika. Dehidracija jaja tijekom sušnog dijela godine u vrste Triops cancriformis uvjet je da se iz njih mogu razviti rakovi tijekom idućega kišnog razdoblja, što nije uvjet za razvoj jaja vrste *Lepidurus apus*.

Leđnoljuskaši se hrane detritusom s dna povremenih lokvi, vješti su predatori, a zabilježen je i kanibalizam. Niz škrga, pokrećući se zajedno tijekom plivanja životinja, vrlo uspješno filtrira vodu bogatu planktonskim organizmima, ali i stružući obraštaj s površine vodenih biljaka i drugih predmeta uronjenih u vodi mogu pribaviti dostatne količine hrane. Na jelovniku leđnoljuskaša mogu se naći i ličinke vodenih kukaca, mnogočetinaši, pa čak i punoglavci.

Prije više od deset godina u lokvama Mokrog polja, u istočnom dijelu parka prirode Lonjsko polje, prvi put je zabilježen rak močvarni leđnoljuskaš *Lepidurus apus*, koji pripada skupini Notostraca. Potaknuti otkrićem da ti neobični rakovi nastanjuju lokve Mokrog polja, studenti Biološkog odsjeka Prirodoslovno-matematičkog fakulteta u Zagrebu, pod vodstvom svojih asistenata, krenuli su u potragu za neobičnim rakovima skupine Notostraca na drugim dijelovima parka prirode Lonjsko polje. Istraživanje je provedeno tijekom 2001. i 2002. godine, na središnjem i istočnom dijelu parka, pri

sexual maturity is achieved in just a few weeks after hatching. In two weeks they can attain the size of an adult individual, of about 4 cm. The development of individuals is mostly parthenogenic, i.e., the new individuals develop from unfertilised sex cells. Populations with males are very rare. Achieving sexual maturity, the females, the bodies of which are still in development, start to lay eggs, creating summer eggs with a thin shell or eggs with a sticky shell that can survive freezing and desiccation. The females deposit a “clutch” every day, with a single evacuation of the sac located on the ventral side of the body, going on with the filling of the sac and the deposition of eggs until they die, which occurs 2 to 4 weeks after ovipositing.

Females of the species *Lepidurus apus* usually deposit eggs on plants that grow in a pool, while females of the species *Triops cancriformis* bury their eggs in the upper layers of the sediment. They may deposit several hundred eggs in this way. When the pool dries out, the eggs of this animal are dehydrated and remain quiescent until the next major rainy period, most often the following spring. However, in extreme conditions of drought, the eggs can wait in the sediment more than a decade. The eggs will then hatch out in just a few days after being under water; however, some of the eggs will not hatch. This is an effective manner of maintaining the population during unexpected fluctuations in environmental factors. The dehydration of eggs during the dry part of the year in the species Triops cancriformis is a condition for the crustaceans being able to develop from them during the next rainy period, which is not a development condition for eggs of the species *Lepidurus apus*.

These crustaceans feed on detritus from the bottoms of the occasional pools and are adroit predators, while cannibalism too has been recorded. The series of gills, moving together while the animal is swimming, are very good at filtering water rich in planktonic organisms, but also scraping the growths from the surface of the water plants and other items submerged in the water they can also obtain good quantities of food. Also on the menu are the larvae of water beetles, polychaeta and even tadpoles.

More than ten years ago, in the pools of Mokro Polje, in the eastern part of Lonjsko Polje Nature Park, for the first time, the marsh crustacean *Lepidurus apus* was recorded; this belongs to the order Notostraca. Prompted by the discovery that these unusual crustaceans inhabit the pools of Mokro Polje, students of the Biology Department, Natural Sciences Faculty of Zagreb University, led by the assistants of the department, set off in search of unusual crustaceans of the order Notostraca in other parts of Lonjsko Polje Nature Park. The research was carried out in 2001 and 2002, in the central and eastern parts of the park, during which it was established that in the temporary pools of Lonjsko

čemu je utvrđeno da u povremenim lokvama Lonjskog polja žive čak dvije vrste leđnoljuskaša: vrsta Lepidurus apus, koja je i prije zabilježena na Mokrom polju, i *Triops cancriformis*, vrsta koja je prvi put zabilježena u parku prirode Lonjsko polje.

Pojavljivanje i sastav rakova skupine Notostraca u Lonjskom polju djelomično su ovisni o hidrološkom režimu staništa, temperaturnim uvjetima i kemizmu vode. Budući da je vrsta *L. apus* prilagođena životu na nižim temperaturama, obično se pojavljuje početkom proljeća, krajem veljače i tijekom ožujka, a životni ciklus završava već sredinom svibnja, iako vode u lokvi još ima. Za razliku od *L. apus*, vrsta *T. cancriformis* prilagođena je životu na višim temperaturama i podnosi veće oscilacije temperature vode pa se pojavljuje tijekom travnja, a zadržava sve do isušivanja lokve.

Razlike u razdoblju plavljenja i porijeklu voda na pojedinim staništima utječu na sastav predstavnika skupine Notostraca u Lonjskom polju. Lokva u kojoj je zabilježena vrsta *L. apus*, osim oborinskom vodom, puni se i podzemnim vodama. U lokvi koju nastanjuje *L. apus* dno prekriva listinac na kojem raste mahovima, dok je dno lokava koje nastanjuje *T. cancriformis* s listincem i muljem ili samo glinovito. Jedna je od lokava na području Mužilovčice povremeno plavljena depresija, nadsvođena krošnjama vrbe i pojedinačnim stablima hrasta, i čini stanište obiju vrsta. Susjedna lokva, koja je slabo zasjenjena, stanište je samo vrste *Triops cancriformis*. Pojavljivanje obje vrste identične veličine u istoj lokvi rijetka je pojava u Europi i zato je važan nalaz za Lonjsko polje. U takvim slučajevima stenotermnija vrsta Lepidurus apus ranije započinje odlagati jaja.

Važan je čimbenik u rasprostranjivanju predstavnika skupine Notostraca u Lonjskom polju ispaša krava i prisutnost svinja koje znatno pridonose raznošenju trajnih jaja. No zasigurno u tome sudjeluju i ptice.

Rezultati istraživanja skupine Notostraca na području parka prirode Lonjsko polje potvrdili su prisutnost močvarnih leđnoljuskaša na tom području, za što zasigurno ima povijesnih razloga, a to je proglašenje Lonjskog polja parkom prirode prije 13 godina. Osim potvrde prisutnosti skupine Notostraca u Lonjskom polju s čak dvije vrste, ovim je istraživanjem utvrđena velika biološka raznolikost povremenih stajačica kojima je potrebno posvetiti posebnu pozornost i brigu da bi se očuvale i zaštitile. Potreba za zaštitom skupine Notostraca i njihovih staništa odraz je prilika i trenda, kako u mnogim europskim zemljama, tako i u Hrvatskoj, a uvjetovana je razvojem poljoprivrede uz uporabu umjetnih gnojiva, herbicida i pesticida, promjenom

Polje there are actually two kinds of crustacean: the species Lepidurus apus, which was previously recorded in Mokro Polje, and *Triops cancriformis*, a species recorded for the first time in Lonjsko Polje Nature Park.

The occurrence and composition of crustaceans of the order Notostraca in Lonjsko Polje are partially dependent on the hydrological regime of the habitat, the temperature conditions and the chemistry of the water. Since the species *L. apus* is adapted to life at lower temperatures, it commonly appears at the beginning of spring, at the end of February and during March, finishing its life-cycle in mid-May, although there is still water in the pools. Unlike *L. apus*, the species *T. cancriformis* is adapted to life at higher temperatures and tolerates greater oscillations in water temperature, and appears during April, staying there right until the drying of the pool.

Differences in the period of inundation and in the origin of the water in given habitats have an impact on the composition of the representatives of the order Notostraca in Lonjsko Polje. the pool in which *L. apus* is recorded, apart from consisting of rainwater, can also be filled from subterranean water. In a pool in which *L. apus* lives, the bottom is covered by leaf mould on which moss grows, while the bottom of puddles inhabited by *T. cancriformis* has leaf mould or mud, or is only clay. One of the pools in the area of Mužilovčica is an occasionally flooded depression, arched over by the crowns of willows and the occasional trunks of oaks, and this is a habitat for both species. The neighbouring pool, which is poorly shaded, is habitat only for the species *T. cancriformis*. The occurrence of both species of identical size in the same pool is a rarity in Europe and so the finding in Lonjsko Polje is rather important. In such cases the stenothermic species Lepidurus apus starts depositing its eggs earlier.

An important factor in the distribution of representatives of the order Notostraca in Lonjsko Polje is the grazing of cows and the presence of pigs, which contribute quite substantially to the dissemination of these enduring eggs. However, birds must take part in this as well.

The results of the research into the order Notostraca in the area of Lonjsko Polje Nature Park have confirmed the presence of marsh crustaceans in this area, for which there must be historical reasons, which include the proclamation of Lonjsko Polje a nature park 13 years ago. Apart from the confirmation of the two species of the order Notostraca in Lonjsko Polje, the investigation also substantiated the great biological diversity of the temporary standing pools to which special attention needs to be devoted, with care for their preservation and protection. The need to protect the order Notostraca and its habitats is a reflection of the conditions and trends, in many European countries

vodnog režima u obliku isušivanja močvarnih staništa, kanaliziranja vodotoka i gradnje akumulacija, različitim oblicima onečišćenja, zaraštavanjem te nizom drugih neposrednih ili posrednih devastacija. Smanjenje broja močvarnih područja koja poplavljuju u proljetnim mjesecima jedan je od kritičnih razloga ugroženosti rakova skupine Notostraca jer je njihov razvoj, kao i cijeli životni ciklus, isključivo prilagođen na povremeno plavljenje lokava i depresija i nestabilne uvjete okoliša.

Rezultati ovog istraživanja ujedno su potaknuli daljnja istraživanja rasprostranjenosti i ekologije ovih rakova na području cijele Hrvatske kako bi novim spoznajama pridonijeli njihovoj uspješnijoj zaštiti kao i zaštiti njihovih staništa.

and in Croatia as well, conditioned by the development of agriculture with the use of artificial fertilisers, herbicides and pesticides, the change in the water regime in the shape of the drainage of the marshland habitats, the channelling of the water courses and the construction of reservoirs, various forms of pollution, overgrowth and a number of other immediate or indirect kinds of devastation. A reduction of the number of wetland areas that are inundated in the spring months is one of the critical reasons for the endangerment of crustaceans of the order Notostraca, because their development and the whole of their life-cycle is exclusively adapted to the occasional inundation of pools and depressions and unstable environmental conditions.

The results of this investigation have also prompted further research into the distribution and ecology of these crustaceans in the area of the whole of Croatia, in order to contribute with new knowledge to the more successful protection of them and of their habitats.

Triops cancriformis, leđnoljuskaš prvi put zabilježen i u Lonjskom polju (foto: K. Žganec) /
Triops cancriformis, crustacean recorded the first time in Lonjsko Polje (photo: K. Žganec)

Triops cancriformis s jasno uočljiva dva sjedilačka oka i trećim nauplijevim okom (foto: K. Žganec) /
Triops cancriformis with clearly visible two flat eyes and the third nauplius or median eye (photo: K. Zganec).

Šumska lokva na području Mužilovčice tijekom proljetnih poplava. Stanište obje vrste skupine Notostraca u Lonjskom polju (foto: K. Žganec). / Forest pool in the area of Mužilovčica during the spring floods. This is a habitat of both species of the order Notostraca in Lonjsko Polje. (Photo: K. Žganec).

Lokva na području Mužilovčice prije proljetnih poplava (foto: K. Žganec) /
Pool in the Mužilovčica area before the beginning of the spring rains. (Photo: K. Žganec).

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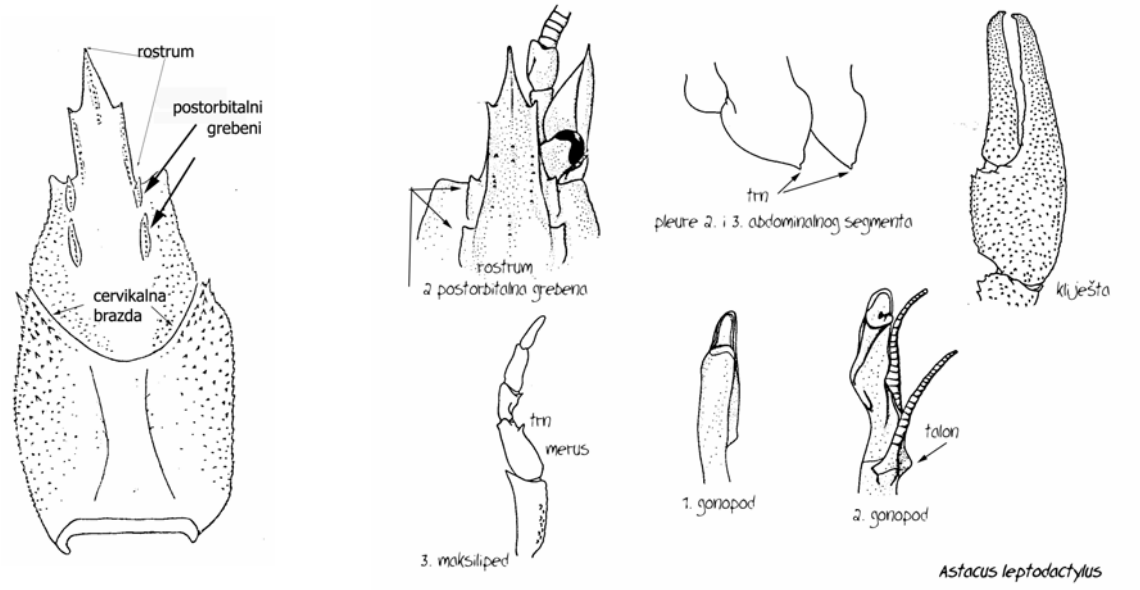
NALAZ VRSTE ASTACUS LEPTODACTYLUS NA PODRUČJU PARKA PRIRODE LONJSKO POLJE

Vrsta *Astacus leptodactylus* (uskoškari rak, barski rak, turski rak) (**slika 1**) jedna je od pet autohtonih vrsta slatkovodnih deseteronožnih rakova iz porodice Astacidae koji naseljavaju europske kopnene vode. A. leptodactylus je prirodno rasprostranjen u europskom dijelu Azije i u istočnoj Europi. Unesen je u neke zemlje zapadne Europe, a širi se prirodnim vodenim putovima na zapad. Za razliku od drugih europskih Astacidae, ta je vrsta aktivna i danju i noću, pa je i unos hrane u organizam veći, što uzrokuje i brži rast no u drugih europskih vrsta. Jedinke mogu narasti do 30 cm ukupne duljine, ali najčešće su dugački do 15 cm (Köksal, 1988.). Variraju u obliku tijela i boji, ali prevladavaju žutosmeđe do maslinastozelene životinje, s bjelkastom ventralnom stranom. Na **slici 2** prikazane su karakteristike prema kojima se vrsta određuje. Rakovi imaju dva para postorbitalnih grebena, s dobro izraženim trnovima (posebno prvi par), a i inače upada u oči velika trnovitost te vrste, posebno iza cervikalne brazde. Abdominalne pleure na vrhu završavaju oštrim trnom. Rostrum je vrlo dugačak, a rostralni trnovi su veliki i šiljati. Dobro istaknuta rostralna rebra mogu biti paralelna, ali i konkavna. Rostrum između rostralnih rebara je duboko žlijebasto izdubljen. Kliješta su jako uska s produljenim prstima. Na nepokretnom prstu kliješta nema udubljenja, iako postoje relativno slabo razvijeni granični trnovi, koji u drugih vrsta okružuju ta udubljenja. U mužjaka su prsti kliješta produljeni i mnogo duži nego u ženka. Kod regeneriranih kliješta prsti su znatno kraći. Prvi par gonopoda ima nesimetričan vrh, dok drugi par ima na bazi dobro razvijen talon. Merus trećeg maksilipeda nosi 1 - 3 dobro razvijena trna. Mužjaci i ženke postaju spolno zreli u trećoj godini života (dužina od 7,5 do 8,5 cm). Broj jaja varira s veličinom ženke, u rasponu od 200 do 800. Sezona parenja je u listopadu i studenom kad temperatura vode padne na 7 - 12°C, a ženke legu jaja 4 - 6 tjedana poslije. Ženke nose jaja 5 - 6 mjeseci (u južnim dijelovima Europe), odnosno 6 - 8 mjeseci u sjevernim dijelovima. Nakon izlijeganja, juvenilni rakovi ostaju sa ženkom do 25 dana i presvuku se jedanput pa zatim započinju samostalno živjeti.

A FIND OF THE SPECIES ASTACUS LEPTODACTYLUS IN THE AREA OF LONJSKO POLJE NATURE PARK

The species *Astacus leptodactylus* (Turkish or Galician crayfish) (**Figure 1**) is one of the five indigenous species of fresh-water decapod crustaceans from the family Astacidae that inhabit European terrestrial waters. A. leptodactylus is naturally distributed in the European part of Asia and in Eastern Europe. It has been introduced into some of the countries of Western Europe and has spread through the natural water routes to the west. Unlike the other European Astacidae, this species is active diurnally and nocturnally, and the input of food into the organism is greater, which means that it grows faster than other European species. Individuals can grow up to 30 cm overall length, but are most commonly up to 15 cm long (Koksal, 1988). They vary in body shape and colour, but yellow-brown and olive-green animals predominate, with a whitish ventral side. **Figure 2** shows the characteristics according to which the species can be determined. The crustaceans have two pairs of post-orbital ridges, with well expressed spines (particularly the first pair), with actually the great spininess of the species being very apparent, especially after the cervical groove. The abdominal pleurae finish at the top with a sharp spine. The rostrum is very long, and the rostral spines are large and pointed. The well expressed rostral ribs can be parallel or concave. The rostrum between the rostral ribs is concave like a deep groove. The claws are very narrow with extended fingers. On the unmoveable finger (dactyl) of the claw there is no concavity, although there are relatively weakly developed marginal spines, which in some other species do surround these concavities. In the males the fingers of the claws are extended, much longer than in the females. In regenerated claws, the dactyls are considerably shorter. The first pair of gonopods has an asymmetrical top, while the second pair has a well developed talon at the bottom. The merus of the third maxilliped bears 1 - 3 well developed spines. Males and females become sexually mature in their third year of life (length from 7.5 to 8.5 cm). The number of eggs varies with the size of the female, ranging from 200 to 800. The mating season is in October and November when the temperature of the water drops to 7 - 12°C, and the females lay their eggs 4 - 6 weeks later. The females carry the eggs 5 - 6 months in the southern parts of Europe and 6 - 8 months in the north. After hatching, the juvenile crayfish remain with the female up to 25 days and moult once and then start living independently.



Slika 2

Figure 2

U svibnju 1999. godine na području parka prirode Lonjsko polje, između Krapja i Puske, mr. sc. Darko Kovačić je sakupio ostatke rakova za koje smo utvrdili da pripadaju vrsti *Astacus leptodactylus*. To je bio prvi službeni nalaz te vrste u Hrvatskoj i potaknuo je istraživanje astakofaune na području parka. Cilj projekta je istražiti raprostranjenost te i eventualno drugih vrsta u vodama na području parka te godišnju dinamiku populacije, nametnike i bolesti na rakovima. Istraživanja su započeta u rano proljeće 2003. godine i do sada su istraženi neki fiziološki parametri rakova (broj hemocita, indeks kondicije…) te je utvrđena prisutnost epibionata iz porodice Branchiobdellidae kao i, prvi put u Hrvatskoj, prisutnost endoparazita Psorospermium haeckeli, čiji je taksonomski položaj i način širenja u europskih Astacidaea još zagonetan.
Prema literaturnim podacima (Karaman, 1929.), u rijeci Savi je živjela vrsta *Astacus astacus* (riječni ili plemeniti rak). Kako tijekom ovog istraživanja nismo utvrdili prisutnost riječnog raka na području parka, pretpostavljamo da ju je *A. leptodactylus* potisnuo zapadnije ili da je ta vrsta izumrla u rijeci Savi (bolesti, onečišćenja) i da ju je zamijenio otporniji turski rak.

In May 1999, in the area of Lonjsko Polje Nature Park between Krapje and Puska, Darko Kovačić MSc collected the remains of crustaceans that we at once identified as belonging to the species Astacus leptodactylus. This was the first official find of the species in Croatia, and prompted research into the crayfish fauna in the park. The objective of the project was to investigate the distribution of this and any other species in the waters in the park and the annual population dynamics, parasites and sicknesses on the crayfish. The research started early in 2003 and so far some physiological parameters of the crayfish have been explored (number of hemocytes, condition index) and the presence of epibionts from the family of Branchiobdellidae have been determined, as well as, for the first time, the presence of the endoparasite Psorospermium haeckeli, the taxonomic position of which and manner of dissemination in the European Astacidaea are still enigmatic.
According to data from the literature (Karaman, 1929) the species Astacus astacus (noble/Danube crayfish) used to live in the Sava River. Since during this investigation we did not determine the presence of the Astacus astacus in the park, we assume that A. leptodactylus has driven it further to the west, or that the species has become extinct in the Sava (sickness, pollution) and that it has been replaced by the more resistant Turkish crayfish.

Slika 1 Turski rak (Astacus leptodactylus)

Figure 1. Turkish crayfish (Astacus leptodactylus)

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FAUNA TRČAKA NA RAZLIČITIM KOPNENIM STANIŠTIMA KRAPJE ĐOLA

SAŽETAK

Mnoga su močvarna područja u sjevernoj i srednjoj Europi zbog melioracije i regulacije vodotokova ili potpuno nestala ili znatno smanjena. Zato je sve manja i ukupna biološka raznolikost. Kako su u Hrvatskoj istraživanja faune beskralježnjaka - pa tako i kukaca - oskudna, odlučili smo istražiti faunu trčaka s rubnih dijelova Krapje đola, staroga rukavca Save. Trčke smo standardnim metodama sakupljali godinu dana u različitim tipovima vegetacije. Pronašli smo 61 vrstu trčaka, koje, uglavnom, pripadaju srednjoeuropskoj i istočnoeuropskoj fauni.

