TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

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The Wetlands Diversity

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

Sibiu - Romania
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IN MEMORIAM

Roger Bacon
(1214-1294)

Roger Bacon was one of the first medieval philosophers to champion experimental science. The details of his life are uncertain and he has become something of a legend, but his lifelong search for truth should be an example and inspiration to scientists today.

He was born, probably in 1214, into a wealthy family in the ancient town of Ilchester in the county of Somerset in S.W. England. This was an unstable and often violent age - *Roger Bacon* himself wrote of how “justice perishes, all peace is broken” - and his family lost property and royal influence in the civil war between Henry III and Simon de Montfort, Earl of Leicester, now regarded as a father of parliamentary democracy.

This was also a time of greatly expanding knowledge. The 12th-13th centuries, the age of Dante, Giotto, St. Francis and St. Thomas Aquinas, saw the flowering of the High Middle Ages, with the growth of universities in Italy, Spain, France and England, the increased use of practical agricultural innovations such as improved crop rotation and the windmill, and much building of great cathedrals in western Europe.

Roger Bacon studied at the University of Oxford, by then well established, remaining there to lecture to students on Aristotle. By the 1240s he was lecturing at the University of Paris, the very hub of European intellectual life. *Roger Bacon* was one of several philosophers, including the great Aristotelian scholar Albertus Magnus (1193-1280), with whom he worked in Paris, who would gradually explore what today we would recognize as science.

In 1256, when he was apparently no longer holding an academic post, *Roger Bacon* joined the Franciscan Order of friars, which greatly curtailed his studies, as friars, although living among the ordinary people and not enclosed in monasteries as were the orders of monks, were prohibited from publishing books without approval from the Order.

However, *Roger Bacon* enjoyed the patronage of Cardinal Guy le Gros de Foulques, who became Pope Clement IV. In 1266 this Pope requested that *Roger Bacon* write an account of the place of philosophy within theology, and he gathered together a body of his work as Opus Maius, effectively an encyclopedia of known science. The section on Optics, a particular interest of *Roger Bacon*, is a wide-ranging scientific account of the subject, influenced by Arab texts. *Roger Bacon* wanted science, and languages (he was concerned that too few scholars read Greek), to be an integral part of the philosophy and theology curriculum that dominated university studies. Above all, he strove to promote the work of Aristotle in medieval scholarship.

Roger Bacon has been credited with being a modern scientist and visionary in an age of superstition and the Church’s intolerance of learning. The truth is much more complex, for he was loyal to the Franciscans and there is no reason to suppose he intended other than to improve the intellectual standing of medieval philosophy and lessen the hold of superstition. He was scrupulous in going back to the original Greek texts of Aristotle, who himself had an impressive knowledge of biology and other subjects. He greatly admired Aristotle’s Secretum Secretorum, which had been translated by Arab scholars, and even produced an edition with his own introduction and notes, after his return to Oxford during the late 1270s or early 1280s.

Roger Bacon also wrote on mathematics, astronomy (including the need to reform the Calendar), medicine and alchemy, famously describing and experimenting with samples of gunpowder, which he may have received via a Franciscan embassy to the Mongol khan. A true scientist, he always championed experimental verification over an uncritical appeal to published authority.

He died in Oxford, probably in 1294. Later generations called him *Doctor Mirabilis*.

The Editors

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Preface

In a global environment in which the climate changes are observed from few decades no more only through scientific studies but also through day by day life experiences of average people which feel and understand allready the presence of the medium and long-term significant change in the “average weather” all over the world, the most comon key words which reflect the general concern are: heating, desertification, rationalisation and surviwing.