UVOD

Močvarna staništa na području srednje i zapadne Europe, kao i flora i fauna koja se u njima razvija, najvećim su dijelom u gusto naseljenim područjima, s intenzivnom poljoprivredom. U Europi su mnoga takva staništa već nestala, što je utjecalo i na rasprostranjenost flore i faune. Kako su trčci jedna od onih skupina koje u srednjoj i sjevernoj Europi služe kao bioindikator, željeli smo odrediti faunistički sastav vrsta oko Krapje đola, močvarnoga područja, otprije poznatog po posebnoj važnosti za ptice močvarice. Krapje đol je u zoni ekstenzivne poljoprivrede i stočarstva, a okružen je većim dijelom degradiranim staništima. Osim uskoga pojasa prirodne vegetacije samoga đola, u okolici su obradiva polja i livade košanice, kao i sastojine neofitskih vrsta. Iako su trčci karnivorne vrste i ne ovise izravno o sastavu vegetacije nekoga područja, njihova brojnost i sastav vrsta u uskoj su vezi s količinom herbivornih i saprofagnih vrsta kojima se hrane. Stoga smo htjeli utvrditi broj vrsta trčaka i njihovu zoogeografsku pripadnost u ovako rascjepkanom okolišu.

Trčci - brojnost i rasprostranjenost

Trčci (lat. Carabidae) su jedna od najbrojnijih porodica reda kornjaši (Coleoptera) i razreda kukci (Insecta). Rasprostranjeni su na cijeloj Zemlji, s velikim brojem vrsta i jedinka. Procjena broja vrsta trčaka razlikuje se od autora do autora, pa

CARABIDAE FAUNA IN DIFFERENT TERRESTRIAL HABITATS OF KRAPJE ĐOL

SUMMARY

Many of the wetland areas in northern and central Europe because of land reclamation or engineering operations on the watercourses have either completely disappeared or been very much reduced in area. For this reason their total biological diversity is constantly on the decline. Since research into invertebrate fauna is in rather short supply and hence research into insects as well we decided to investigate the Carabidae or ground beetle fauna on the verges of Krapje đol, a Sava oxbow. We collected the beetles for a year by the standard methods in various kinds of vegetation. We collected 61 species of Carabidae, which on the whole are part of the fauna of Central Eastern Europe.

INTRODUCTION

Wetland habitats in Central and Western Europe, like the flora and fauna that grow in them, are mostly located in densely populated areas with intensive agriculture. In Europe many such habitats have already disappeared, which has impacted the distribution of flora and fauna. Since ground beetles are one of the groups that are used as bioindicators in Central and Northern Europe, our aim was to determine the faunistic composition of the species around Krapje đol, a marshy area, previously known to be of particular importance for waterfowl. Krapje đol is in an area of extensive agriculture and animal husbandry, and is surrounded very largely by degraded habitats. Except for in a narrow zone of natural vegetation of the oxbow itself, there are in the surrounds arable fields and hay meadows, as well as vegetation units of neophyte species. Although ground beetles are carnivorous species and do not directly depend on the composition of the vegetation of a given area, their abundance and the composition of species is tightly correlated with the quantity of herbivorous and saprophagous species upon which they prey. For this reason we wished to determine the number of ground beetle species and their zoogeographic affiliation in such a dissected environment as this.

Ground beetles their abundance and distribution

The ground beetles (Carabidae) are one of the most numerous families of the order of coleopterans (Coloeoptera), class of the insects (Insecta). They are distributed world-wide, with a large number of species and individuals. The estimate of how many ground beetles there are varies from writer to writer,

KRYZHANOVSKY (1983) govori o 25.000 vrsta, a THIELE (1977) drži da taj broj doseže i 40.000. U odraslom i ličinačkom obliku trčci su edafski organizmi, što znači da provode život na površini ili u različitim slojevima tla (THIELE, 1977; TRAUTNER I GEIGENMÜLLER, 1987). Naseljavaju različita staništa: od podzemnih do gornjih slojeva tla livada, oranica, stepa, savana, pustinja i šuma. Trčci su osobito osjetljivi na promjene u temperaturi i vlazi površinskih slojeva tla, pa su to dva osnovna ekološka čimbenika koji utječu na rasprostranjenost pojedinih vrsta (THIELE, 1977). Uglavnom su noćni (nokturalni) organizmi, a njihovo je tijelo najčešće tamno obojeno, ponekad metalnoga sjaja. Mali je broj dnevnih (diuralnih) vrsta, a one su uglavnom živo obojene.

Značaj trčaka u hranidbenoj mreži

S obzirom na veliku brojnost, trčci su značajni organizmi u hranidbenoj mreži, u različitim ekosustavima. Većina vrsta je polifagna, a samo ih je nekoliko oligofagnih (THIELE, 1977). Samo rijetke vrste trčaka, npr. iz rodova *Amara* i *Harpalus*, hrane se isključivo biljem te se mogu razmnožiti u nekim poljoprivrednim kulturama gdje nanose velike štete. Većina vrsta su karnivori, a neke su omnivori.
Hrane se plijenom različite veličine. Najčešće su to puževi, gujavice, ličinke drugih kukaca i skokunci. No, mnogobrojne karnivorne vrste u pojedinim razvojnim fazama upotpunjuju svoju prehranu gljivama, sjemenkama, voćem i drugim dijelovima biljaka. Trčci imaju važnu ulogu kao predatori ličinačkih i odraslih stadija kukaca na poljoprivrednim dobrima ili u šumama. Hraneći se njima, utječu na gustoću populacija tih vrsta, pa se rabe u biološkoj kontroli gospodarski štetnih vrsta. No, trčci su važni u hranidbenoj mreži i kao hrana drugim životinjama. Osobito su bitni u prehrani tamnoprsoga ježa (*Erinaceus europeus Linnaeus*) za kojega se, prema nekim istraživanjima (THIELE, 1977), pretpostavlja da pojede najviše trčaka. Ličinačkim oblicima trčaka hrane se rovke (vrste porodice *Soricidae*). Veliki šišmiš (*Myotis myotis Borkhausen*) prehranjuje se u rano proljeće, nakon hibernacije, jedino trčcima jer drugoga plijena i nema. Trčci mogu biti i plijen manjih životinja, poput mrava i pauka (THIELE, 1977).

Trčci kao bioindikatori

Istraživanjem brojnosti i dinamike populacija trčaka bave se brojni stručni i znanstveni radovi što je

with KRYZHANOVSKY (1983) speaking of 25,000 species, and THIELE (1977) saying that the number will actually reach 40,000. In the adult and larval forms the ground beetles are edaphic organisms, which means that they spend their lives on the surface of or within various layers of the soil (THIELE, 1977; TRAUTNER AND GEIGENMULLER, 1987). They colonise various habitats: from the subterranean to the surface layers of the soils of meadows, arable fields, steppes, savannahs, deserts and forests. Ground beetles are particularly sensitive to changes in temperature and humidity in the surface layers of the soil; these are the two basic ecological factors that affect the distribution of given species (THIELE, 1977). On the whole they are nocturnal organisms, and their bodies are mostly dark coloured, sometimes with a metallic shine. There is a small number of diurnal species, which are on the whole bright coloured.

The importance of ground beetles in the food network

Considering their great abundance, ground beetles are important organisms in the food network in various ecosystems. Most of the species are polyphagous, while only a few of them are oligophagous (THIELE, 1977). Only rare species of ground beetle, for example from the genera *Amara* and *Harpalus*, feed only on plants, and they can reproduce in some agricultural crops on which they accordingly inflict enormous damage. Most of the species are carnivorous, and some of them are omnivorous.
They feed on prey of various sizes. The most frequent prey consists of snails, worms, larvae of other insects, and springtails. But numerous carnivorous species in certain phases of their development do supplement their diet with fungi, seeds, fruit and other parts of plants. They have an important role as predators of the larval and adult stages of insects on farmlands or in forests. Feeding on them, they affect the population density of such species, and are used in the biological control of economically harmful species. But they are also important in the food chain as food for other animals. They are particularly essential in the food of the hedgehog (*Erinaceus europeus Linnaeus*), which in some investigations have been hypothesised to feed mainly on ground beetles. Shrews (species of the family *Soricideae*) feed mainly on larval forms of ground beetles. The bat (*Myotis myotis Borkhausen*) feeds in early spring, after hibernation, exclusively on ground beetles because there is actually no other prey. Ground beetles can also be the prey of smaller animals, such as ants and spiders (THIELE, 1977).

Ground beetles as bioindicators

Many review and research articles have dealt with the numbers and population dynamics of ground

pridonijelo da se ta skupina upotrebljava u primijenjenim istraživanjima vezanim uz procjenu područja za zaštitu. Trčci su dobri ekološki indikatori, jer na njihove vrste i populacije snažno utječu promjene uvjeta na staništu. Stoga brojne vrste služe kao indikatori održivoga iskorištavanja terestričkih staništa (EYER I LUFF, 1990), osobito vodenih i vlažnih, koja su danas diljem Europe ugrožena, te im je potrebna dobra strategija razvoja i očuvanja prirodnoga bogatstva (CASALE, 1990). Dobri su indikatori zbog ovih svojstava: rasprostranjeni su na svim terestričkim staništima, mogu se sakupljati standardiziranim metodama (lovne posude), taksonomija cijele grupe je ustaljena, a vrste se mogu razmjerno lako odrediti (KIRBY, 1992). Tako se mogu rabiti - a neke vrste se i rabe - u istraživanjima vezanim uz zaštitu prirode i evaluaciju staništa (MAELFAIT I DESENDER, 1990).

Zaštita trčaka

Glavni su razlozi smanjene gustoće populacije i brojnosti vrsta trčaka u svijetu hidromelioracijski procesi, intenzivna poljoprivredna proizvodnja, upotreba biocida, što u konačnici pretvara prirodna staništa u antropogeno utjecana staništa (CASALE, 1990; TRAUTNER I GEIGENMÜLLER, 1987). Intenzivni melioracijski radovi i reguliranje tekućica na prostoru Europe tijekom posljednja dva stoljeća doveli su do nestanka mnogih močvarnih staništa. Melioracijom su stvorena poljoprivredna tla osrednje kakvoće, a rijeke više ne mogu stvarati brojne meandre, značajne za njihove donje tokove. Nestanak močvarnih staništa uzrokovao je i nestanak mnogih biljnih i životinjskih vrsta. Stoga je jedinstvena riječna nizina Save, s bogatim i raznolikim biljnim i životinjskim svijetom, izuzetno vrijedan i osebujan prirodni krajolik. Veliki je nedostatak što zaštita prirode i vrsta u pojedinim dijelovima Europe (TRAUTNER I GEIGENMÜLLER, 1987), a i u nas, nije dosegla važnost kakvu ima na području sjeverne, središnje i zapadne Europe.

Istraživanje trčaka Krapje đola

Fauna trčaka kontinentalne Hrvatske, pa time i parka prirode Lonjsko polje slabo je poznata. Iako su u prošlosti brojni domaći i strani entomolozi sakupljali kornjaše na području kontinentalne Hrvatske, a neki su, poput Josipa Schlosera Klekovskog, Antuna Korlevića, Viktora Apfelbecka i Franje Koščeca, ostavili i velike zbirke, malo je pisanih radova o

beetles, which has led to this group being used in applied research connected with the appraisal of areas for the purpose of conservation. Ground beetles are good ecological indicators, for changes in habitat conditions have a profound impact on species and populations. For this reason, many species are indicators of the sustainable use of terrestrial habitats (EYER AND LUFF, 1990), and particularly of aquatic and wetland habitats, which are endangered today throughout Europe, and need a good strategy for development and the preservation of their natural richness (CASALE, 1990). What makes them such good indicators lies in the following characteristics: they are distributed over all terrestrial habitats; they can be collected with standardised methods (pot traps), the taxonomy of the whole group is settled, and the species can be relatively easily identified (Kirby, 1992). Thus they can be and some are used in research concerning nature conservation and habitat evaluation (MAELFAIT AND DESENDER, 1990).

Protection of ground beetles.

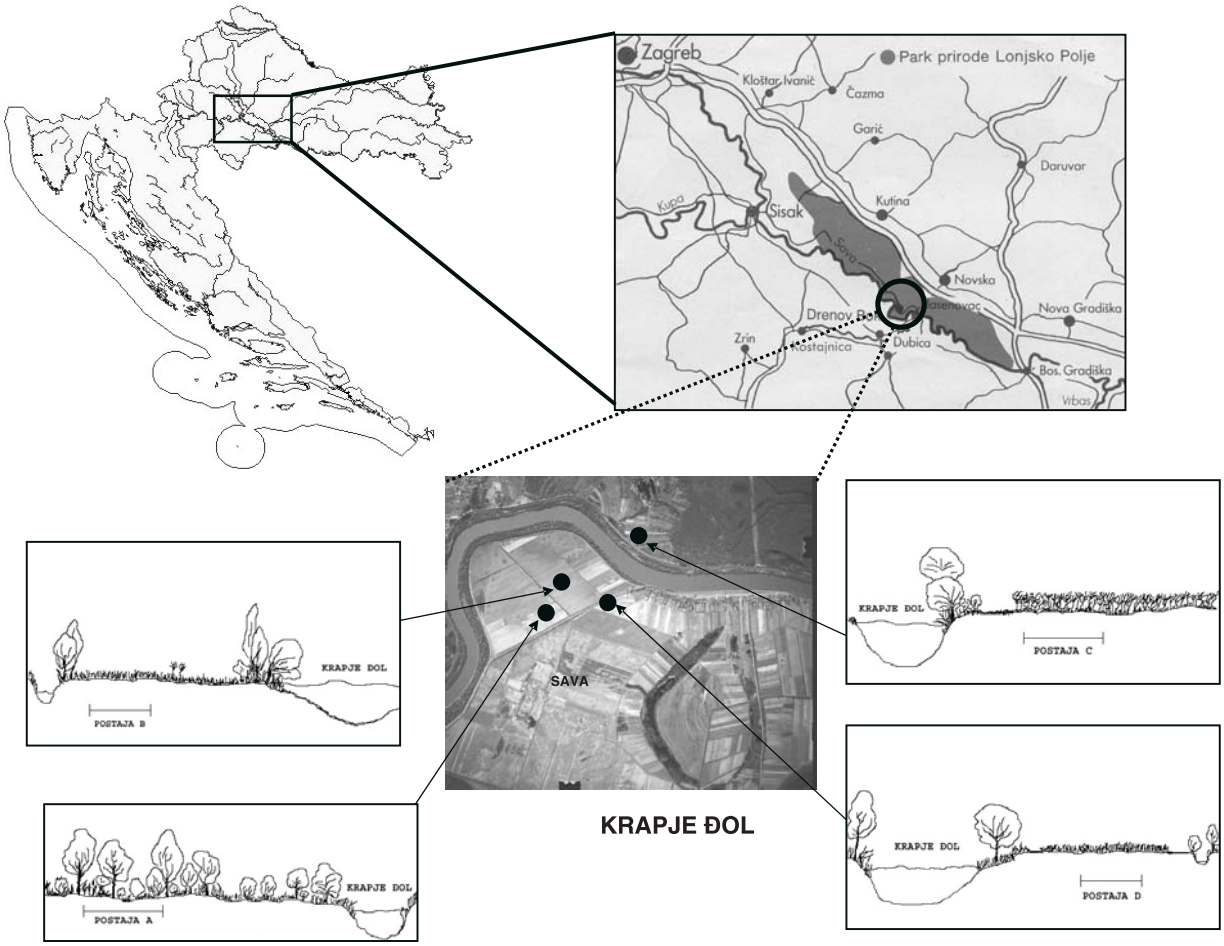
The main reasons for the diminution of population densities and the abundance of species of ground beetles all over the world are river engineering and reclamation, intensive agriculture, and the use of biocides, which ultimately is turning natural habitats into anthropogenically impacted habitats (CASALE, 1990; TRAUTNER AND GEIGENMÜLLER, 1987). Intensive land reclamation and engineering operations on streams in Europe have over the last two centuries led to the disappearance of many wetland habitats. The reclamation operations have created agricultural soils of mediocre quality, and the rivers can no longer create their many meanders, characteristic of lower courses. The vanishing of marshy habitats has led to the disappearance of many plant and animal species. For this reason the river plain of the Sava is unique, with its rich and diverse plant and animal world, its exceptionally valuable and distinctive natural landscape. It is a great drawback that nature and species protection in some parts of Europe (TRAUTNER AND GEIGENMÜLLER, 1987), including in this country, has not achieved the level of importance that it has in the area of northern, central and western Europe.

Investigation of the ground beetles of Krapje đol

The ground beetle fauna of inland Croatia, including of course Lonjsko Polje Nature Park, is little known. Although in the past many domestic and foreign entomologist collected coleopterans in the area of inland Croatia, some of them, such as JOSIP SCHLOSER KLEKOVSKI, ANTUN KORLEVIć, VIKTOR APFELBECK AND FRANJO KOščEC, having left large collections, few papers have been written on their observations and finds of species. If we do not take into consideration preliminary

njihovim zapažanjima i nalazima vrsta. Ako ne uzmemo u obzir preliminarna istraživanja (DURBEŠIĆ I SUR., 2000), sustavna istraživanja faune trčaka ovih nizinskih područja nisu provedena u posljednjih stotinjak godina (APFELBECK, 1904; SCHLOSER KLEKOVSKI, 1877-1879). Jedan od ciljeva provedenog istraživanja, rezultati kojega su izneseni u ovom radu, bilo je utvrditi faunu trčaka na nekoliko različitih staništa Krapje đola. Izabrane su četiri međusobno vegetacijski različite postaje (postaja A, B, C i D). Postaje su smještene u neposrednoj blizini močvarnog područja, staroga rukavca rijeke Save (slika 1). Geografska udaljenost istraživanih postaja nije velika pa su pedološki i geološki uvjeti slični. Razlika među njima je u različitim tipovima vegetacije pa je zasjenjenost tla na tim postajama različita, a to mijenja i mikroklimatske uvjete na staništu. Naime, s obzirom na snažnu insolaciju, nastaju promjene u temperaturi i vlazi površinskih slojeva tla, na što su trčci osobito osjetljivi (EYRE I LUFF, 1990; THIELE, 1977).

research (DURBEšIć ET AL., 2000), systematic research into the ground beetle fauna of these lowland areas has not been carried out in the last hundred or so years (APFELBECK, 1904; SCHLOSER KLEKOVSKI, 1877-1879). One of the aims of the research undertaken, the results of which are given in this work, was to determine the ground beetle fauna in several different habitats of Krapje đol. Four habitats differing in vegetation were selected (stations A, B, C. and D). The stations were all situated in the immediate vicinity of the marshy area, an oxbow of the Sava River (Fig. 1). The physical distance of the stations investigated is not great and the soil and geological conditions are similar. The difference among them is in the various kinds of vegetation, hence the degree of shade of the ground is also different, which conditions the microclimatic conditions in the habitat. Strong insolation, that is, will produce changes in the temperature and humidity of the surface layers of the soil, to which ground beetles are particularly sensitive (EYRE AND LUFF, 1990; THIELE, 1977).



Slika 1: Zemljopisni položaj istraživanih postaja na području Krapje đola
Figure 1: Geographical position of the stations investigated in the area of Krapje đol.

Postaja A smještena je na neplavljenom jugozapadnom rubu rukavca Krapje đola i na njoj je razvijena asocijacija *Corno-Ligustretum* Ht. 1956, zajednica grmlja visokoga najviše 3 - 4 m. Riječ je o prirodnoj vegetaciji u čijem se flornom sastavu razvijaju naše autohtone vrste grmova i zeljastih biljaka.

Zapadna strana rukavca je niža i razvedenija, zastupljena obnovljenim pašnjačkim površinama. Na toj strani nalazi se postaja B. Ta postaja je zapuštena oranica u sukcesiji, koja nije obrađivana ni košena u posljednje tri do četiri godine. Na postaji se razvila sastojina neofitske vrste *Erigeron annuus* (L.) Pers., koja se obično razvija kao pionirska zajednica na površinama zapuštenih oranica. Srednja je visina vegetacije oko 80 cm. Gustoća sastojine nije velika. Na postaji ima i pojedinačnih grmova neofitske vrste *Amorpha fruticosa* Linnaeus, koji dosežu visinu od 130 do 140 cm.

Postaja C smještena je na sjeveroistočnoj strani Krapje đola. Na toj je postaji razvijena sastojina neofitske vrste *Amorpha fruticosa*, koja je ujedno dominantna i jedina vrsta u sloju grmlja. Grmovi vrste *Amorpha fruticosa* su visoki oko 3 m. U prizemnom je sloju malen broj vrsta, a prevladavaju one iz roda *Rubus* i neofit *Solidago gigantea Aiton*, dok sve ostale vrste nalazimo samo pojedinačno.

S istočne strane, na malo uzdignutom terenu u odnosu na ostale postaje, Krapje đol je omeđen livadama i manjim privatnim parcelama na kojima se uzgajaju različite ratarske kulture. Upravo je na toj strani smještena postaja D, na kojoj nalazimo zajednicu neofitske vrste *Erigeron annuus* u početnom stadiju razvitka. Naime, površina sastojine je još godinu prije provedenog istraživanja služila kao oranica.

MATERIJALI I METODE

Rezultati ovoga rada temelje se na terenskim i laboratorijskim istraživanjima. Terenska istraživanja trajala su od 8. travnja 2000. do 10. travnja 2001.

Na postajama A, B i C primijenjena je metoda lovnih posuda, danas jedna od najznačajnijih u istraživanju kvantitativnih odnosa faune tla, osobito predatorskih vrsta, kao što su trčci (THIELE, 1977; POWELL I SUR., 1996). Na tim postajama postavljeno je po deset plastičnih posuda volumena 0,5 dm^3. Glatke stijenke posuda smanjile su mogućnost bijega upalim jedinkama. Posude su ukopane do gornjega ruba u tlo i natkrivene krovićima od stiropora da bi se zaštitile od oborina. Posude su do trećine bile ispunjene tekućinom (vinski ocat, etanol i voda u jednakim

Station A is situated in the southwest corner of the Krapje đol oxbow, out of the reach of flood waters, where the association *Corno-Ligustretum* Ht. 1956 grows, a community of shrubs about 3 4 m high at most. This is natural vegetation in the floral composition of which indigenous Croatian bushes and herbaceous plants grow.

The western side of the oxbow is lower and more irregular, with revived pastureland areas. On that side lies station B. This station is an abandoned ploughed field in the succession; it has not been mown or cultivated for the last three or four years. At this station a vegetation unit of the neophyte species *Erigeron annuus* (L.) Pers., has developed; this usually grows as a pioneering community on areas of abandoned plough-land. The mean height of the vegetation is about 80 cm. The vegetation unit is not very dense. There are some individual bushes of the neophyte species *Amorpha fruticosa* Linnaeus, which reaches a height of 130 to 140 cm.

Station C is located on the northeast side of Krapje đol. At this station a vegetation unit of the neophyte species *Amorpha fruticosa* has developed; this is at once the only and the dominant species in the frutescent layer. Shrubs of the species false indigo, *Amorpha fruticosa*, are about 3 m high. There are few species in the epigeal layer, those from the genus *Rubus* and the neophyte *Solidago giganetea Aiton* dominating, while other species can be found only in individuals.

On the east, on ground slightly elevated as compared with the other stations, Krapje đol is surrounded by meadows and small privately owned plots on which various arable crops are grown. It is on this side that station D is situated; on it we can find the community of the neophyte species daisy fleabane, *Erigeron annuus*, in the early stage of development. For the area of this vegetation unit was just a year before the investigation still used as plough-land.

MATERIALS AND METHODS

The results of this paper are based on field and laboratory investigations. Field research lasted from April 8 2000 until April 10 2001.

At stations A. B. and C we applied the pitfall trap method, today one of the most important methods in the exploration of the quantitative relations of the ground fauna, particularly predatory species such as ground beetles (THIELE, 1977; POWELL ET AL., 1996). At these stations ten plastic pitfall traps with a volume of 0.5 dm3 were positioned. The smooth sides of the traps reduced the possibility that individuals that had fallen in could escape. The traps were dug in to the soil up to their rims, and covered with polystyrene lids to protect them from rainfall. The pots were filled one third of the way up with a liquid (wine vinegar, ethanol and water in equal volume ratios), which served as attractant and

volumnim omjerima) koja je služila kao atraktant i konzervans. Da bi se smanjila površinska napetost tekućine, dodana je kap deterdženta neutralna mirisa. Zbog moguće pojave visokih voda na području istraživanja, posude su 6 cm ispod gornjeg ruba probušene tankom iglom. Uzorci su tijekom vegetacijske sezone sakupljani svaka dva tjedna, a od studenoga 2000. do travnja 2001. svaka tri tjedna, dakle, na postajama A, B i C sakupljeni su tijekom 21 terenskog izlaska.

Na postaji D primijenjena je metoda ponovnog ulova. Metoda ponovnog ulova sastoji se u tome da se žive jedinke trčaka upalih u posude označe kako bi se razlikovali od neuhvaćenih jedinka populacije. Budući da je cilj primijenjene metode uloviti žive jedinke trčaka, posude nisu bile ispunjene konzervansom. Postavljeno je 100 lovnih posuda istoga volumena kao na postajama A, B i C. Posude su postavljene u mrežu 10×10 m i međusobno udaljene jedna od druge 1 m. Rub posude nalazio se u visini s okolnom zemljom. Istraživanje je trajalo od 8. travnja do 8. listopada 2000., uz 43 izlaska na teren. Sakupljanje uzoraka na postaji D obavljano je u pravilnim razmacima svaka dva tjedna, a svaki izlazak na teren trajao je tri dana. Tijekom ta tri dana posude su bile otvorene pa su u njih upadali različiti predstavnici beskralježnjaka i kralježnjaka. Svaka dvadeset i četiri sata posude su pregledane. Ulovljene jedinke trčaka su sakupljene i određene. Tijekom svibnja i rujna na teren se izlazilo svakoga tjedna zbog intenzivne aktivnosti trčaka.

Određivanje vrsta porodice trčaka (Carabidae) obavljeno je pomoću dihotomskih ključeva iz sljedeće literature: TRAUTNER I GEIGENMÜLLER (1987), WACHMANN I SUR. (1995), CSIKI (1946), GANGLBAUER (1892) I SCHATZMAYR (1942). Za određivanje pripadnosti vrste višim sistematskim kategorijama porodice i roda primijenjena je sistematika prema KRYZHANOVSKIJ I SUR. (1995).

Utvrđene vrste trčaka na području Krapje đola analizirane su prema zoogeografskoj pripadnosti i ekološkim zahtjevima pojedinih vrsta, prema tome kakve uvjete vlage i temperature zahtijeva vrsta za razvoj. Zoogeografska područja određena su prema WINKLERU (1924-1932) i RATTIJU I SUR. (1998), a ekološke skupine na temelju relevantnih europskih literaturnih podataka (iz BOHÁČ I FUCHS, 1994., prema LOHSE I LUCHT, 1989; GEORGES, 1994; KEGEL, 1994; NYILAS, 1994; THIELE, 1977 i WACHMANN I SUR., 1995).

preservative. To reduce the surface tension of the liquid, a drop of neutrally smelling detergent was added. Because of the possible appearance of high water in the investigation area, 6 cm below the lower edge the traps were perforated with a narrow needle. During the vegetation season the samples were collected every two weeks and from November 2000 to April 2001 every three weeks; that is, at stations A, B and C they were collected during 21 field trips.

At station D the recapture method was used. The recapture method consists of live individuals of beetles that have fallen into the pots being marked in order to distinguish them from previously uncaptured individuals of the population. Since the objective of the method employed was to capture live specimens of beetles, the pots were not filled with preservative. One hundred traps of the same volume as at stations A, B and C were positioned. They were placed in a grid of 10 x 10 m, the distance between the pots being 1 m. The rims of the pots were at the level of the surrounding ground. The investigation lasted from 8 April to 8 October 2000 and involved 43 field trips. The collection of the samples at Station D was done in regular intervals every two weeks, and each field trip lasted three days. During these three days the pots were open and various specimens of vertebrates and invertebrates fell into them. Every twenty-four hours, the pots were inspected. The ground beetle specimens caught were collected and identified. During May and September, field trips were made every week in response to vigorous ground beetle activity.

Determination of the species of the family of ground beetles (Carabidae) was carried out with the assistance of the dichotomous keys from the following literature: TRAUTNER AND GEIGENMüLLER (1987), WACHMANN ET AL. (1995), CSIKI (1946), GANGLBAUER (1892) AND SCHATZMAYR (1942). For the determination of the affiliation of species to higher systematic categories of family and genus the systematics of KRYZHANOVSKI ET AL., was used (1995).

The ground beetle species identified in the area of Krapje đol were analysed according to zoogeographic affiliation and the ecological requirements of given species, according to what kind of humidity and temperature conditions the species needed for development. Geographic areas were determined according to Winkler (1924-1932) and RATTI ET AL.,(1998) while ecological groups were identified according to the relevant European literature data (from BOHAč AND FUCHS, 1994 and according to LOHSE AND LUCHT, 1989; GEORGES, 1994; KEGEL, 1994; NYILAS, 1994; THIELE, 1977 and WACHMANN ET AL).

REZULTATI

Na području Krapje đola, tijekom jednogodišnjeg istraživanja na postajama A, B i C te šestomjesečnog istraživanja na postaji D, utvrđena je 61 vrsta trčaka, od čega je 55 vrsta određeno do vrste, a 6 do roda. U tablici 1 navedene su vrste koje su svrstane u četiri skupine, prema učestalosti pojavljivanja na istraživanim postajama. Svim istraživanim postajama zajedničko je četrnaest vrsta. Te su vrste svrstane u prvu skupinu (tab. 1). Drugu skupinu čini deset vrsta koje su zabilježene na tri postaje (tab. 1). Vrste koje su zabilježene na dvije postaje pripadaju trećoj skupini, a ta skupina obuhvaća 9 vrsta. Istraživanjima su utvrđene i diferencijalne vrste, koje dolaze samo na jednoj postaji, a izostaju na drugima. Od ukupnog broja vrsta trčaka (61 vrsta), 28 vrsta dolazi samo na jednoj od istraživanih postaja.

S obzirom na uvjete staništa ekološka valencija euritopnih vrsta je široka, a u ovom istraživanju zabilježene su 32 euritopne vrste trčaka (tab. 1). Deset vrsta su stenotopne te imaju usku ekološku valenciju i zahtijevaju određene mikroklimatske uvjete u tlu. Higrofilnih vrsta je 16, a kserofilnih 13. Tri vrste su termofilne, a pet vrsta je kserotermofilno. Za 13 vrsta nisu pronađeni literaturni podaci o mikroklimatskim uvjetima koje te vrste preferiraju na staništu, a šest vrsta je određeno samo do roda i za njih nisu prikazani ekološki podaci.

Zoogeografska rasprostranjenost određena je za 49 vrsta trčaka i prikazana je u tablici 1. Sve vrste utvrđene ovim istraživanjem rasprostranjene su na palearktičkom području.

RESULTS

In the area of Krapje đol, during a year-long investigation at stations A, B and C and a six-month-long investigation at Station D, 61 species of ground beetle were identified, of which 55 were identified to species level, and 6 to genus level. Table 1 shows all the species, which we classified into four groups according to frequency at the stations investigated. Fourteen species were common to all the investigated stations. These species were put into the first group (Table 1). The second group consists of ten species that were recorded at three stations (Table 1). Species that were recorded at two stations belong to Group 3, and this group covers nine species. The research also determined differential species that came to one station but were absent at others. Of the total number of species recorded (61 species), 28 species came to only one of the stations investigated.

Considering the habitat conditions the ecological valence of eurytopic species was broad, and in this investigation, 32 eurytopic species of beetles were discovered (Table 1). Ten species were stenotopic and had a narrow ecological valence and required certain microclimatic conditions in the soil. There were 16 hygrophilous and 13 xerophilous species. Three species were thermophilous and five were xerothermophilous. No literature data were found about the microclimatic conditions preferred at the habitat for 13 of the species, and six species were determined only as far as genus and no ecological data are shown for them.

The zoogeographic distribution has been identified for 49 ground beetle species, and is shown in Table 1. All species determined in this research are distributed over the Palaearctic area.

Tablica 1: Trčci (Carabidae) različitih tipova staništa oko Krapje đola. Legenda: 1. skupina - vrste zabilježene na sve četiri postaje, 2. skupina - vrste zabilježene na tri postaje, 3. skupina - vrste zabilježene na dvije postaje, 4. skupina - vrste zabilježene na jednoj postaji.

Table 1. Ground beetles (Carabidae) of various types of habitat around Krapje đol. Key: Group 1 species recorded at all four stations; Group 2 species recorded at three stations; Group 4 species recorded at two stations; Group 4 species recorded at once station.

	VRSTA	OBILJEŽJA VRSTA	PODRUČJE RASPROSTRANJENOSTI
1. SKUPINA	*Badister bipustulatus* Fabricius, 1792	stenotopna, higrofilna	Europa Mediterranea Sibiria
	Brachinus crepitans Linnaeus, 1758	euritopna, kserotermofilna	Regio palaeartica
	Brachinus ganglbaueri Apfelbeck, 1904	stenotopna, termofilna, higrofilna	Asia Mediterranea orientalis
	Carabus cancellatus Illiger, 1798	euritopna	Regio palaeartica
	Harpalus diffinis Dejean, 1829	termofilna	Europa centralis Mediterranea Caucasus
	Harpalus luteicornis Duftschmid, 1812		Europa centralis borealis Caucasus Sibiria
	Harpalus neglectus Serville, 1821	kserofilna	Europa Caucasus
	Harpalus progrediens Schauberger, 1929		Europa centralis
	Leistus ferrugineus Linnaeus, 1758	euritopna, kserotermofilna	Europa
	Poecilus cupreus Linnaeus, 1758	euritopna, kserotermofilna	Europa Asia
	Poecilus cursorius Dejean, 1828	euritopna	Hungaria Europa meridionalis
	Pterostichus melanarius Illiger, 1798	euritopna, higrofilna	Europa centralis borealis Sibiria
	Pterostichus melas Creutzer,1799	euritopna	Europa centralis Caucasus
	Trechus quadristriatus Schrank, 1781	euritopna, kserofilna	Turanico Europa Mediterranea
2. SKUPINA	*Bembidion sp.1*		
	Bembidion sp.2		
	Carabus granulatus Linnaeus, 1758	euritopna, higrofilna	Europa centralis borealis
	Chlaenius nigricornis Fabricius, 1787	euritopna, higrofilna	Europa Asia
	Harpalus distinguendus Duftschmid, 1812	kserofilna	Regio palaeartica
	Harpalus rufipes De Geer, 1774	euritopna, kserotermofilna	Regio palaeartica
	Microlestes fisuralis Reitter, 1900	stenotopna	Mediterranea orientalis Asia centralis
	Platynus dorsalis Pontoppidan, 1763	euritopna	Europa Asia Marocco
	Pterostichus ovoideus Sturm, 1824	euritopna	
	Stomis pumicatus Panzer, 1796	euritopna, higrofilna	Europa Caucasus Asia minor
3. SKUPINA	*Acupalpus meridianus* Linnaeus, 1758	euritopna, kserofilna	Europa
	Agonum livens Gyllenhal, 1810	euritopna	Europa centralis borealis Sibiria
	Amara sp.		
	Bembidion properans Stephens, 1828		
	Callistus lunatus Fabricius, 1775	kserotermofilna	Europa centralis borealis Sibiria
	Carabus clathratus auraniensis Linnaeus, 1761	stenotopna, higrofilna	Dalmatia Europa centralis borealis
	Clivina fossor Linnaeus, 1758	euritopna, higrofilna	Europa Asia
	Harpalus rupicola Sturm, 1818	euritopna	Europa centralis Mediterranea
	Pterostichus vernalis Panzer, 1796	euritopna, higrofilna	Regio palaeartica
4. SKUPINA	*Agonum marginatum* Linnaeus, 1758	euritopna, higrofilna	Europa
	Agonum viridicupreum Goeze, 1777		Europa centralis Asia orientalis
	Amara aenea De Geer, 1774	euritopna, kserofilna	Regio palaeartica
	Amara aulica Panzer, 1797	euritopna	Europa Asia
	Amara eurynota Panzer, 1797	euritopna, kserofilna	Europa Mediterranea Sibiria
	Badister sodalist Duftschmid, 1812	stenotopna, higrofilna	Europa Mediterranea orientalis
	Badister sp.		
	Bembidion inoptatum Schaum, 1857	stenotopna, higrofilna	
	Bembidion obliquum Sturm, 1825	euritopna, higrofilna	
	Brachinus explodens Duftschmid, 1812	stenotopna	
	Cicindela germanica Linnaeus, 1758	euritopna, kserofilna	Europa Asia
	Dyschirius sp.		
	Harpalus puncticollis Paykull, 1798		Europa Caucasus Sibiria
	Harpalus aenus Fabricius, 1792	euritopna, kserofilna	Europa Asia
	Harpalus cordatus Duftschmid, 1812	stenotopna, termofilna	Europa centralis borealis Sibiria
	Harpalus dimidiatus Rossi, 1790	euritopna	Europa centralis meridionalis Transcaucasus
	Harpalus oblitus Dejean, 1829		Mediterranea orientalis,
	Harpalus smaragdinus Duftschmid, 1812	euritopna, kserofilna	Europa Asia occidentalis
	Harpalus sp.		
	Harpalus tardus Panzer, 1797	euritopna, kserofilna	Europa Asia
	Metabletus obscuroguttatus Duftschmid, 1812	stenotopna,	Europa Mediterranea
	Microlestes minutulus Goeze, 1777	euritopna, kserofilna	Europa Asia
	Olistophus rotundatus Paykull, 1798	kserofilna	Europa centralis borealis Caucasus
	Panageus crux-major Linnaeus, 1758	stenotopna, higrofilna	Europa Asia Marocco
	Pterostichus angustatus Duftschmid, 1812	kserofilna	Europa centralis borealis Caucasus Sibiria
	Pterostichus niger Schaller, 1783	euritopna, higrofilna	Europa Asia minor
	Pterostichus taksonyis Csiki, 1930		
	Stenolophus teutonus Schrank, 1781	euritopna, higrofilna	Europa Mediterranea Transcaspia

RASPRAVA

Smještaj Krapje đola u nizinskom dijelu Hrvatske, kojeg čini aluvijalna ravan ispunjena pleistocenskom glinom i praporom te recentnim nanosom, a vegetacija najvećim dijelom izmijenjena djelovanjem čovjeka, temeljni su čimbenici koji su utjecali, i još utječu, na sastav faune trčaka Krapje đola. Utjecajem čovjeka nekadašnja nepregledna područja poplavnih šuma i livada svedena su na manje površine, što uzrokuje usitnjavanje staništa, a to se osobito odražava u nestajanju nekih vrsta koje trebaju velike areale za održavanje brojnosti populacije. Rubni dijelovi tih površina, kao i poljoprivredne površine prepuštene sukcesiji u posljednjih dvadesetak godina često zaraštavaju neofitskim vrstama, kao što je *Amorpha fruticosa*. Iako su utjecaji na životinje lakše uočljivi na većim organizmima, osobito na pticama i sisavcima, oni su jako izraženi i u fauni beskralježnjaka.

Lonjsko polje, zbog značenja svojih močvara i različitih tipova staništa, izloženih periodičnim poplavama, te zbog bogatstva flore i faune, upisano je na Ramsarski popis močvara od međunarodnoga značaja (RADOVIĆ, 1999). Međutim, koliko je fauna kralježnjaka poznata, toliko je fauna beskralježnjaka ovog područja nepoznata. Rascjepkanost i raznolikost staništa upućuje na mogućnost razvoja različitih vrsta trčaka, pa smo ovim istraživanjima željeli istražiti samo neke od najčešćih kopnenih staništa.

Kornjaši su među najbolje istraženim beskralježnjacima u Hrvatskoj. Međutim kad bi danas netko pokušao napraviti katalog bilo koje porodice iz reda kornjaša, zatekao bi se pred velikim problemom. U Hrvatskoj je, prema katalogu DROVENIK I PEKS, 1994. utvrđena 561 svojta trčaka. Uvidom u taj katalog i pregledom vrsta koje su zabilježene u susjednim državama, lako je pretpostaviti da je broj vrsta trčaka u Hrvatskoj daleko veći nego što je dosad poznato. Razlog je u tome što su dosadašnja istraživanja trčaka bila usmjerena najviše na krški dio naše zemlje jer se tamo stalno otkrivaju nove i endemične vrste, zanimljive s različitih aspekata znanosti. Zato svako istraživanje u kontinentalnom dijelu Hrvatske pridonosi povećanju našega znanja o broju vrsta i njihovoj rasprostranjenosti.

Velika brojnost vrsta trčaka istraživanih tipova staništa posljedica je antropogenog utjecaja na samom staništu. S obzirom na to da je područje oko Krapje đola agrarno te da ga okružuju njive na kojima se uzgajaju ratarske kulture, livade košanice na

DISCUSSION

The situation of Krapje đol in the lowland part of Croatia, consisting of an alluvial plain filled with Pleistocene clay and loess and recent sediments, the vegetation being almost entirely modified by human activities, are the basic factors that have affected and are still affecting the composition of the ground beetle fauna of Krapje đol. By anthropogenic factors, the once vast areas of riparian forests and water meadows have been reduced to smaller areas, which has resulted in the fragmentation of the habitats, particularly manifested in the disappearance of some species that need large ranges to keep up their population numbers. The fringes of these areas, and the agricultural areas abandoned to the succession in the last score of years have often been overgrown with neophyte species such as *Amorpha fruticosa*. Although the impact on animals is easier to observe with respect to larger organisms, particularly birds and mammals, they are also highly manifested in the invertebrate fauna.

Lonjsko Polje, because of the importance of its marshes and various kinds of habitats, exposed to periodical inundation, and because of the richness of its flora and fauna, has been placed on the Ramsar List of wetlands of international importance (RADOVIC, 1999). However, as much as the vertebrate fauna of the area is familiar, so much is the invertebrate fauna unknown. The fragmentation and diversity of habitats indicates the possibility of the development of various species of beetle, and in this research we wished to explore some of the most frequent terrestrial habitats.

Coleopterans are among the best investigated invertebrates in Croatia. However if today someone were to attempt to make a catalogue of any one of the families of the order of Coleoptera they would be confronted with a major problem. According to the catalogue of DROVENIK AND PEKS of 1994, 561 taxa of ground beetle have been identified in Croatia. By looking into this catalogue and by considering the species that have been recorded in neighbouring countries, it can easily be hypothesised that the real number of ground beetle species in Croatia is much greater than has been determined to date. The reason for this is that all previous research into ground beetles has been oriented towards the karst area of the country, because it is there that new and endemic species of interest from various aspects of science are constantly being discovered. For this reason, every investigation in the inland part of the country contributes to an increase in our knowledge about the number of species and their distribution.

The large numbers of species of beetles of the types of habitat investigated is the consequence of the anthropogenic impact on the habitat itself. Considering that the area around Krapje đol is agrarian and that it is surrounded by fields on which arable crops are growing, hay meadows on which livestock grazes, it is clear that human activity has

kojima pase stoka, čovjek svojom djelatnošću znatno utječe na živi svijet ovoga područja, uzrokujući promjene uvjeta na staništu. Prema istraživanjima MOSSAKOWSKOG I SUR. (1990), protivno očekivanjima, utvrđeno je da se degradacijom staništa povećava broj vrsta, a razlog je u povećanju raznolikosti staništa. Stoga veći broj ulovljenih vrsta su ubikvisti koji naseljavaju različita staništa, pa i agrarna područja.

Iako je ovo istraživanje trajalo godinu dana, može se sa sigurnošću pretpostaviti da bi se za idućih istraživanja otkrile u fauni trčaka Krapje đola još neke nove vrste. Usporedbom vrsta trčaka iz roda *Carabus*, koje su utvrđene ovim istraživanjem, s vrstama ovoga roda koje se na ovom području mogu očekivati prema literaturnim podacima (PAVIČEVIĆ I SUR., 1997) može se pretpostaviti veći broj vrsta. Tako se, na primjer, u Lonjskom polju očekuju dvije vrste koje prema IUCN-u pripadaju kategoriji ugroženih vrsta, a to su *Carabus nemoralis* Müller i *C. auronitens* Palliardi. Također, upotrebom dodatne metode, lovom na svjetlosne mamce, broj vrsta trčaka iz potporodica Bembidinae i Trechinae bi se povećao. Vrste tih potporodica love se u malom broju lovnim posudama te najviše nedostaju u rezultatima provedenog istraživanja. Izostajanje manjih vrsta trčaka, poput ovih, tumači se njihovom sposobnošću izbjegavanja zamke (LUFF, 1975), sposobnošću percipiranja ruba posude (HALSALL I WRATTEN, 1988) te mogućnošću bijega iz posude (iz THIELE, 1977, prema PETRUšKA, 1969). Osim toga, provedenim istraživanjima nisu obuhvaćeni svi tipovi staništa.

Trčci su osjetljivi na razlike u mikroklimatskim uvjetima na staništu. Jedan od najvažnijih čimbenika što će utjecati na rasprostranjenost trčaka u različitim staništima svakako je vlaga (THIELE, 1977). Higrofilne vrste preferiraju vlažna staništa, a - za razliku od njih - kserofilne i kserotermofilne vrste preferiraju suha staništa u kojima je koncentracija vlage u tlu mala. Zasigurno se postavlja pitanje kako ovako dvije oprečne skupine životinja mogu koegzistirati na istom staništu. Naime, vrste koje imaju različite mikroklimatske zahtjeve mogu naseljavati isto stanište, a razlog tome je struktura tla (CASALE, 1990). Tla na području Krapje đola pripadaju hidromorfnim (semiterestričkim) tlima, od kojih su najzastupljenija močvarno glejna tla s podtipovima hipoglejno, epiglejno i amfiglejno. Neka od tih tala su pod izravnim utjecajem poplavnih voda, a vlaže se, ovisno o tipu, površinskim ili podzemnim vodama (MAYER, 1992). Ta tla imaju visoki postotak

had a considerable effect on the biosphere of this area, involving modification of habitat conditions. According to the investigations of MOSSAKOWSKI ET AL., (1990), in despite of expectations, it has been determined that the degradation of habitats leads to an increase in the number of species, the reason being the increase in the diversity of habitats. For this reason quite a large number of species captured are ubiquists that populate different kinds of habitats, including agrarian areas.

Although this investigation lasted a year, it can be concluded with certainty that in future research still more new species would be discovered in the ground beetle fauna of Krapje đol. By comparison of the species of ground beetle from the genus *Carabus*, as determined in this research, with the species of this genus that could be expected in the area according to the data from the literature (PAVIČEVIĆ ET AL, 1997), a larger number of species can be hypothesised. Thus, for example, two species that according to the IUCN belong to the category of endangered species, to wit *Carabus nemoralis* Muller and *C. autonitens* Palliardi can be expected to be found in Lonjsko Polje. In addition with the use of the additional method of catching with luminous bait the number of ground beetles from the sub-families Bembidinae and Trechinae would be increased. Species of these subfamilies are caught in a small number of pots and are those that are most deficient in the results of the research carried out. The absence of smaller species of ground beetles such as these is interpreted by their ability to avoid traps (LUFF, 1975), their ability to perceive the edge of the trap (HALSALL AND WRATTEN, 1988) and their capacity to escape from the pitfall trap (from THIELE, 1977, according TO PETRUšKA, 1969). Apart from that, not all kinds of habitat were covered by the research undertaken.

Ground beetles are sensitive to differences in habitat microclimatic conditions. One of the most important factors influencing the distribution of ground beetles in various different habitats is certainly humidity (THIELE, 1977). Hygrophilous species prefer moist habitats, while, unlike them, xerophilous and xerothermophilous species like dry habitats in which there is little concentration of humidity in the ground. The question must certainly arise as to how completely opposed groups of animals can coexist in the same habitat. Species that have different microclimatic demands can certainly populate the same habitat, the reason being the structure of the soil (CASALE,1990). The soil in the area of Krapje đol belongs to the hydromorphic (semiterrestrial) kinds of soil, the most common of which is the marshy gley soil with its subtypes of hypogley, epigley and amphigley. Some of these soils are directly impacted by flood waters, and are also humid because of, depending on the type, surface or subterranean waters (MAYER, 1992). These soils have a high

gline zbog čega se tijekom kišnih razdoblja, što znači zimi, u rano proljeće i kasnu jesen, voda zadržava u tlu. Tada su tla bogata vlagom i u ulovu prevladavaju higrofilne vrste trčaka. U kasno proljeće i ljeti ta tla se djelovanjem sunca i izostankom oborina suše. Posljedica je da se na vanjskoj površini stvaraju čvrste pokorice, koje ako je godina sušna, mogu raspucati i dubinu tla. U suhom stanju su ta tla jako zbijena i tvrda (SCHNEIDER-JACOBY I ERN, 1993). U kasno proljeće i ljeto, dakle, količina vlage u tlu je mala, što pogoduje kserofilnim i kserotermofilnim vrstama koje tada prevladavaju u ulovu (KRIŽANIĆ, 2002).

Velik broj higrofilnih vrsta upućuje na blizinu močvarnoga staništa. Trčci su izrazito pokretne vrste koje kao ličinke mogu živjeti na malo povišenijem suhom staništu, a kao odrasle jedinke u razdoblju povoljne vlažnosti mogu osvajati nova područja na kojima ima hrane. Osim toga, mnoge vrste u odraslom stadiju mogu i letjeti, iako to čine rijetko zbog velikog utroška energije (THIELE, 1977). No, let im omogućuje privremeni boravak i/ili osvajanje područja koja su periodično pod vodom. Neke od higrofilnih vrsta su ujedno i stenotopne, što upućuje na značenje močvarnih staništa koja su presudna za opstanak takvih vrsta.

Opće prihvaćena Sclater-Wallacova zoogeografska podjela svijeta je osnova na kojoj brojni drugi autori temelje svoju podjelu. Područje Europe, a posebice Balkanski poluotok, pojedini autori svrstavaju u različite niže zoogeografske cjeline. Područje Krapje đola po svom zoogeografskom položaju, prema HADŽIJU (1931), preinačeno prema FINKU (1965), pripada subalpsko-slavonskom dijelu subalpsko-slavonsko-srijemske krajine, nizinskom pojasu europskoga potpodručja, starom sjevernom području (Palearktis) i sjevernom podsvijetu (Holarktis), pa se zato moglo očekivati da će fauna trčaka, utvrđena u kopnenim staništima oko njega, po svojoj rasprostranjenosti biti ili široko rasprostranjena ili srednje i istočnoeuropski rasprostranjena. Općenito, fauna trčaka koja prati slijevove velikih rijeka, kao što je Sava, u cijeloj Europi pokazuje određenu uniformnost.

Prema VUJČIĆ-KARLO (1999.), veću faunističku sličnost pokazuju zajednice trčaka na geografski bližim područjima. Upravo naprotiv, na istraživanim postajama, iako su jedna drugoj blizu, utvrđen je relativno malen broj zajedničkih vrsta. Međutim, analizom gustoće tih zajedničkih vrsta ustanovljeno je da su to vrste koje pripadaju dominantnim i subdominantnim vrstama trčaka ovog područja

percentage of clay, because of which during the rainy periods, which means in winter, early spring and late autumn, they retain the water. The soils are then rich in humidity and in the catch hygrophilous species of beetle are dominant. In late spring and summer the soils are exposed to sun and there is little moisture from rainfall. The consequence of this that on the other layer a hard crust is formed, which if the year is very dry can crack down into the deeper layers of the soil. In the dry state these soils are very compact and hard (SCHNEIDER-JACOBY AND ERN, 1993). In late spring and summer, then, the amount of moisture in the soil is small, which suits the xerophilous and xerothermophilous species that then dominate the catch (KRIŽANIĆ, 2002).

The large number of hygrophilous species suggests the propinquity of the marshy habitat. Ground beetles are highly mobile species that can live in the larval state on a slightly elevated dry habitat, but as adult individuals in a period of suitable humidity can appropriate new areas in which there is food. Apart from that, some of the species can fly in the adult stage, although they do this really, because it involves a large expenditure of energy (THIELE, 1977). However, flight does allow them to live in and/or colonise areas that are periodically inundated. Some hygrophilous species are at the same time stenotopic, which points up the importance of the wetland habitats that are crucial for the survival of such species.

The universally accepted Sclater-Wallace zoogeographic division of the world is the basis on which many other authors have grounded their division. The European area, and particularly the Balkan peninsula, is placed in various different zoogeographic units by different authors. The area of Krapje đol, according to its zoogeographic position, as determined by HADŽI (1931), modified by FINK (1965) belongs to the sub-Alpine-Slavonian part of the sub-Alpine-Slavonian-Syrmium area, to the lowland zone of the European sub-area, to the old northern area (Palaearctic) and to the northern hemisphere (Holarctic), and thus it is to be expected that the ground beetle fauna identified in the terrestrial habitats around it will be in terms of distribution either widely distributed or distributed in Central and Eastern Europe. In general, the ground beetle fauna that accompanies the drainage basins of the great rivers, such as the Sava, shows a certain uniformity throughout Europe.

According to VUJČIĆ-KARLO (1999), communities of ground beetles in geographically similar areas show a rather large faunistic similarity. But quite to the contrary, in the stations investigated for this paper, although close to each other, a relatively small number of species in common was established. However, through an analysis of the density of these common species, it was established that these are

(KRIŽANIĆ, 2002). Vrste *Brachinus crepitans, B. ganglbaueri, Harpalus neglectus, Leistus ferrugineus, Poecilus cupreus, Pterostichus melanarius i Trechus quadristriatus* uglavnom naseljavaju otvorena staništa, kao što su oranice, livade i pašnjaci, te su rasprostranjene na području cijele Europe (THIELE, 1977; LUFF, 1996). Vrste roda Carabus u nizinskim poplavnim područjima naseljavaju listopadne šume i livade (slika 2). Vrste koje se pojavljuju na manjem broju postaja prolazne su vrste, i prije su indikatori stresa u okolišu nego znak bogatstva i raznovrsnosti faune trčaka Krapje đola. Naime, polja oko samog đola pod različitim su ratarskim kulturama ili pod pašnjacima, što ima eliminirajući učinak na ličinačke stadije mnogih vrsta trčaka. Vrste na postaji D pionirske su vrste koje tek naseljavaju područje na kojemu odnedavno nema utjecaja poljoprivrede.

ZAKLJUČCI

- U različitim tipovima staništa oko Krapje đola utvrđena je 61 vrsta trčaka, od čega je 55 vrsta određeno do vrste, a šest do roda. Utvrđene vrste većinom pripadaju srednjoeuropskoj i istočnoeuropskoj fauni.
- Svega 14 vrsta utvrđeno je na svim istraživanim postajama, iako su one međusobno malo udaljene. Na tri postaje utvrđeno je svega 10 vrsta. To upućuje na činjenicu da se one ne razmnožavaju ovdje nego da migriraju sa susjednih područja.
- Osim higrofilnih vrsta, koje su očekivane zbog blizine močvare, utvrđen je i određeni broj kserofilnih i kserotermnih vrsta. Lonjsko polje je velikim dijelom prekriveno glinom, pa za ljetnih suša te vrste ovdje nalaze pogodno područje za život. To su vrste koje mogu letjeti i na ovo su područje migrirale iz okolnih povišenih dijelova koji nisu pod vodom.
- Relativno veliki broj utvrđenih vrsta upućuje na veliki biološki potencijal okolnoga područja. Fauna trčaka je veoma raznovrsna, s obzirom na ekološke prilike istraživanih staništa, što se objašnjava utjecajem čovjeka i veoma različitim tipovima staništa koja se nalaze u blizini istraživanih postaja.

species that belong to the dominant and sub-dominant species of ground beetles in this area (KRIŽANIĆ, 2002). The species *Brachinus crepitans, B. ganglbaueri, Harpalus neglectus, Leistus ferrugineus, Poecilus cupreus, Pterostichus melanarius and Trechus quadristriatus* on the whole populate open habitats, such as plough-land, meadows and pastureland, and are distributed over the whole area of Europe (THIELE, 1977; LUFF, 1996). In lowland floodplain areas species of the genus Carabus tend to colonise deciduous forests and meadows (Figure 2). Species that appear in a smaller number of stations are visiting species, and are more of an indicator of environmental stress than a sign of the richness and diversity of the ground beetle fauna of Krapje đol. The fields around the oxbow are under various arable crops or grazing areas, which has an eliminating effect on the larval forms of many species of ground beetle. The species at Station D are pioneering species that are just colonising the area on which there has been no agricultural impact for a short period of time.

CONCLUSIONS

- In various kinds of habitat around Krapje đol, 61 species of ground beetle were determined, of which 55 were identified to species level, six to genus level. The species identified on the whole belong to the fauna of Central and Eastern Europe.
- No more than 14 species were identified at all the stations in the investigation, although they were but little distant from each other. At three stations, only 10 species were identified. This indicates that they do not reproduce here, rather migrate from neighbouring areas.
- Apart from the hygrophilous species that were expected because of the vicinity of the marshes, a number of xerophilous and xerothermophilous species were also determined. Lonjsko Polje is largely covered with clay, and in the summer droughts these species can find suitable areas for life here. These species can also fly, and have probably migrated to the area from the surrounding raised areas that are not under water.
- A relatively large number of species identified relates to the great biological potential of the surrounding area. The ground beetle fauna is very diverse, because of the ecological conditions of the habitats research, which is explained by the anthropogenic impact and the very diverse types of habitat that are to be found close to the stations investigated.

LITERATURA

Apfelbeck, V. (1904): Die Käferfauna des Balkanhalbinsel, mit Berücksichtigung Klein-Asiens und der Insel Kreta. I band. R. Friedländer und Sohn Verlag, Berlin, 422 pp.

Boháč, J. i Fuchs R. (1994): Carabidae and Staphylinidae of Bohemian villages. U: Desender, K., Dufrene, M., Loreau, M., Luff, M. L. i Maelfait, J. P. (ed): Carabid beetles, Ecology and Evolution. Kluwer Academic Publishers, Dordrecht, 235 241.

Casale, A. (1990): Carabid Communities of Aquatic and Semi-aquatic Environments in North-western Italy: their Role as Ecological Indicators. U: Stork, N.E. (ed): The Role of Ground Beetles in Ecological and Environmental Studies. Intercept, Andover, 349-357.

Csiki, E. (1946): Die Käferfauna des Karpaten-Beckens. I band. Allgemeiner Teil und Caraboidea. Kubascha, Naturwissenschaftliche Monographien, Budapest, 798 pp.

Drovenik, B. i Peks, H. (1994): Catalogus Faune. Carabiden der Balkanleander. Coleoptera Carabidae. Peks, Schwanfeld, 103 pp.

Durbešić, P., Vujčić-Karlo, S. i Šerić, L. (2000): The Ground Beetles (Coleoptera, Carabidae) of Some of the Forest Communities of Lonjsko Polje. International Assocation for Danube Research. 33, 151-156.

Eyer, M. D. i Luff, M. L. (1990): A Preliminary Classification of European Grassland Habitats using Carabid Beetles. U: Stork, N.E. (ed): The Role of Ground Beetles in Ecological and Environmental Studies. Intercept, Andover, 227-243.

Fink, N. (1965): Ekologija životinja i zoogeografija. Sveučilište u Zagrebu, Zagreb, 1 162.

Ganglbauer, L. (1892): Die Käfer von Mitteleuropa. I band. Carl Gerold's Sohn Verlag, Wien, 557 pp.

Georges, A. (1994): Carabid beetle spatial patterns in cultivated wetlands. The effects of engineering works and agricultural management in Marais Poitevin (western France). U: Desender, K., Dufrene, M., Loreau, M., Luff, M. L. i Maelfait, J. P. (ed): Carabid beetles, Ecology and Evolution. Kluwer Academic Publishers, Dordrecht, 283 - 295.

Hadži, J. (1931): Zoogeografske karte Kraljevine Jugoslavije. Zbirka karata geografskog društva, Beograd.

Halsall, N. G. i Wratten, S. D. (1988): The efficiency of pitfall trapping for polyphagous predarory Carabidae. Ecological Entomology 13, 293-299.

Kegel, B. (1994): The biology of four sympatric Poecilus species. U: Desender, K., Dufrene, M., Loreau, M., Luff, M. L. i Maelfait, J. P. (ed): Carabid beetles, Ecology and Evolution. Kluwer Academic Publishers, Dordrecht, 157 - 165.

Kirby K. J. (1992): Habitat fragmentation. Species At Risk. Invertebrate Group Identification. English Nature Research Reports 89, 171 pp.

Križanić, A. (2002): Fauna trčaka (Coleoptera, Carabidae) Ornitološkog rezervata Krapje Đol. Diplomski rad, Sveučilište u Zagrebu, Zagreb, 116 pp.

Kryzhanovsky, O. L. (1983): Coleoptera Adephaga: Rhysodidae, Trachypodidae and Carabidae. Fauna SSSR, 1 (2), Leningrad, 341 pp.

Kryzhanovsky, O. L., Belousov, I. A., Kabak, I. I., Kataev, B. M., Makarov, K. V. i Shilenkov, V. G. (1995): A checklist of the Ground-beetles of Russia and Adjacent lands (Insecta, Coleoptera, Carabidae). Pensoft, Sofia, 271 pp.

Lohse, G. A. i Lucht, W. H. (1989): Die Käfer Mitteleuropas. I Supplementband mit Katalogteil. Goecke & Evers Verlag, Krefeld.

Luff, L. M. (1975): Some features influencing the efficiency of pitfall traps. Oecologia 19, 345-357.

Luff, M. L. (1996): Use of Carabids as environmental indicators in grassland and cereals. Annales Zoologici Fennici 33, 185-195.

Maelfait, J. P. i Desender, K. (1990): Possibilities of Short-term Carabid Sampling for Site Assessment Studies. U: Stork, N. E. (ed): The role of Ground Beetles in Ecological and Environmental Studies. Intercept, Andower, 217-225.

Mayer, B. (1992): Šumska tla Republike Hrvatske pri kraju XX. stoljeća. U: Rauš, Đ. (ed): Šume u Hrvatskoj. Šumarski fakultet Sveučilišta u Zagrebu i "Hrvatske šume", Zagreb, 19-32.

Mossakowski, D. Fräbs, H. i Baro, A. (1990): Carabid Beetles as Indicators of Habitat Destruction. U: Stork, N.E. (ed): The Role of Ground Beetles in Ecological and Environmental Studies. Intercept, Andover, 237 243.

Nyilas, I. (1994): Habitat distribution of Brachinus species in alkaline and salty steppes and loess grassland (Coleoptera, Carabidae). U: Desender, K., Dufrene, M., Loreau, M., Luff, M. L. i Maelfait, J. P. (ed): Carabid beetles, Ecology and Evolution. Kluwer Academic Publishers, Dordrecht, 193-199.

Pavičević D., Mesaroš G., Ognjenović D., Bjelić Mesaroš S. (1997): Carabini of Yugoslavia and adjecent areas. CD-ROM Encyclopedia, Eclibri-BIONET, Beograd.

Petruška, F. (1969): On the possibility of escape of the various components of the epigaeic fauna of the fields from the pitfall traps containing Formalin (Coleoptera). Acta Universitatis Palackianae Olomucensis Facultas Rerum Naturalium 31, 99-124.

Powell, W., Walton, M. P. i Jervis, M. A. (1996): Populations and communites. U: Jervis, M. i Kidd, N. (ed): Insect natural enemies Practical approaches to their study and evaluation. Chapman & Hall, London, 223 - 260.

Radović, J. (ed.) (1999): Pregled stanja biološke i krajobrazne raznolikosti Hrvatske. Državna uprava za zaštitu prirode i okoliša, Zagreb, 151 pp.

Ratti, E. , Busato, L., De Martin, P. i Zanella, L. (1998): I coleotteri carabidi dei colli euganei (Veneto) (Insecta Coleoptera Carabidae). Bollettino del Museo civico di Storia naturale di Venezia 48, 5 65.

Schatzmayr, A. (1942): Bestimmungstabellen europäischer Käfer.V Heft, VIII Stück. Bestimmungstabellen der europäischen und nordafrikanischen Pterostichus-u. Tapinopterus-Arten. Albert Winkler Verlag, Wien, 143 pp.

Schlosser Klekovski, J. (1877 - 1879): Fauna kornjašah Trojedne kraljevine, I III, JAZU, Zagreb, 995 pp.

Schneider-Jacoby, M. i Ern, H. (1993): Park prirode Lonjsko polje - raznolikost uvjetovana poplavljivanjem. Hrvatsko ekološko društvo, Zagreb, 135 pp.

Thiele, H. U. (1977): Carabid Beetles in Their Environments. Springer Verlag, Berlin, 369 pp.

Trautner, J. i Geigenmüller, K. (1987): Tiger Beetles and Ground Beetles, Illustrated Key to the Cicindelidae and Carabidae of Europe. Margraf Publishers, Aichtal, 487 pp.

Vujčić-Karlo, S. (1999): Faunističko-ekološka istraživanja trčaka (Carabidae) u različitim šumskim zajednicama Hrvatske. Disertacija, Sveučilište u Zagrebu, Zagreb, 256 pp.

Wachmann, E., Platen, R. i Brandt, D. (1995): Laufkäfer Beobachtung, Lebenweise. Naturbuch Verlag, Augsburg, 295 pp.

Winkler, A. (1924-1932): Catalogus Coleopterorum Regionis Palaearcticae. Albert Winkler Verlag, Wien, 1698 pp.

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KOSCI (*CREX CREX*), GLOBALNO UGROŽENA VRSTA PTICA, I DALJE SE USPJEŠNO GNIJEZDE U PARKU PRIRODE LONJSKO POLJE

Kosci - gnjezdarice vlažnih travnjaka

Europski travnjački ekosustavi (pašnjaci i livade) najčešće su nastali sječom šuma u davnoj prošlosti. Iako to nisu prirodni ekosustavi, znatno su obogatili biološku i krajobraznu raznolikost. Močvarni i poplavni travnjaci u dolinama nizinskih rijeka bili su, ovisno o režimu poplavljivanja, iskorištavani kao pašnjaci ili livade na kojima se proizvodilo sijeno. Samo one poljoprivredne površine koje su bile izvan dohvata poplavnih voda služile su kao oranice. Tijekom druge polovice 20. stoljeća način uporabe livada i pašnjaka se izrazito mijenja: oni se zasijavaju, gnoje i mehanički obrađuju; ručno košenje zamjenjuju traktorske kosilice. Opsežnim hidromelioracijskim radovima i regulacijom vodotoka mijenja se režim poplavljivanja takvih površina i omogućava njihova intenzivnija uporaba ranijom i ponavljanom košnjom. S druge strane, s opadanjem brojnosti stoke i s nestajanjem tradicionalnih seoskih domaćinstava, velike travnjačke površine na nekim se područjima zapuštaju i ne kose pa zarastavaju u šikare i grmlje. Takav je trend nestajanja travnjaka osobito izražen u tranzicijskim zemljama istočne Europe, pa i u Hrvatskoj (slika 1). Ciklus razmnožavanja ptica koje se gnijezde na travnjacima bio je gotovo savršeno usklađen s tradicionalnim načinom iskorištavanja travnjaka. Ako se livade kose tijekom sezone gniježđenja, ptice ostaju bez zaklona; ako se zasijavaju i gnoje, vegetacija postaje pregusta, a ako se potpuno prestanu iskorištavati, one zarastu u šikaru i postanu neprikladne za gniježđenje.

Takve promjene u načinu iskorištavanja travnjaka uzrokom su ugroženosti ne samo travnjačkih ptica nego i svekolike flore i faune tih područja. Jedna je od globalno ugroženih vrsta ptica, koja se gnijezdi na vlažnim travnjacima, kosac, *Crex crex* (L.).

Kosac je ptica iz porodice kokošica (Gruiformes: Rallidae). Velik je poput goluba, perje mu je tople smeđe boje, a noge relativno duge i snažne. Kosci žive vrlo skrovito i rijetko se mogu vidjeti; svoju prisutnost mužjaci odaju noćnim pjevom, kreks-kreks, sličnim zvuku brušenja kose (otud mu i ime), a za tihih noći čuje se na udaljenosti i do 1 km. Brojnost

THE CORNCRAKE (*CREX CREX*) A GLOBALLY ENDANGERED BIRD SPECIES CONTINUES TO NEST SUCCESSFULLY IN LONJSKO POLJE NATURE PARK

Corncrakes - nesting birds of the water meadow

European grassland ecosystems (pastures and meadows) have most often come into being as a result of the felling of forests in the distant past. Although they are thus not natural ecosystems, they have considerably added to biological and landscape diversity. The wetland and floodplain grasslands in the valleys of the lowland rivers were, depending on the inundation regime, used as pastureland or grasslands in which hay was produced. Only those agricultural areas that were out of reach of the flood water were used for arable purposes. During the second half of the 20th century the manner of using the meadows and pasturelands continued considerably: they were sowed, manured and tilled mechanically; hand mowing, scything, was replaced by tractor-drawn reapers. Extensive hydraulic engineering works and straightening of the water courses led to the changing of the inundation regime of such areas and made it possible for them to be exploited intensively with early and second mowing. On the other hand, with the decline in the numbers of livestock and with the disappearance of traditional rural households, the large grassland areas were abandoned in some areas and were not mowed, and thus were overgrown by scrub and brush. This trend towards the disappearance of the grasslands is particularly marked in the transitional countries of Eastern Europe, including in Croatia (Fig. 1). The reproduction cycle of the birds that nest in the grasslands is almost perfectly harmonised with the traditional manner of using the meadows. If these are mown during the nesting season, the birds lose their cover; if they are sown and manured, the vegetation becomes too dense, and if they completely cease to be used, they will degenerate into scrub and become inappropriate for nesting.

Such changes in the manner of using the grasslands have led to the endangerment of not only the grassland birds, but of all the flora and fauna of the areas. One of the globally endangered species of bird that nests in the wet grasslands is the corncrake, *Crex crex* (L.). The corncrake is a bird from the family of the rails (Gruiformes: Ralidae). It is about as big as a pigeon, with plumage of a warm brown colour, and relatively long powerful legs. The corncrakes live a very secretive way of life and can seldom be seen; the males give away their presence with their nocturnal song, crake-crake, which is like

kosaca u cijeloj Europi opada tako naglo da im danas prijeti izumiranje. Glavni je razlog nestajanje vlažnih i ekstenzivno iskorištavanih livada košanica s visokom i bujnom travom. Modernizacija poljoprivrede na travnjacima (uporaba traktorskih kosilica) i uništavanje staništa melioracijama i prenamjenom uzrokom su da danas u Europi ima 50% manje kosaca nego prije 20 godina. Kosci su upisani na IUCN-ov popis globalno ugroženih vrsta ptica, nalaze se na popisu 2. aneksa Konvencije o zaštiti migratornih vrsta i njihovih staništa (Bern, 1979.), a 1996. donesen je i Europski akcijski plan za zaštitu te vrste. U Hrvatskoj je kosac zaštićen po »Pravilniku o zaštiti pojedinih vrsta ptica (Aves)«, (»Narodne novine«, broj 43/95). Protuzakonito ga je ubiti, zatočiti ili uznemirivati, uništavati mu gnijezda i jaja. Prema pravilniku o visini naknade štete prouzročene nedopuštenom radnjom na zaštićenim životinjskim vrstama (NN 84/96), odšteta za ubijanje pojedinog primjerka je 4000,00 kn.

U Hrvatskoj se kosci gnijezde na vlažnim travnjacima uz rijeku Savu (uključujući Turopolje, Lonjsko, Sunjsko i Mokro polje), Kupu i Dravu, a manji dio populacije gnijezdi se na gorskim livadama (npr. Ćićarija, Plitvice, Gorski kotar). Procjenjuje se da u Hrvatskoj ima 500 - 1000 mužjaka kosaca.

Oko pola hrvatske populacije kosaca gnijezdi se u srednjoj Posavini (područje između Zagreba i Nove Gradiške), uključujući i područje parka prirode Lonjsko polje. Zadnja istraživanja kosaca na tom području obavljena su krajem 80-ih (Schneider-Jacoby, 1991., Flade, 1991.). Ratna događanja, izumiranje tradicionalnoga seljačkog domaćinstva i poljoprivrede te privatizacija pogodila su i to područje. Jedan od ciljeva istraživanja koje je 2003. godine provedeno u okviru projekta »Zaštita kosaca (*Crex crex*) na području srednje Posavine« bio je utvrditi veličinu populacije kosaca na području parka prirode Lonjsko polje i povezati promjene u veličini populacije s promjenama u načinu iskorištavanja travnjaka Lonjskog polja.

Travnjaci parka prirode Lonjsko polje

Mogućnost gniježđenja kosaca uvjetovana je u prvom redu visinom i gustoćom vegetacije na nekom travnjaku - ona mora biti viša od 20 cm i dovoljno gusta da pruža zaklon, a da ne otežava prohodnost. Vodni režim vlažnih travnjaka osigurava veliku produkciju velikih kukaca i puževa te drugih beskralježnjaka kojima se kosci hrane, pa je to vjerojatni razlog zašto se oni najčešće gnijezde u močvarnim i poplavnim područjima (Green at all, 1997.). S obzirom na mogućnosti gniježđenja kosaca

the sharpening of a scythe, whence derives its name in Croatian [kosac = mower]; during quiet nights it can be heard at a distance of up to 1 km. The numbers of corncrakes in the whole of Europe have declined so suddenly that they are today threatened with extinction. The main reason is the disappearance of the wet and extensively used hay meadows with their high, verdant vegetation. The modernisation of agriculture on the grasslands (the use of mechanical mowers) and the destruction of the habitats with land reclamation and change of purpose are the reason why there are in Europe today 50% fewer corncrakes than there were 20 years ago. The corncrakes are entered on the IUCN list of globally endangered bird species, they are on the list of the second annex of the Migratory Birds and their Habitats Convention (Berne, 1979), while in 1996 the European Action Plan for the protection of the species was adopted. In Croatia the corncrake is protected according to the Regulations Concerning the Protection of Some Species of Birds (Aves) (OG no. 43/95). It is illegal to kill, capture or disturb it, to destroy its nests and eggs. According to the regulations concerning the damages to be paid for illegal actions relating to protected animal species, the fine for killing a single specimen is 4000 kuna.

In Croatia, corncrakes nest on water meadows along the Sava River (including Turopolje, Lonjsko, Sunjsko and Mokro Polje), the Kupa and the Drava rivers, and a minor part of the population also nests on the mountain meadows (for example, Ćićarija, Plitvice and Gorski Kotar). It is estimated that there are about 500 - 1000 male corncrakes in Croatia.

About a half of the Croatian population nest in Central Posavina (the area between Zagreb and Nova Gradiška), including the area of the LPNP. The last research into corncrakes in this area was carried out at the end of the 80s (Schneider-Jacoby, 1991; Flade, 1991). The events of the war, the extinction of the traditional rural household and agriculture and privatisation all hit this area. One of the aims of the research that was carried out in 2003 within the framework of the project “Protection of the Corncrake (*Crex crex*) in Central Posavina” was to determine the size of the corncrake population in Lonjsko Polje Nature Park and to link changes in the size of the population with changes in the manner of using the grasslands of Lonjsko Polje.

Grasslands of Lonjsko Polje Nature Park.

The corncrake's ability to nest is conditioned primarily by the height and density of the vegetation in a grassland area - it has to be more than 20 cm high, and thick enough to provide cover, without making it impassable. The water regime of the water meadows provides for a large production of big insects and snails and other invertebrates on which

na području parka, možemo razlikovati tri tipa travnjaka (Flade, 1991.) :

Tip 1 - livade visokoga šaša s vrbama. To su poplavni i do u kasno ljeto vlažni travnjaci visokoga šaša, s pojedinačnim stablima i grmljem vrba (*Salix sp.*). Tijekom istraživanja na takvim je travnjacima paslo vrlo malo svinja i goveda, a zbog suše i malog prinosa trava na livadama košanicama dio je takvih travnjaka krajem ljeta pokošen. Na tim travnjacima dominiraju visoki šaševi (*Carex gracilis, C. riparia, C. elata*) i žute perunike (*Iris pseudacorus*). Sredinom svibnja vegetacija je bila visoka oko 70 - 80 cm. Vegetacija je vrlo homogena i takvi travnjaci nalikuju na pravo more visokoga šaša. Velike površine takvih travnjaka nalaze se južno od sela Gračanice, Repušnice i Osekova. Takvi travnjaci razvijaju se i na vlažnijim dijelovima pašnjaka.

Tip 2 - vlažne livade trava i ljetnog drijemovca. Također periodično poplavljivani travnjaci, ali ne tako vlažni kao prethodni tip. Uglavnom su bez drveća; prevladavaju tipične vrste trava vlažnih travnjaka: koljenčasti repak (*Alopecurus geniculatus*), bijela rosulja (*Agrostis stolonifera*), žabnjak (*Ranunculus repens*), ljetni drijemovac (*Leucojum aestivum*), trbulja (*Oenanthe silaiifolia*), drijemnina (*Lychnys flos cuculi*). Na nižim i vlažnijim dijelovi travnjaka pojavljuju se »otoci« šaševa i žutih perunika. Početkom svibnja 2003. zbog suše je vegetacija tih travnjaka bila rijetka i visoka oko 30 cm. Takav je tip travnjaka najljepše razvijen na livadama Kreše, kraj sela Mlake, a manja područja su istraživana sjeverno od Čigoća, Suvoja i Mužilovčice. Te livade se kose jedanput godišnje, najčešće u dugom razdoblju, od srpnja do kolovoza. Često na njima do početka svibnja pase stoka, koja se nakon povlačenja poplavnih voda premješta na pašnjake.

Tip 3 - «suhe» livade. Livade izvan dohvata poplavnih voda, na kojima dominiraju trave, npr. livadna vlasnjača (*Poa trivialis*), medunika (*Holcus lanatus*) i dr. Na takvim livadama nema šaševa i irisa. Početkom svibnja 2003. vegetacija je bila visoka oko 10 cm i rijetka. Takve su livade u blizini sela Suvoj, Mužilovčica, Osekovo. Kose se najčešće jedanput, rijetko dvaput godišnje, a tijekom razdoblja poplava na pašnjacima koriste se i za ispašu stoke.

Metode istraživanja

Brojnost kosaca utvrđuje se noćnim (od 23 do 4 sata) prebrojavanjem mužjaka koji svoju prisutnost odaju pjevom. Prebrojavanje se obavljalo tijekom sezone

the corncrake feeds, and this is very likely the reason why they most often nest in wetland and riparian areas (Green et al, 1997). With respect to the ability of the corncrake to nest in the area of the Park, we can distinguish three types of vegetation (Flade, 1991).

Type 1 - meadows with high rushes or sedge and willows. These are inundated grasslands with high rushes wet until late summer, with the occasional tree and bushes of willow (*Salix sp.*). During research into such grassland, there was very little pasturing by pigs and cattle, and because of the drought, a very small yield of grass on the hay meadows, some of the grass on such grasslands was mown at the end of the summer. On such grasslands high sedge or rushes are dominant (*Carex gracilis, C. riparia, C. elata*) and yellow irises (*Iris pseudacorus*). In the middle of May the vegetation was high, about 70-80 cm. The vegetation was very homogeneous and such grasslands resemble a vast sea of high rushes. Great areas of such grassland are to be found south of the villages of Gračanica, Repušnica and Osekovo. Such grasslands also develop in the wet parts of the pastureland.

Type 2 - grassland of grass and summer snowflake. These are also periodically inundated grasslands, but are not as wet as the previous type. They are on the whole treeless: typical species of water meadows predominate: water foxtail, *Alopecurus geniculatus*; spreading bentgrass, *Agrostis stolonifera*; creeping buttercup, *Ranunculus repens*; summer snowflake, *Leucojum aestivum*; narrow-leaved water dropwort, Oenanthe silaifolia, and ragged robin, *Lichnys flos cuculli*. Islands of rushes and yellow irises also appear in the lower and wetter parts of these grasslands. At the beginning of May 2003, because of the drought, the vegetation of these grasslands was sparse and about 30 cm high. This kind of grassland is most developed on the meadows of Kreše, by the village of Mlaka, while smaller areas were also research north of Čigoć, Suvoj and Mužilovčica. These meadows are often mown once a year, most often in a long period from July to August. Until the beginning of May livestock often grazes here, for after the withdrawal of the flood water, they are moved to the meadows.

Type 3 - dry meadows. Meadows completely out of the reach of flood water, dominated by grasses, for example bird grass, *Poa trivialis*, *Holcus lanatus* and others. In such meadows there are no rushes or irises. At the beginning of May 2003 the vegetation was about 10 cm high and sparse. There are such meadows in the vicinity of the villages of Suvoj, Mužilovčica, Osekovo. There is mostly one haymaking a year, occasionally twice, and during the

gniježđenja kosaca, tj. od svibnja do početka srpnja, najmanje dvaput na istom lokalitetu. Istodobno su mjereni i parametri staništa (visina i gustoća trave, način i intenzitet košenja i ispaše). Lokaliteti istraživanja su izabrani tako da se u istraživanje uključe različiti travnjaci, s obzirom na način i intenzitet gospodarskog iskorištavanja. U istraživanja su uključena i područja za koje postoje literaturni podaci o brojnosti i gniježđenju kosaca (Schneider-Jacoby. 1991., Flade, 1991.).

Rezultati

Istraživanjima je obuhvaćeno više od 1300 ha travnjaka na različitim lokalitetima parka, na kojima je zabilježeno ukupno 78 mužjaka kosca. Istraženo je 140 ha pašnjaka, 90 ha suhih livada, 510 ha vlažnih livada i 635 ha travnjaka visokog šaša. Najviše kosaca glasalo se među visokim šašem (travnjaci tipa 1), 59 mužjaka, tj. 76%, a njih 24%, tj. 19, gnijezdilo se na vlažnim livadama košanicama (tip 2). Na suhim livadama (tip 3) nije zabilježen nijedan kosac.
Gustoća pjevajućih mužjaka nije na svim područjima bila jednaka. Najveća gustoća kosaca zabilježene je na velikim (> 100 ha) travnjacima šaša na području Gračanice i Repušnice (tablica 1.). Upravo su takvi poplavni travnjaci možda i jedina prava prirodna europska staništa kosaca. Vjerojatno su tijekom povijesti, a prije utjecaja čovjeka, razvoj šume na ovakvim površina priječile redovite poplave i ispaša divljih biljoždera. Zbog intenzivnih melioracija takvi travnjaci gotovo i ne postoje u zapadnoj Europi, a zadržali su se samo na području nekoliko riječnih dolina u srednjoj i jugoistočnoj Europi, od kojih je jedna i poplavna ravnica rijeke Save (Flade, 1997.).

periods of inundation of the pastureland, they are also used to graze livestock on.

Research methods

The abundance of corncrakes is determined by the nocturnal counting (from 23.00 to 04.00 hours) of the males who reveal their presence by their singing. The counting was done during the corncrake nesting season, i.e., from May until early July, at least twice on the same locality. At the same time, the parameters of the habitat were measured (height and density of the grass, manner and intensity of mowing and grazing). The research localities were selected in such a way as to include different grasslands into the research, different with respect to the manner and vigour of their employment for economic purposes. Areas for which there are comparable data concerning numbers and nesting of corncrakes in the literature were taken (Schneider-Jacoby, 1991; Flade, 1991).

Results

The research covered more than 1300 ha of grassland in various localities of the park, with a total of 78 male corncrakes being counted. The following were investigated: 140 ha of grassland, 90 ha of dry meadows, 510 ha of water meadows and 635 ha of high rush grassland. There were the most corncrakes singing among the high rushes (Grassland Type 1), 59 males, i.e., 76%, while 24%, i.e., 19 of them, nested on the haymaking water meadows (Type 2). Not a single corncrake was recorded in the dry meadows (Type 3).
The density of singing males was not the same in all the areas. The greatest density of corncrakes was recorded on large (> 100 ha) reed grasslands in the area of Gračanica and Repušnica (Table 1). Such inundated grasslands are perhaps the only true natural European corncrake habitat. Probably, during history, before the influence of people, the development of forests in such areas was prevented by regular inundations and the grazing of wild herbivores. Because of intensive land reclamation, such grasslands almost do not exist in Western Europe, and have remained only in the area of central and south east Europe, one of which is the floodplain of the Sava River (Flade, 1997).

Lokalitet /površina	Tip travnjaka	Podaci iz 2003. Broj kosaca / Gustoća na 100 ha	Podaci iz razdoblja 1986. - 88. (Schneider – Jacoby, 1991.): Broj kosaca /Gustoća na 100 ha
Gračanica/220 ha	livade visokog šaša s vrbama	11 / 5,0	7 / 1,8
Repušnica/140 ha	livade visokog šaša s vrbama	10 / 4,8	8 / 2,7
Osekovo/100 ha	livade visokog šaša s vrbama	3 / 3,0	5 / 5,0
Čigoć/50 ha	livade visokog šaša s vrbama	1 / 2,0	5 / 5,0
Mokro polje/ 100 ha	livade visokog šaša s vrbama	5 / 5,0	3 / 1,0
Jasenovac, spomen-područje/70 ha	vlažne livade trava i drijemovca	5 / 7,1	-
Mlaka, livada Kreše/140 ha	vlažne livade trava i drijemovca	5 / 3,6	5 / 5,0

Tablica 1.: Brojnost i gustoća kosaca (pjevajućih mužjaka/100 ha) na različitim lokalitetima tijekom različitih sezona gniježđenja.

Na području takvih travnjaka sjeverno od Čigoća gustoća kosaca je najmanja (tablica 1., slika 1.). Područje je vrlo gusto obraslo grmljem vrba i amorfa, a jednolične površine pod šašom ovdje su puno manje. Takvo zatvaranje prostora grmolikom vegetacijom očito odbija kosce. Zbog izgradnje nasipa režim poplava je promijenjen, a voda se tijekom poplava dulje zadržava, pa su za vlažnih godina travnjaci ovog dijela Lonjskog polja dugo poplavljeni. Kosci su selice i na europska gnjezdilišta se vraćaju krajem travnja. Ako su u to doba travnjaci poplavljeni, kosci ih neće upotrijebiti kao gnjezdilišta. Dugotrajna poplava je vjerojatan razlog negniježđenja kosaca i na području Poganovog polja. Zbog velike vlažnosti na Poganovom polju velike površine prekrivaju tipične močvarne biljke, npr. ježinac (*Spraganium erectum*) i vodoljub (*Butomus umbellatus*). Tijekom sušnoga razdoblja te biljke zajedno sa šaševima stvaraju visoke, ali vrlo neprohodne travnjake .
Na livadama kraj sela Suvoj, Mužilovčica i Trebež ove godine nisu utvrđeni kosci. Flade (1991.) spominje veliku brojnost kosaca na livadama između sela Lonje i Trebeža (15 > na 35 ha vlažnih livada 1990. godine), a na istom je području kosce bilježio i Schneider - Jacoby (1991.) u razdoblju od 1986. do 1988. Dva su vrlo vjerojatna uzroka ovogodišnjeg izostanka gniježđenja kosaca na tim područjima. Zbog izuzetne suše trava je na livadama bila preniska

Table 1.: Numbers and density of corncrakes (singing males/100 ha) at various locations during the different nesting seasons.

In the area of such grasslands north of Čigoć the density of corncrakes is the lowest (Table 1, Figure 1). The area is very densely covered with willows and bastard indigo, and the uniform areas covered with reeds are much smaller here. Such an enclosure of the space with bushy vegetation obviously repels the corncrakes. Because of the building of the dyke, the flood regime has changed, and the water stays longer during the floods, so that during wet years the grasslands of this part of Lonjsko Polje are flooded for a long time. Corncrakes are migratory and return to the European nests at the end of April. If at this time the grasslands are flooded, the corncrakes will not be able to use them as nesting places. Long-lasting flooding is probably the reason for the non-nesting of the corncrake in the area of Poganovo polje. Because Poganovo polje is very wet, great areas of it are covered with typical marshland plants, for example *Spraganium erectum* and *Butomus umbellatus*. During the dry period these plants, together with the reeds, created high but extremely impassable grasslands.
On the meadows near the villages of Suvoj, Mužilovčica and Trebež corncrakes were not identified this year. Flade (1991) mentions a large abundance of corncrakes in the meadows between the villages of Lonja and Trebez (15 > on 35 ha of water meadows in 1990), and in the same area Schneider-Jacoby also recorded the corncrake (1991), in the period between 1986 and 1988. There are two probable reasons for this year's failure of the

za sigurno gniježđenje (u svibnju je vegetacija bila visoka 10 cm). Dio livada uz Savu na području Trebeža, koje su po opisu Fladea (1991.) 1990. bile okružene živicom amorfe (*Amorpha fruticosa*) u razmaku od 20 do 50 m, danas su gusto proraštene grmljem jer su ih ljudi prestali kositi. I u jednom i u drugom slučaju staništa nisu pogodna za kosce.
Jedine vlažne livade trava na kojima su pronađeni kosci nalaze se na području Jasenovca (70 ha) i na lokalitetu Kreše kraj sela Mlake (140 ha). Iako su takve vlažne livade zabilježene na gotovo svim lokalitetima, mogućnost gniježđenja kosaca na njima ovisi i o veličini livade kao i o visini vegetacije na njoj. Npr. takve livade u Gračanici i Repušnici su se tijekom proljeća iskorištavale kao pašnjaci, a zbog sušnog proljeća 2003. trava početkom svibnja nije bila dovoljno visoka za kosce.
Analizom karte vegetacije parka, koja je napravljena na osnovi Landsat TM satelitske snimke iz 1995. godine, procjenjuje se da je površina travnjaka koji su pogodna gnjezdilišta kosaca oko 3900 ha (tipovi 1. i 2.). Prosječna gustoća mužjaka kosaca zabilježenih 2003. godine na svim lokalitetima je 6,2 mužjaka/100 ha. Iz tih podataka može se procijeniti da se na području parka gnijezdi oko 240 mužjaka kosaca. Kosci su sukcesivno poligamni, tj. jedan se mužjak može tijekom sezone gniježđenja pariti s više ženki, koje se same brinu o mladima. Zato je vrlo teško procijeniti broj parova, pa se govori o brojnosti, tj. gustoći mužjaka. Flade (1991) procjenjuje da se na području Posavine, između Siska i Stare Gradiške (uključujući Lonjsko, Sunjsko i Mokro polje), gnijezdilo 210 - 450 mužjaka kosaca, a Schneider - Jacoby za isto područje spominje oko 400 mužjaka u razdoblju 1986. - 88. Budući da park prirode zauzima oko polovicu rečenoga područja, može se tvrditi da se brojnost kosaca na području parka u proteklih 15 godina nije promijenila.

Budućnost kosaca u Lonjskom polju

Poplave i tradicionalna uporaba travnjaka na području Posavine osnova je velike biološke raznolikosti toga područja. Iako je čovjek krčenjem šuma promijenio izgled prirodnog, šumskog krajolika, mali intenzitet iskorištavanja omogućuje stvaranje mozaika pašnjaka, livada košanica i oranica. Mala promjena nadmorske visine uvjetuje duljinu i količinu poplava te zadržavanje oborinskih voda na travnjacima, a time je određen i način iskorištavanja travnjaka. Zona vlažnih livada i pašnjaka nastavlja se jedna na drugu: pašnjaci su na nižim područjima, pa su dulje poplavljeni, a stoka se, ovisno o količini vode, premješta s jednog na drugo

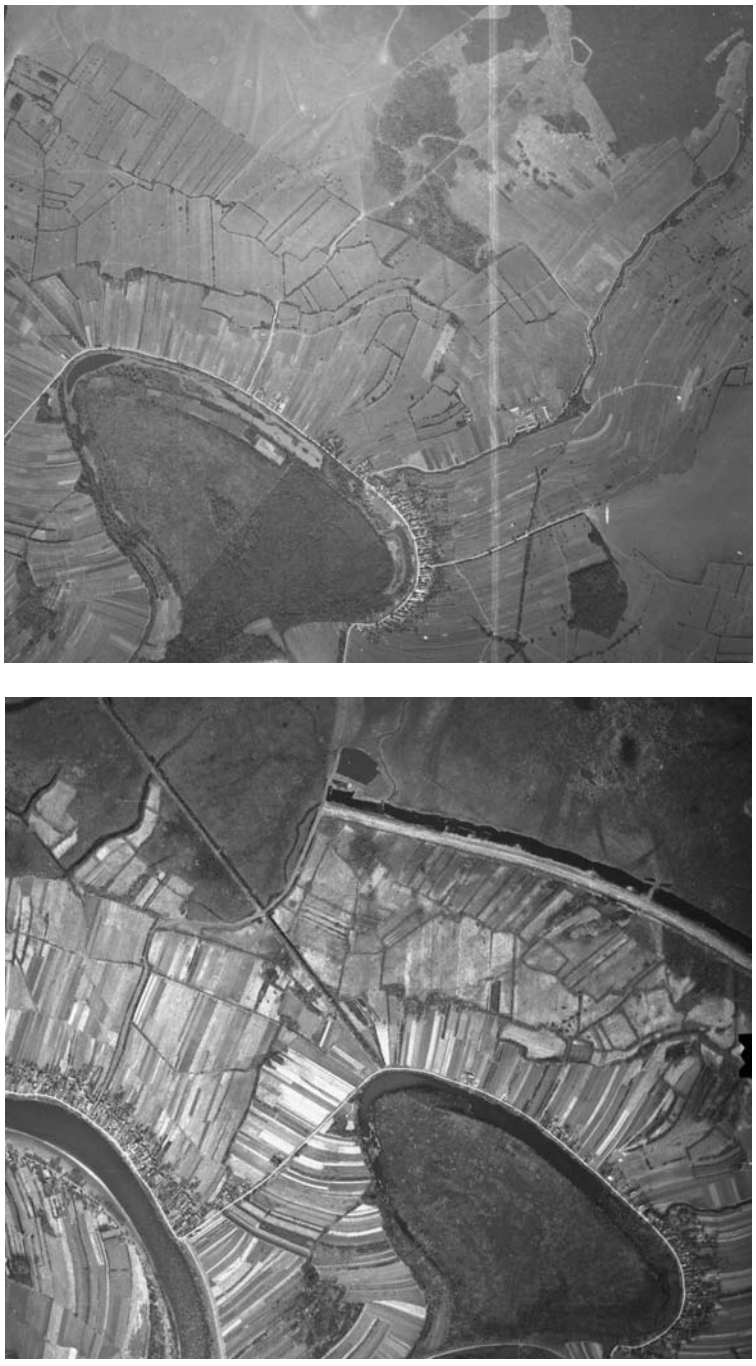
corncrake to nest in the areas. Because of the exceptional drought, the grass in the meadows was too low for secure nesting (in May the vegetation was 10 cm high). Part of the meadows along the Sava in the area of Trebež, which according to Flade's description (1991) were surrounded by a hedge of *Amorpha fruticosa* at distances of 20 to 25 m are today densely overgrown with bushes, because people have stopped mowing them. In both cases, then, the habitats do not suit the corncrake.
The only water meadows on which corncrakes have been found are in the area of Jasenovac (70 ha) and at Kreše by the village of Mlaka (140 ha). Although such water meadows are recorded in almost all localities, the possibility that corncrakes will nest in them depends on the size of the meadow and the height of the vegetation. For example, such meadows in Gračanica and Repušnica were used during spring as grazing areas, yet because of the dry spring of 2003 the grass was not high enough for the corncrakes during the beginning of May.
In an analysis of the park's vegetation map, done according to the Landsat TM satellite images of 1995 it is assessed that the area of grasslands suitable for corncrake nesting come to about 2900 ha (types 1 and 2). The average density of male corncrakes recorded in 2003 at all localities is 6.2 males per 100 ha. From these figures it can be estimated that about 240 male corncrakes nest in the park. Corncrakes are successively polygamous, that is, one male may during the nesting season mate with several females, which themselves look after the young. Thus it is very difficult to guess the number of pairs, and so one talks of the abundance, that is, density, of males. Flade (1991) estimated that in the area of Posavina between Sisak and Stara Gradiška (including the Lonjsko, Sunjsko and Mokro poljes) from 210 to 450 male corncrakes nested, while Schneider-Jacoby mentions about 400 males in the 1986-88 period. Since the nature park occupies about a half of the area mentioned, it can be stated that the numbers of corncrakes in the area of the park has not changed in the last 15 years.

The future of the corncrake in Lonjsko polje

Floods and the traditional use of the grasslands in the area of Posavina is the basis for the great biological diversity of the area. Although people have changed the appearance of the natural, forest landscape by clearing the forests, the low intensity of exploitation enables the creation of a mosaic of pasture areas, hay meadows and plough land. Quite small differences in altitude condition the length and volume of the flooding and the retention of the precipitation water on the grasslands, and hence the manner in which the grassland can be used. The zone of water meadows and pastureland follow on from each other: the pastures are on the

područje. Izgradnjom nasipa prekida se ovaj postupni prijelaz između livada košanica i pašnjaka. Livade se sad nalaze izvan područja retencije i postaju suše, a na pašnjacima (područje retencije) voda se zadržava predugo. Suhe se livade mogu kositi puno ranije (svibanj, lipanj), pa se kosci na njima ne mogu uspješno gnijezditi jer traktorske kosilice uništavaju i gnijezda i mlade ptiče. Ako je livada vlažna i kosi se tek u srpnju, kosci imaju dovoljno vremena podići barem jedno leglo. Osiguravanje što prirodnijeg režima voda jedan je od glavnih uvjeta očuvanja staništa kosaca. Drugi važan uvjet je očuvanje tradicionalnoga stočarstva. Površine poplavnih livada šaša ne ovise toliko o redovitoj košnji kao livade. Smanjenjem broja stoke smanjuje se i potreba za proizvodnjom sijena. Livade izvan dohvata poplava važna su gnjezdilišta kosaca u vlažnim godinama kad su područja pod šašem dugo poplavljena. Njihovo zaraštavanje i isušivanje uzrokovat će opadanje brojnosti kosaca. Tradicionalna poljoprivreda Lonjskoga polja zasniva se na obiteljskim gospodarstvima. Takva gospodarstva temelje se na iskorištavanju malih parcela, pa se tako sve livade na jednom području najčešće ne kose istovremeno i zato se kosci mogu skloniti u nepokošene dijelove. Privatizacija i okrupnjavanje vlasništva na pojedinim područjima mijenja intenzitet iskorištavanja prostora. Npr., velike vlažne livade na području Kreše i spomen-područja Jasenovac ove je godine kosio samo jedan zakupac koji je mogao za svega nekoliko dana pokositi cijelo područje. Zbog suše te su livade košene sredinom lipnja pa je najmanje 10 parova kosaca ostalo bez mogućnosti uspješnog gniježđenja.

lower area, and are flooded longer, while the livestock, depending on the amount of water, is shifted from one region to the other. The construction of dykes halts this gradual transition between hay meadows and pasture land. The meadows are now outside the retention pool area and become drier, and in the pasture land, the retention area, the water stays too long. The dry meadows can be cut much earlier (May, June) and so the corncrakes cannot nest successfully on them, for the mechanical mowers destroy both nests and young birds. If the water meadow is mown only in July, the corncrakes have time enough to raise at least one nest. The provision of as natural a water regime as possible is one of the main conditions for preserving corncrake habitats. The other important condition is the preservation of the traditional form of animal husbandry. The areas of inundated reed meadows do not depend so much on regular mowing as meadows do. Reduction of the numbers of livestock also reduces the need for the production of hay. The meadows beyond the reach of the floods are important nesting sites of corncrakes in wet years when the areas under reed are inundated too long. If they are drained or allowed to become overgrown, this will lead to a fall in the numbers of corncrakes. Traditional agriculture in Lonjsko Polje is based on the family farm. Such an economy is based on the use of small fields or plots, and thus not all the meadows in a single area are cut at the same time, and the corncrakes are able to take shelter in the parts not mown. Privatisation and consolidation of property in some of the areas has changed the intensity of use of the area. For example, the large water meadows in the area of Kreše and the Jasenovac memorial area were this year mown by a single lessee who was able to mow the whole area in just a few days. Because of the drought, these meadows were mown in mid-June, and thus at least 10 pairs of corncrakes were unable to nest successfully.



Slika 1. Usporedba zračnih snimaka okolice sela Čigoć iz 1962. i 1999./2000. godine. Izgradnja nasipa te opadanje brojnosti stoke i stanovništva uzrokom je promjene u načinu uporabe poljoprivrednog zemljišta. Područje sjeverno od nasipa je područje retencije Lonjsko polje i dulje je izloženo poplavama. Dio vlažnih livada košanica pretvoren je u pašnjak, a najveći dio je zarašten u grmlje vrba i amorfa (gornji desni dio slika).

Figure 1. Comparison of aerial photographs of the village of Cigoc of 1962 and 1999./2000. The construction of the dyke and the decline in the numbers of livestock and of population is the cause in the changes in the manner in which the agricultural land is used. The area to the north of the dyke is the retention pool area of LP and is exposed a longer time to floods. Part of the hay water meadows have been turned into pasture land, and most of it is overgrown with bush of willow and bastard indigo (upper right part of the picture).

Projekt »Zaštita kosaca (Crex crex) na području srednje Posavine« provela je Udruga za zaštitu prirode i okoliša »Eleonora«. Projekt je financijski podržao Ured za udruge Vlade Republike Hrvatske. Aktivnosti projekta bile su: utvrđivanje veličine populacije kosaca na području srednje Posavine, praćenje stanja gnjezdilišta te edukacija lokalnog stanovništva. Projekt su proveli članovi Udruge uz pomoć djelatnika PP Lonjsko polje kojima ovim putem zahvaljujemo.

The project entitled "The Protection of the Corncrake (Crex crex) in the area of Central Posavina" was carried out by the Eleonora Nature and Environment Protection Association. The project was financially supported by the Office for Associations of the Government of the Republic of Croatia. The activities of the project were: determining the size of the corncrake population in the area of Central Posavina, monitoring the state of the nesting areas, and education of the local population. The project was carried out by members of the Association, with help from Lonjsko Polje Nature Park staff members, whom we would like to thank on this occasion.

Literatura

Flade, M. (1991): Die Habitate des Wachtelkönigs während der Brutsaison in drei europäischen Stromtälern (Aller, Save,Biebrza). Die Vogelwelt 112 (1-2):14-40.

Flade, M. (1997): Wo lebte der Wachtelkönig (Crex crex) in der Urlandschaft? Vogelwelt 118:141-146.

Green, R. E., G. Rocamora i N. Schäffer (1997): Populations, ecology and threats to the Corncrake (Crex crex) in Europe. Vogelwelt 118:117-134.

Schneider-Jacoby, M. (1991):Verbreitung und Bestand des Wachtelkönigs in Jugoslawien. Die Vogelwelt 112 (1-2):48-56.

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MALI VRANAC (PHALACROCORAX PYGMEUS, PALL.), NOVA GNJEZDARICA PARKA PRIRODE LONJSKO POLJE

Mali vranac je rijetka gnjezdarica europskoga juga, rasprostranjena na području Sredozemlja, Crnog i Azovskog mora (Hagemeijer, Blair 1997.). U Hrvatskoj u posljednjih desetak godina vrsta ponovno zauzima svoja nekadašnja gnjezdišta (Kopački rit, Vransko jezero). Radović i drugi (2003.) navode sljedeća gnjezdišta u Hrvatskoj: Kopački rit, Vransko jezero, Krapje Đol. Darko Kovačić ovom popisu može dodati još i područje Guduće (NP Krka), gdje je 1989. u sezoni gniježđenja promatrao jedan par, te ribnjake Donji Miholjac, dio kod sela Đurađ, gdje je 1992. u sezoni gniježđenja promatrao do 30 jedinki.
U podrobnom radu o pticama srednjeg Posavlja za razdoblje 1986. - 1993. Schneider-Jacoby (1993.) navodi višekratno opažanje vrste (tri opažanja u tri različita polja opažanja veličine 2x2 km^2). Gnijezđenje vrste nije zabilježio, a ne daje o njoj ni druge podatke. No vrsta je uvrštena u ornitofaunu područja u kojemu je zabilježeno 238 vrsta, od čega 134 gnjezdarice (Schneider-Jacoby, 1993.).

U svibnju 2002. zapaženo je višekratno pojavljivanje malog vranca u području mješovite kolonije ornitološkoga rezervata Krapje đol. Mali vranac se pojavio u doba kada je već započelo gniježđenje žličarke, male bijele čaplje, gaka, čaplje dangube, vrsta koje prevladavaju u toj mješovitoj koloniji. Ptice su izgradile četiri gnijezda na maloj međusobnoj udaljenosti (2-3 metra). Gnijezda su smještena na rakitu (Salix cinerea), 1,5 do 3 metra iznad površine vode. Ispred gnijezda, koja su okrenuta jugozapadu, nije bilo druge vegetacije, nego samo otvorena voda, dijelom pokrivena flotirajućom vegetacijom. D. Kovačić je u više navrata promatrao hranjenje malog vranca u zapadnom dijelu Krapje Đola. Ptice su se koristile suhim granjem, trskom i busenima trave za promatrališta i odmorišta, a lovile su (sitnu ribu i kukce) u plitkoj vodi između otoka vegetacije. Možda je upravo porast brojnosti riba u Krapje đolu, što je rezultat izgradnje cijevi između đola i rijeke Save (Deželić i Schneider-Jacoby, 1999.), doveo do gniježđenja malog vranca u Krapje đolu. Redovito opažanje vidre i njezinih tragova u đolu dokazuju da je ponuda riba dovoljna i za veće predatore.
Godine 2003. gniježđenje se nije ponovilo jer je bila

THE PYGMY CORMORANT (PHALACROCORAX PYGMAEUS, PALL.), A NEW NESTING BIRD OF LONJSKO POLJE NATURE PARK

The pygmy cormorant is a nesting bird of the south of Europe, distributed in the area of the Mediterranean, the Black Sea and the Sea of Azov (Hagemeijer, Blair 1997). In Croatia in the last ten years or so the species has once again taken up its one-time nesting places (Kopački rit, Lake Vrana). Radović et al. (2003) cite the following nesting areas in Croatia: Kopacki rit, Lake Vrana and Krapje Dol. The first author can also add to this list the area of Guduće (Krka NP), where in the nesting season, he observed one pair in 1989, and the fishponds of Donji Miholjac part of the village of Đurađ, where he observed 30 individuals in the nesting season in 1992.

In a detailed paper concerning the bird fauna of Central Posavina during the 1986-1993 period, Schneider-Jacoby (1993) reported several sightings of the species in the area (three observations in three different fields of observation of 2 x 2 square kilometres). Thus the species was classified into the bird fauna of an area that includes 238 species, 134 of which are nesting birds (Schneider-Jacoby, 1993).

In May 2002 the multiple appearance of the pygmy cormorant in the area of the mixed colony in the ornithological reserve of Krapje Đol was observed. The pygmy cormorant appeared at the time when the nesting of the spoonbill, the small egret, the black crowned night heron and the purple heron had already begun, that is, of the species that make up the bulk of this mixed colonies. The birds built four nests at a little distance from each other (2-3 metres). The nests were placed on grey willow, *Salix cinerea*, at a distance of 1.5 to 3 m above the water. In front of the nests, which faced south-west, there was no other vegetation, rather open water partially covered with floating vegetation. Several times Darko Kovačić observed the feeding of the pygmy cormorant in the western part of Krapje Đol. The birds used dry twigs, reeds and tufts of grass for observation and resting places, and caught their prey (small fish and insects) in the shallow water between the islands of vegetation. It is possible that the increased in the abundance of fish in Krapje Dol, occurring as a result of the construction of pipes between Đol and the Sava River (Deželić and

iznimno sušna i nepovoljna. No, 2004. mali se vranac ponovno gnijezdi u Krapje đolu. To gniježđenje je vjerojatno i dio procesa oporavka populacije malog vranca u Europi koja broji oko 6000 ptica (Hagemeijer, Blair, 1997.). Opetovano gniježđenje malog vranca u Krapje đolu dopušta da listi gnjezdarica parka prirode Lonjsko polje dodamo još jednu vrstu, rijetku i ugroženu na europskoj i svjetskoj razini. U Bonskoj konvenciji mali vranac je upisan u dodatak II., kao i u Bernskoj konvenciji. U Hrvatskoj je vrsta zaštićena, a u Crvenoj knjizi ugroženih ptica Hrvatske (Radović i drugi, 2003.) svrstana u kategoriju CR - kritično ugrožena vrsta.

Schneider-Jacoby, 1999) ultimately brought about the nesting of the pygmy cormorant in Krapje Đol. The regular observation of the otter and traces of it in Đol show that the supply of fish is big enough even for larger predators.

The nesting was not repeated in 2003, for this was a year of exceptional drought and was very unfavourable. In 2004 the pygmy cormorant is nesting again in Krapje Đol. This nesting is probably part of the general process of the recovery of the pygmy cormorant population in Europe, which now numbers about 6000 birds (Hagemeijer, Blair 1997). The repeated nesting of the pygmy cormorant in Krapje Đol allows us to add one more species, rare and endangered at a European and world level, to the list of nesting birds of the Lonjsko Polje Nature Park. In the Bonn Convention the pygmy cormorant is to be found in Annex 2, as it is in the Berne Convention. In Croatia it is a protected species, and in the Red Book of Endangered Species of Croatia (Radović et al, 2003) it is placed in the critically endangered (CR) category.

Literatura:

Deželić, R., Schneider-Jacoby, M.,(1999): Obnova kolonije žličarki u Krapje đolu, Park prirode Lonjsko polje, Hrvatska. Bilten parka prirode Lonjsko polje, 1.1.: 29-31.
Hagemeijer, W.,J.,M., Blair, M.J.(Editors) (1997): The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance. T&AD Poyser, London. 903 pp.
Radović, D., Kralj, J., Tutiš. V., Ćiković, D., (2003): Crvena knjiga ugroženih ptica Hrvatske. Ministarstvo zaštite okoliša i prostornog uređenja, Zagreb. 179 pp.
Schneider-Jacoby, M., (1993): Vögel als Indikatoren für das ökologische Potential der Saveauen und Möglichkeit für deren Erhaltung. Naturerbe Verlag Jürgen Resch, Überlingen. 261 pp.es between Đol and the Sava River (Deželić and

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KONCENTRACIJA ATRAZINA U TLU I SEDIMENTU PARKA PRIRODE LONJSKO POLJE

Sažetak

U jesen 2002. sabirani su uzorci tla s kukuruznih polja i iz prirodnih područja Lonjskoga polja da bi se istražilo ima li u njima atrazina. Atrazin nije pronađen u uzorcima tla ili sedimenta koji su prikupljeni u prirodnom području, što pokazuje da u mjerljivim količinama nije ovamo prenesen s kukuruznih polja na kojima se primjenjuje. Izmjerena količina na tim poljima iznosila je od 3,41 do 453 pmol/g.

Uvod

Herbicid atrazin služi suzbijanju korova u poljima kukuruza, sirka, šećerne repe, ananasa, u šumarstvu i vinogradarstvu, a najviše u proizvodnji kukuruza (1). U SAD-u proizvodnja kukuruza "uzima" 75% od 76 milijuna funti, koliko se ondje svake godine potroši na atrazin. Atrazin je, s više od 200 radova koji se bave njegovim utjecajem na okoliš i na zdravlje ljudi, a izrađeni su nakon 1995., u svijetu jedan od najbolje istraženih pesticida. S obzirom na njegovu raširenost u poljoprivrednim područjima, izrađena je studija (US Geological Survey) u kojoj je utvrđeno da je atrazin najčešći herbicid u uzorcima sakupljenima iz 303 bunara diljem poljoprivrednog područja na američkom srednjem zapadu (2). U Hrvatskoj se atrazin u prvom redu rabi u zaštiti od širokolisnih korova u kukuruzu (3). Jednako se primjenjuje u tu svrhu u velikim količinama u granicama parka prirode Lonjsko polje, kao i u područjima koja su hidrološki s njime povezana.

Cilj ovih istraživanja bio je utvrditi je li atrazin primijenjen u kukuruznim poljima parka prirode dospio u tlo i sediment dna vodotoka u prirodnim dijelovima parka, posebno do ekološki vrlo vrijednih dijelova.
Da bi se istražila prisutnost atrazina u prirodnim područjima Lonjskoga polja, sediment je sakupljen u jezerima (trajnim i povremenim), a površinski uzorci i uzorci dubljih slojeva uzeti su s pašnjaka i iz šuma. Površinski i dublji slojevi tla sakupljeni su s polja na kojima se redovito primjenjivao atrazin kako bi se odredila količina rezidualnog atrazina na kraju vegetativne sezone.
Prijenos atrazina s tih kukuruznih polja na prirodna

SOIL AND SEDIMENT ATRAZINE CONCENTRATIONS IN LONJSKO POLJE NATURE PARK

Abstract

Soils from corn fields and natural areas, and pond bottom sediments in the Lonjsko Polje Nature Park were collected and analyzed for atrazine in the autumn of 2002. Atrazine was not found in any of the soil or sediment samples collected in the natural areas, indicating that detectable levels of atrazine were not being transported off-site from atrazine treated corn fields. Quantifiable atrazine concentrations in soil collected from corn fields in the park that had been treated with atrazine ranged from 3.41 to 453 pmol/g.

Introduction

The herbicide atrazine is used to control weeds in corn, sorghum, sugar cane, pineapple, forestry, orchards, and vineyards, with the largest usage in corn production (1). In the USA, corn production consumes 75% of the 76 million pounds of atrazine used annually. Atrazine is also one of the world's most extensively studied pesticides with more than 200 environmental fate and health effects studies conducted since 1995. A sense of atrazine's ubiquity in agricultural areas is provided by a US Geological Survey study in which atrazine was the most commonly detected herbicide in 303 wells samples across the US midwestern agricultural heartland (2). In Croatia, atrazine is used primarily for the control of broad-leaved weeds in corn (3), and it is used extensively for this purpose both within the Lonjsko Polje Nature Park boundaries, and in border areas hydrologically connected to the Park.

The objectives of this study were to determine if atrazine applied to corn fields within the Nature Park was being transported to soils and pond sediments in the Park's natural areas, particularly to high-value ecological resources. To assess the occurrence of atrazine in natural areas within the Lonjsko Polje, sediments were collected from ponds (permanent and ephemeral), and both surface and subsurface (cores) samples were collected from fields and forests. Surface and subsurface soil samples were also collected from corn fields routinely treated with atrazine to determine residual atrazine concentrations at the end of the growing season. Atrazine transport from treated corn fields to pristine

područja parka moguć je u obliku otopljenih ili adsorbiranih (na česticama erodiranog tla) atrazina tijekom sezonskih poplava, uobičajenih u Lonjskom polju. Mjesta za uzorkovanje odabrali su glavni istraživač i osoblje Parka ovisno o ekološkoj vrijednosti područja i vodeći računa da se uzorci tla uzmu s kukuruznih polja različita načina uzgoja. Svi uzorci su sakupljeni između 9. rujna i 2. listopada 2002. U drugom dijelu tog razdoblja bere se kukuruz s polja na kojima se primjenjuje atrazin.

areas in the Park may occur through overland transport of dissolved or sorbed (on eroded soil particles) atrazine during the seasonal flooding common in Lonjsko Polje.
Sampling sites were selected by the lead investigator and park personnel based on the value of the ecological resource and to sample soil under a variety of corn production methods. All samples were collected between September 9 and October 2, 2002. The latter part of this period marked the beginning of the corn harvest from the atrazine treated fields.

Materijal i metode

Uzorkovanje i analiza tla i sedimenta

Većina uzoraka je sakupljena metodom transekta kroz polja i šume na dubinama tla od 0 do 5 cm upotrebom 24" sonde za tlo. Dodatno je sakupljen ograničeni broj uzoraka na dubinama tla od 0 do 35 cm. Uzorci sedimenta su sakupljani sondom za tlo na obalama vodotoka. Sakupljeni uzorci tla ili sedimenta smješteni su u prethodno izvagane plastične posude sa 20 ml polypropilena koje su zatim zatvorene. U laboratoriju je 10 ml otopine za ekstrakciju, koja se sastoji od 70 postotne otopine metanola u vodi, dodano svakom uzorku tla. Posude s uzorcima snažno su protresene rukom, a zatim su uzorci stavljeni u grijač na 55-60 ^{0}C i protresani ručno svakih 30 minuta tijekom 4 sata. Nakon četverosatnoga razdoblja ekstrakcije, uzorak je izvađen iz grijača, protresen snažno rukom i odložen da se slegne preko noći. Sličnu tehniku ekstrakcije povećanom temperaturom primjenjivali su Huang i Pignatella (4). Sljedećega dana supernatant ekstrakta tla je poipetiran u 20 mililitarsku staklenu kušalicu. Ostatak sedimenta i ekstrahirana otopina smješteni su nepoklopljeni preko noći na temperaturu od 105 ^{0}C da se osuše kako bi se odredila suha masa tla i sedimenta. U sljedećem koraku 2 mililitra ekstrahirane tekućine stavljamo u 20 mililitarske kušalice u koje dodajemo još 10 ml vode. Taj volumen ekstrakta se tada pušta kroz prekondicionirane C18 SPE kolone. SPE kolone su isprane sa 2 ml 10-postotnoga metanola, a zatim je atrazin otopljen iz kolona sa 2 ml 100-postotnoga metanola. Ta otopina je posve isušena, a tada je atrazin ponovno otopljen u 200 l metanola i u 1300 l vode da bi se stvorio konačan uzorak za HPLC analizu. Uspješnost ekstrakcije tom metodom iznosi 86,2 ± 1,2 %. Uvjeti HPLC primijenjene analize bili su 1,2 ml/min za 50/10/40 metanol/acetonitril/voda, 4 - C8 kolona i

Material and methods

Soil and sediment collection and analysis

Most samples were collected in transects across fields or forests at the 0-5 cm depth using a 24" soil auger. These samples were supplemented by a limited number of cores from the 0-35 depth. The sediment samples were collected near shore using the auger. Following collection, the soil or sediment samples were placed in pre-weighed 20-ml polypropylene vials and capped. In the laboratory, 10 ml of a 70% methanol/water extraction solution was added to each vial. The vials were shaken vigorously by hand and then placed in an oven at 55-60^{O}C and shaken manually every 30 minutes over a 4h period. After the 4h extraction period, the samples were removed from the oven, shaken vigorously by hand, and allowed to settle overnight. This elevated temperature extraction technique is similar to that used by Huang and Pignatello (4). The next day, the supernatant of the soil extracts was pipetted into 20-ml glass vials. The remaining sediment and extraction solution was placed uncapped in a 105^{O}C oven overnight to dry to allow determination of the soil and sediment dry weights. In the next step, 2-ml aliquots of the extracts were transferred to 20-ml glass vials, to which an additional 10 ml of water was added. This extract volume was then passed through pre-conditioned C18 SPE columns. The SPE columns were washed with 2 ml of 10% methanol and then the atrazine was eluted from the columns with 2 ml of 100% methanol. This volume was evaporated to dryness, then the atrazine was redissolved 200 uL of methanol followed by 1300 uL of water to constitute the final extract for HPLC analysis. The extraction efficiency of this technique was 86.2 + 1.2%. The HPLC conditions used for analysis were 1.2 ml/min of 50/10/40 methanol/acetonitrile/water, a 4-m C8 column, and an analytical wavelength of 230 nm. Using this method, the limit of quantitation of

analitička valna duljina od 230 nm. Uz uporabu ove metode granica utvrđenoga određivanja atrazina u uzorcima tala i sedimenta Lonjskog polja bila je blizu 3,50 pmol/g ili 0,75 ng/g.

Rezultati i rasprava

Prirodna područja. Uzorci tla su sakupljeni u parku prirode Lonjsko polje, posebno zaštićenom području blizu Čigoća, na šumskom području uz cestu Krapje - Novska, u plavljenom području uz rijeku Česmu i u Lonjskom polju uz Osekovo (Osekovsko polje). Sediment je sakupljen u barama kod Čigoća i u Osekovskom polju. Nijedan od tih uzoraka nije sadržavao mjerljivu količinu atrazina. To nije iznenađujuće kada se zna da velika količina atrazina treba biti prenesena s kukuruznih polja, na kojima je primjenjivan, do prirodnih područja kako bi to rezultiralo mjerljivim količinama u prirodnom tlu. Osim toga, proces razrijeđenja i degradacije koji djeluju tijekom ljeta smanjit će koncentracije atrazina eventualno prenesenog s kukuruznih polja.

Kukuruzna polja. Veći broj kukuruznih polja s različitim vrstama korova uzorkovan je na području Lonjskoga polja. Slike 1. i 2. prikazuju koncentracije atrazina u tlu na transektima kroz šest različitih kukuruznih polja u parku prirode. Najveća utvrđena koncentracija atrazina iznosila je 453 pmol/g. Srednja koncentracija za sve transekte, prikazane na slikama 1. i 2., iznosila je 33,3 pmpl/g. Za usporedbu: ako je atrazin primijenjen u koncentraciji herbicida od 1000 g/ha, koncentracija u gornjem sloju tla (0 - 5 cm

atrazine in Lonjsko Polje soil and sediment samples was near 3.50 pmol / g or 0.75 ng / g.

Results and Discussion

Natural areas. Soil samples were collected in the Lonjsko Polje Nature Park's special protection area near Cigoc, from forested areas off the Krapje to Novska road, the Chesma river flood plain, and Osekovo polje. Sediments were collected from ponds in the Park's special protection area near Cigoc and in Osekovo polje. None of these samples contained detectable levels of atrazine. This was not unexpected as large amounts of atrazine would have to be transported from the treated corn fields to the natural areas to result in detectable amounts in the natural soils. In addition, the processes of dilution and degradation operating over the course of the summer would have reduced the concentration of any atrazine transported from the corn fields.

Corn fields. A number of corn fields with varying weed populations were sampled in Lonjsko Polje. Figures 1 and 2 depict the atrazine concentrations of transects taken across 6 different corn fields in the Park. The highest concentration of atrazine detected was 453 pmol/g. The median concentration for all transects represented in Figures 1 and 2 was 33.3 pmol/g. For purposes of comparison, if atrazine was applied at the herbicide label rate of 1000 g/ha, the concentration in the top 0-5 cm of soil immediately after application would approximate 6000 pmol/g.

Figure 1. Atrazine surface soil concentration in Lonjsko Polje corn fields.
Koncentracija Atrazina u tlu na poljima kukuruza u Lonjskom polju

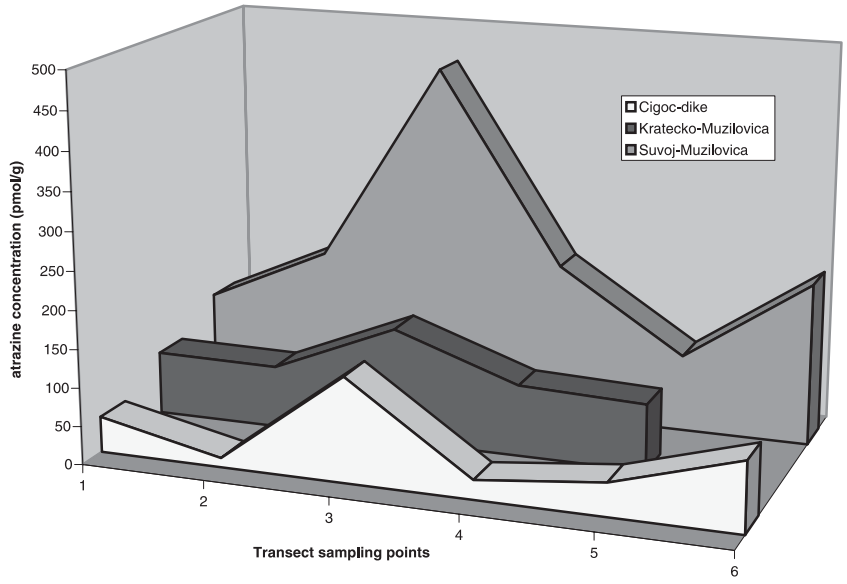
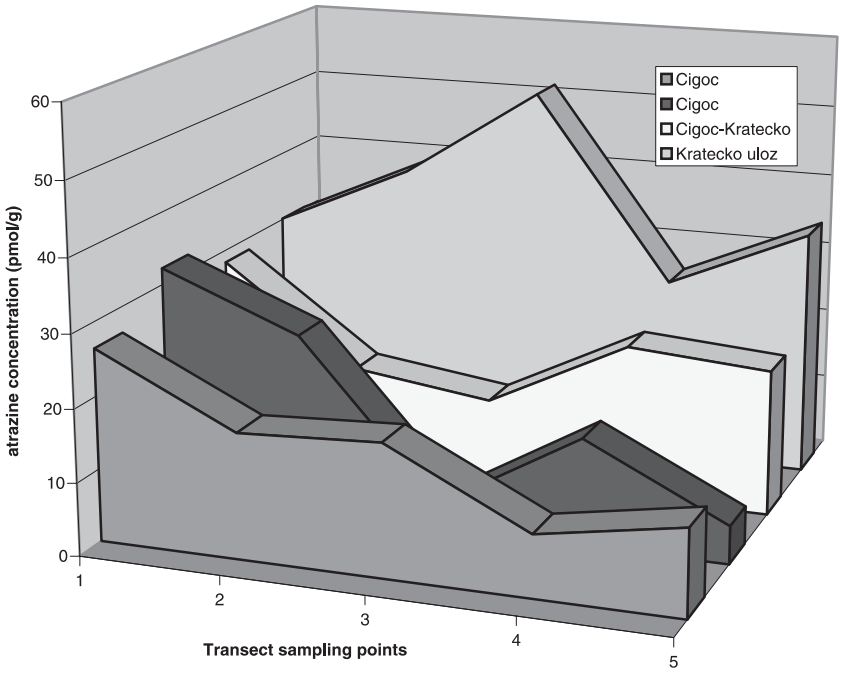


Figure 2. Atrazine surface soil concentration in Lonjsko Polje corn fields.
Koncentracija Atrazina u tlu na poljima kukuruza u Lonjskom polju



dubine), odmah nakon primjene bit će otprilike 6000 pmol/g. Uzmemo li tu početnu koncentraciju atrazina, više od pola uzoraka tla skupljenih iz sloja 0 - 5 cm dubine sadrži manje od 1% teoretske koncentracije atrazina u trenutku primjene.

Slike 3. i 4. prikazuju uzorke tla sakupljene s kukuruznih polja uz cestu prema ulazu u Lonjsko polje kod Kratečkog. Kako je i očekivano, najveća koncentracija atrazina nađena je u površinskom sloju tla. Na grafičkim prikazima može se vidjeti da koncentracija atrazina s dubinom opada, a onda opet

Given this initial atrazine concentration, more than half of the soil samples collected from the 0-5 cm depth contained less than 1.0% of the theoretical atrazine concentration at application.

Figures 3 and 4 depict soil cores collected from corn fields in Kratecko uloz polje. As expected, the highest atrazine concentrations were detected near the soil surface. In the two figures a pattern of atrazine concentration decreasing and then increasing with depth may be observed. While it is not possible to make definitive conclusions based on

Figure 3. Atrazine concentration at different soil depths in a corn field in Kratecko ulaz polje 1
Koncentracija Atrazina na različitim dubinama tla na kukuruznim poljima u Kratecko ulaz polje 1.

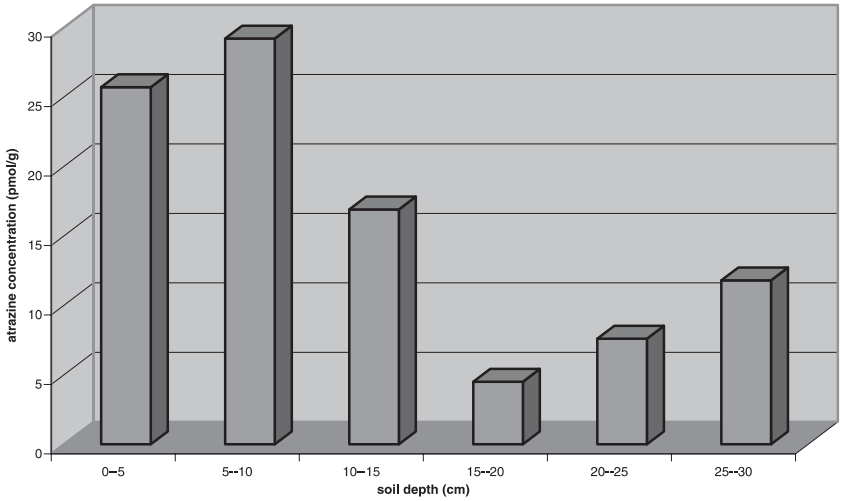
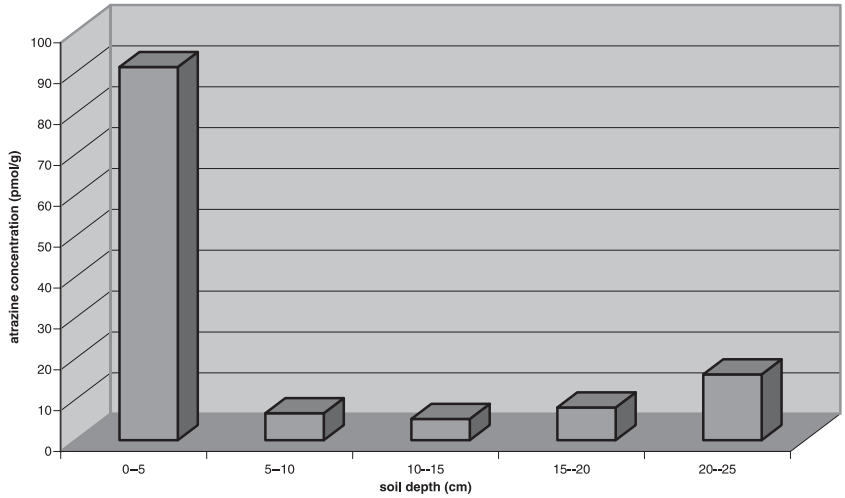


Figure 4. Atrazine concentration at different soil depths in a corn field in Kratecko ulaz polje 2.
Koncentracija Atrazina na različitim dubinama tla na kukuruznim poljima u Kratecko ulaz polje 2.



raste. Iako nije moguće donositi konačne zaključke, s obzirom na mali broj uzoraka, prividno povećanje koncentracije atrazina na većim, najnižim dubinama uzorkovanja može se pripisati smanjenju stupnja degradacije atrazina u nižim slojevima tla kao posljedici smanjenja aktivnosti bakterija i molekularne koncentracije kisika.

Istraživanja su pokazala da atrazin može djelovati kao remetitelj endokrinog sustava u organizmima. Tako može smanjiti reproduktivni uspjeh osjetljivih vrsta. Nedavno je otkriveno da otopina atrazina čak u malim koncentracijama od 0,1 ěg/l izaziva hematofroditizam kod afričke češnjače (5). Koncentracija atrazina u vodi pora između čestica tla u uzorcima sakupljenim u ovoj studiji premašuju 0,1 ěg/l, iako u jednoj drugoj studiji analiza podzemne i površinske vode pokazuje da koncentracije rijetko prelaze tu vrijednost (6).

Zahvale

Ova istraživanja koncentracije atrazina u parku prirode Lonjsko polje zahvaljujemo zajedničkom naporu, što ga je poduprlo veleposlanstvo SAD-a u Zagrebu preko Embassy Science Fellows programa, Agencije za zaštitu okoliša SAD-a i Ministarstva zaštite okoliša i prostornog uređenja RH.

these limited data sets, the apparent increase in atrazine concentration at the lowest sampled depths may be attributed to decreased atrazine degradation rates at the lower soil depths resulting from reduced microbial activity and molecular oxygen concentrations.

Research has indicated that atrazine can act as an endocrine disruptor, reducing the reproductive success of susceptible species. Recently, atrazine aqueous concentrations as low as 0.1 mg / L were found to induce hermaphroditism in African clawed frogs (5). The atrazine concentration in the soil pore waters of many of the soil samples collected in this study would certainly exceed the 0.1 mg / L concentration; however, in an additional study, analysis of ground and surface waters' concentrations in Lonjsko Polje rarely exceeded this concentration (6).

Acknowledgements

This study to measure atrazine concentrations in the Lonjsko Polje Nature Park was a cooperative effort supported by the US Consulate in Zagreb through the Embassy Science Fellows program, the US Environmental Protection Agency, and the Croatian Ministry of the Environmental and Physical Planning.

Literatura:

(1) Hicks, B., 1998. Generic Pesticides The products and markets. Agrow Reports, PJB Publications.

(2) Kolpin, D.W., Thurman, E.M., Goolsby, D.A., 1996. Occurrence of selected pesticides and their metabolites in near-surface aquifers of the Midwestern United States. Environ. Sci. Technol. 30:335-340.

(3) Hrlec, G., 1990. Restriction in herbicide applications. Glas. Zast. Bilj. 13:252-255.

(4) Huang LQ, Pignatello JJ. 1990. Improved extraction of atrazine and metolachlor in field samples. J Assoc Of Anal Chem 73:443-446.

(5) Hayes, T.B., Collins, A., Lee, M., Mendoza, M., Noriega, N., Stuart, A., Vonk, A. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. Proc. Natl. Acad. Sci. USA, 99:5476-5480.

(6) Bouchard, D.C., Kovacic, D., Gugic, G. 2003. Measuring atrazine levels in Lonjsko Polje surface and well waters. Lonsko Polje Nature Park Bulletin, xx-xx.

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MJERENJE RAZINE ATRAZINA U POVRŠINSKIM I BUNARSKIM VODAMA PARKA PRIRODE LONJSKO POLJE

Sažetak

Uvid u koncentracije atrazina u površinskim i podzemnim vodama parka prirode Lonjsko polje izvršen je u jesen 2002. Nijedan od uzoraka podzemne vode nije sadržavao mjerljive koncentracije atrazina, što znači da su u tom pogledu bili ispunjeni uvjeti koji se traže za pitke vode. Ipak, koncentracija atrazina u nekim površinskim vodama bila je viša od one za koju se odnedavno zna da škodi vodozemcima.

Uvod

Herbicid atrazin ide u red pesticida s najširom uporabom, a kako je o njegovu utjecaju na okoliš i zdravlje ljudi od 1995. provedeno više od 200 istraživanja, ujedno je i jedan od najbolje proučenih pesticida. Atrazin se širom svijeta primjenjuje za suzbijanje korova u kukuruzu, prosu, šećernoj repi, ananasu, šumama, voćnjacima i vinogradima, a najviše u proizvodnji kukuruza (1). U SAD-u se na atrazin potroši 76 milijuna funti godišnje, a 75% toga iznosa odnosi se na njegovu primjenu u proizvodnji kukuruza. Spoznaja o njegovoj posvemašnjoj prisutnosti u poljoprivrednim područjima potvrđena je studijom US Geological Survey, u kojoj je atrazin najčešće utvrđen herbicid u 303 uzorka bunarske vode srednjega zapada Sjedinjenih Država (2). U Hrvatskoj se atrazin uglavnom upotrebljava za suzbijanje širokolisnih korova u kukuruzu (3), a ekstenzivno za iste svrhe jednako širom parka prirode Lonjsko polje i u rubnim područjima koja su s njim hidrološki povezana.

Istraživanjima se htjelo utvrditi je li atrazin primijenjen u kukuruznim poljima parka prirode prenesen površinskim ili podzemnim vodama u druge dijelove parka, posebno u ekološki visoko vrijedna područja. Postojanje i razmjeri kontaminacije podzemnih voda istraženi su uzorkovanjem bunara što služe za poljoprivredu i domaćinstva. Kako bi se istražilo pojavljivanje atrazina u površinskim vodama, uzorci su sakupljeni iz rijeka, stajaćih voda (trajnih ili povremenih) i iz drenažnih kanala u poljima. Atrazin se u površinske vode može prenijeti na dva načina: vezom kontaminirane podzemne vode s površinskom vodom i/ili transportom tlom otopljenog

MEASURING ATRAZINE LEVELS IN LONJSKO POLJE NATURE PARK SURFACE AND WELL WATERS

Abstract

A survey of atrazine concentrations in surface and ground waters in the Lonjsko Polje Nature Park was performed in the autumn of 2002. None of the ground water samples contained any detectable atrazine, indicating that the sampled wells met drinking water standards with respect to atrazine. However, atrazine concentrations in some surface waters exceeded those recently shown to have deleterious effects on amphibian populations.

Introduction

Atrazine herbicide is one of the world's most widely used pesticides; and, with more than 200 environmental fate and health effects studies conducted since 1995, it is also one of the world's most thoroughly studied pesticides. Atrazine is used world-wide for weed control in corn, sorghum, sugar cane, pineapple, forestry, orchards, and vineyards, with the largest usage in corn production (1). In the USA, 76 million pounds of atrazine are used yearly, with 75% of this amount being used in corn production. A sense of atrazine's ubiquity in agricultural areas is provided by a US Geological Survey study in which atrazine was the most commonly detected herbicide in 303 wells samples across the US midwestern agricultural heartland (2). In Croatia, atrazine is used primarily for the control of broad-leaved weeds in corn (3), and it is used extensively for this purpose both within the Lonjsko Polje Nature Park boundaries, and in border areas hydrologically connected to the Park.

The objectives of this study were to determine if atrazine applied to corn fields within the Park was being transported to surface and ground waters in other areas in the Park, particularly to high-value ecological resources. The existence and extent of ground water contamination was assessed through sampling of both agricultural and domestic use wells. To assess the occurrence of atrazine in surface waters, samples were collected from rivers, ponds (permanent and ephemeral), and field drainage canals. Atrazine transport to surface waters may occur through two processes: through connection of contaminated ground-waters with surface waters, and/or through overland transport of dissolved or sorbed (on eroded soil particles) atrazine. Given the

ili adsorbiranog (na erodiranim česticama tla) atrazina. Kako su u Lonjskom polju česte sezonske poplave, početna analiza pruža indicije da nadzemni prijenos u parku možda prevladava.
Mjesta uzorkovanja odabrali su vodeći istraživači i osoblje Parka prema vrijednosti vodnoga dobra i na temelju prethodnoga znanja o vodama izloženima onečišćenju. Svi uzorci su sakupljeni između 9. rujna i 2. listopada 2002. Završni dio tog razdoblja podudara se s početkom žetve kukuruza s polja na kojima je rabljen atrazin.

Materijali i metode

Uzorci vode su sakupljani iz površinskih voda i bunara u parku prirode Lonjsko polje i oko njega te pohranjeni u 500 mililitarske polipropilenske posude na temperaturi okoliša kraće od 24 sata. Štrcaljkama za jednokratnu uporabu 300 ml tekućine iz svakog uzorka propušteno je kroz C-18 ekstraktor krute faze (SPE), patrone prethodno kondicionirane sa 5 ml 80-postotne otopine metanola u vodi i isprane sa 5 ml vode neposredno prije uporabe. SPE ekstrakcijska patrona je tada pohranjena u 20 mililitarsku polipropilensku kušalicu do ekstrakcije i analize u laboratoriju. U laboratoriju je patrona stavljena u cijevni vakuumski aparat, isprana sa 2 ml 10-postotnoga metanola i tada za pet minuta osušena na zraku. Atrazin je zatim otopljen sa 2 ml 100-postotnoga metanola i spremljen u plastičnu kušalicu. Otopina je filtrirana kroz 0,45 m PTFE filtar koji je zatim ispran s dodatnih 1 ml metanola. Otopina je zatim osušena do krute faze, ohlađena, a potom je 200 ml metanola dodano u kušalicu i miješano kako bi se atrazin otopio. Količina od 1300 ml vode dodana je uzorku kako bi konačni ekstrakt sadržavao 1,5 ml. Ekstrakt je tada propušten kroz 0,2 m prethodno kondicionirani PTFE filtar i skupljen u HPLC kušalicu za analizu na instrumentu. Ekstrakcijska uspješnost primijenjene tehnike iznosi 89,9 + 1,7 %. Uvjeti u HPLC analizi koji su ovdje primijenjeni iznose 1,2 ml/min za 50/15/35 metanol/acetonitril/voda, uz 4 -m C8 kolonu i analitičku valnu duljinu od 230 nm. U primjeni ove metode granične vrijednosti utvrđene koncentracije atrazina u uzorcima vode iz Lonjskoga polja bile su oko 0,14 nmol/l ili 0,03 mg / l.

Rezultati i rasprava

Podzemne vode. Atrazin nije nađen u uzorcima vode iz bunara. Uzorkovani bunari ukjučuju bunare na pašnjacima i u šumovitom području na rubovima pašnjaka (Čigoć, Kratečko, Pavlinov Kljun-

prevalence of seasonal flooding in Lonjsko Polje, an initial assessment indicated that the overland transport process was probably the dominant one in the Park.
Sampling sites were selected by the lead investigator and park personnel based on the value of the water resource, and on a priori knowledge of the water bodies' susceptibility to contamination. All samples were collected between September 9 and October 2, 2002. The latter part of this period marked the beginning of the corn harvest from the atrazine treated fields.

Material and methods

Water was collected from surface water bodies or from wells in and around the Lonjsko Polje nature park and stored in 500-ml polypropylene containers at ambient temperature for less than 24h. Using a disposable syringe, a 300-ml aliquot of each sample was passed through a C-18 solid phase extraction (SPE) cartridge that had been preconditioned with 5-ml of 80% methanol-water and then washed with 5 ml of water prior to use. The SPE extraction cartridges were then stored in 20 ml polypropylene vials until laboratory extraction and analysis. In the laboratory the cartridges were placed on a vacuum manifold apparatus, washed with 2 ml of 10% methanol, and then dried for 5 minutes using ambient air. The atrazine was then eluted from the column with 2 ml of 100% methanol and collected in a glass vial. The eluate was filtered through a 0.45-m PTFE filter and the filter washed with an additional 1 ml of methanol. The eluate was evaporated to dryness, cooled, and 200 mL of methanol added to the vial and swirled to solubilize the atrazine. A 1300-mL aliquot of water was added to bring the final extract volume to 1.5 ml total, and the extract was passed through a 0.2-m preconditioned PTFE filter and collected in an HPLC vial for instrumental analysis. The extraction efficiency of this technique was 89.9 + 1.7%. The HPLC conditions used for analysis were 1.2 ml/min of 50/15/35 methanol/acetonitrile/water, a 4-m C8 column, and an analytical wavelength of 230nm. Using this method, the limit of quantitation of atrazine in Lonjsko Polje water samples was near 0.14 nmol / L or 0.03 mg / L.

Results and Discussion

Ground waters. No atrazine was found in any of the sampled well waters. The sampled wells included wells in the agricultural pastures or in forested areas on a pasture periphery (Gigoc, Kratecko oyracteri

Mužilovčica) te bunar u selu s pitkom vodom (Mužilovčica). Odsutnost atrazina u uzorkovanim bunarima pomalo iznenađuje ako se zna kakva je uporaba atrazina u području. Međutim, tlo je ovdje slabo propusno što sprječava prijenos atrazina s površine do podzemnih voda i podržava nadzemni prijenos. Koncentacija atrazina u tlima Lonjskoga polja predmet je sljedećeg izvješća.

Ako se uzmu u obzir granične vrijednosti utvrđenoga atrazina u ovoj studiji, može se reći da uzorkovani bunari ispunjavaju postojeće standarde za atrazin u pitkoj vodi koji vrijede u SAD i EU. Glede toga je poučno vidjeti različite pristupe pri određivanju standarda za pitke vode u SAD-u i u EU. U SAD-u je trenutačno US Environmental Protection Agency svrstao atrazin kao "vjerojatno nije karcinogen". Tako je po propisu o pitkim vodama (US Safe Drinking Water Act) primijenjeni standard za najveću razinu zagađivala (Maximum Contaminant Level) za atrazin vrijednost postavljena na 3 mg / l. U EU je primijenjen drugi pristup postavljanjem vezanih ciljeva za pitku vodu koji se ne poštuju uvijek zbog tehničkih ili ekonomskih razloga. Bilo kako bilo, EU je postavila standard od 0,10 mg / l za svaki pojedini pesticid u pitkoj vodi, sa zbirnim limitom od 0,50 mg / l za sve pesticide u uzorku vode.

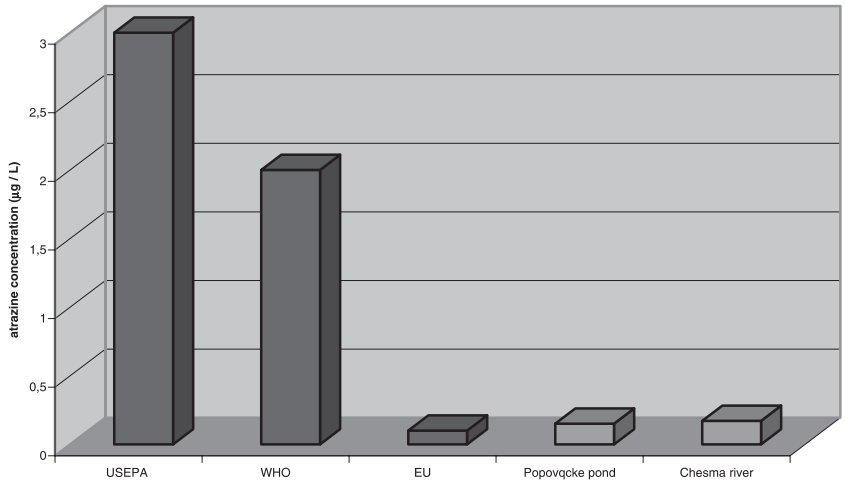
Površinske vode. Analiza uzoraka površinskih voda zahtijeva otkrivanje mjerljive koncentracije atrazina u dva uzorka. Kako je već rečeno, svi uzorci potječu iz jesenskog razdoblja, dugo nakon proljetne primjene atrazina i od proljetno-ljetnog doba kada se očekuje njegova najviša koncentracija. U prethodnim istraživanjima koncentracija atrazina u uzorcima iz rijeke Save iznosila je između 0.06 mg / l i 1,7 mg / l u lipnju i kolovozu, nakon čega je naglo opadala u jesen (3). Sličan sezonski obrazac nađen je u vodama onečišćenim atrazinom sa svinjogojske farme u okolici Zagreba (4).
Slika 1. prikazuje koncentacije atrazina u ta dva uzorka u usporedbi s različitim standardima za pitku vodu. Iako te dvije onečišćene površinske vode nisu javni izvori pitke vode, usporedba sa standardima za pitku vodu je informativna u tome što su standardi za pitku vodu više vezanog tipa nego standardi kakvoće vode za druge namjene, kao što je rekreacija ili poljoprivreda. Otkriće atrazina u jezeru u popovačkim nizinskim šumama pomalo iznenađuje jer u neposrednoj blizini nema velikih kukuruznih polja. Možda je atrazin primijenjen u uzgojnim radovima u okolnim šumama.
Što se tiče fiziološkog i ekološkog utjecaja atrazina, istraživanja pokazuju da atrazin može remetiti endokrine procese. Primijećeno je da pri

posnjale, Pavlinav Klijuor), and a domestic drinking water well (Muzilovica). The lack of atrazine in the sampled wells was somewhat surprising given the history of atrazine use in the area. However, the soils in the area are of low permeability and this would impede atrazine transport from the soil surface to ground water and enhance overland transport. Atrazine soil concentrations within Lonjsko Polje are the subject of a subsequent report.

Given the limit of detection of atrazine in this study, it can be stated that all of the sampled wells meet existing water quality standards for atrazine in the USA and the EU. In this regard, it is informative to look at the different approaches for setting drinking water standards in the USA and in the EU. In the USA, atrazine is currently classified by the US Environmental Protection Agency as "not a likely carcinogen;" and, under the US Safe Drinking Water Act, an enforceable standard, the Maximum Contaminant Level for atrazine, has been set at 3 mg / L. The EU takes a different approach by setting stringent drinking water goals that are not always enforced due to technical or economic considerations. Hence, the EU has set one standard of 0.10 mg / L for any individual pesticide in drinking water, with a limit of 0.50 mg / L for all of the pesticides in one sample.

Surface waters. Analysis of surface water samples revealed quantifiable atrazine concentrations in two samples. As noted above, all of the sampling occurred in the fall, long after spring atrazine application, and at a time later than the spring-summer period when atrazine concentration peaks would be expected. In a prior study, the atrazine concentration in samples collected from the Sava river ranged between 0.06 and 1.7 mg / L in July and August and then rapidly decreased in the autumn (3). A similar seasonal pattern was also observed in atrazine-contaminated waters from pig breeding operations in the Zagreb area (4).
Figure 1 depicts the atrazine concentration in these two samples as compared to various drinking water standards. Although these two contaminated surface waters are not public drinking water sources, comparisons to drinking water standards are informative in that drinking water standards are more stringent than water quality standards set for other uses, such as recreational or agricultural uses. The detection of atrazine in the Popovqke pond was somewhat surprising in that this area was not adjacent to any large corn fields. However, it is possible that atrazine was being used in the active forestry operations in the area.
Looking at the physiological and ecological effects of atrazine, research has indicated that atrazine can

Figure 1. Atrazine concentration in Lonjsko Polje nature park surface waters compared to drinking water values.
Koncentracija Atrazina u parku prirode Lonjsko polje - vrijednosti u površinskim vodama u usporedbi sa vrijednostima vode za piće



koncentraciji od 100 -m mola atrazin inhibira fiziološko vezanje liganda na androgeni receptor i na androgeni vezni protein kod štakora (5). Zapaženo je također da se atrazin ponaša kao kompetitor s estrogenom 17E estradiol za vezu na receptor estrogena u ekstraktu proteina pripravljenom iz jajovoda krokodila (6). Nedavno je otkriveno da otopina atrazina u koncentracijama tako malim kao što je 0,1 mg / l izaziva hermafroditizam u afričke češnjače (7). Činjenica da je na oba lokaliteta - jezero u popovačkim nizinskim šumama i u rijeci Česmi - utvrđena koncentracija atrazina iznad 0,1 mg / l, treba zabrinuti Upravu Parka prirode Lonjsko polje jer ugrožava zdravlje populacija vodozemaca, što je važno s obzirom na njihovu ulogu u prehrambenim mrežama. Buduća istraživanja koncentracija atrazina u površinskim vodama parka trebala bi dokumentirati sezonske varijacije koncentracija atrazina i dati osnovu s kojom bi se uspoređivali rezultati studija o ekološkom utjecaju atrazina.

act as an endocrine disruptor. At 100-mmolar concentration, atrazine has been observed to inhibit physiological ligand binding to the androgen receptor and to rat androgen binding protein (5). Atrazine has also been shown to compete with the estrogen 17$-estradiol for binding to the estrogen receptor in a protein extract prepared from the alligator oviduct (6). More recently, atrazine aqueous concentrations as low as 0.1 mg / L were found to induce hermaphroditism in African clawed frogs (7). Since both the Popovqcke pond and Chesma river sites yielded atrazine concentrations above the 0.1 mg / L level, this may be some cause for concern within the Lonjsko Polje Nature Park given its wealth of amphibian populations and the role that these populations play in the food web. Further investigations on atrazine surface water concentrations in the Park should attempt to document seasonal variations in atrazine concentration; this work could provide a baseline against which ecological effects studies could be compared.

Zahvala

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Literatura:

(1) Hicks, B., 1998. Generic Pesticides - The products and markets. Agrow Reports, PJB Publications.

(2) Kolpin, D.W., Thurman, E.M., Goolsby, D.A., 1996. Occurrence of selected pesticides and their metabolites in near-surface aquifers of the Midwestern United States. Environ. Sci. Technol. 30:335-340.

(3) Hrlec, G., 1990. Restriction in herbicide applications. Glas. Zast. Bilj. 13:252-255.

(4) Gojmerac, T., 1996. Seasonal atrazine contamination of drinking water in pig-breeding farm surroundings in agricultural and industrial areas of Croatia. Bull. Environ. Contam. Toxic. 56:225-230.

(5) Danzo, J.D., 1997. Environmental xenobiotics may disrupt normal endocrine function by interfering with the binding of physiological ligands to steroid receptors and binding proteins. Environ. Health Perspect. 105:294-301.

(6) Vonier, P.M., Crain, D.A., McLachlan, J.A., Guillette, L.J., Arnold, S.F., 1996. Interaction of environmental chemicals with the estrogen and progesterone receptors from the oviduct of the American alligator. Environ. Health. Perspect. 104:1318-1322.

(7) Hayes, T.B., Collins, A., Lee, M., Mendoza, M., Noriega, N., Stuart, A., Vonk, A. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. Proc. Natl. Acad. Sci. USA, 99:5476-5480.

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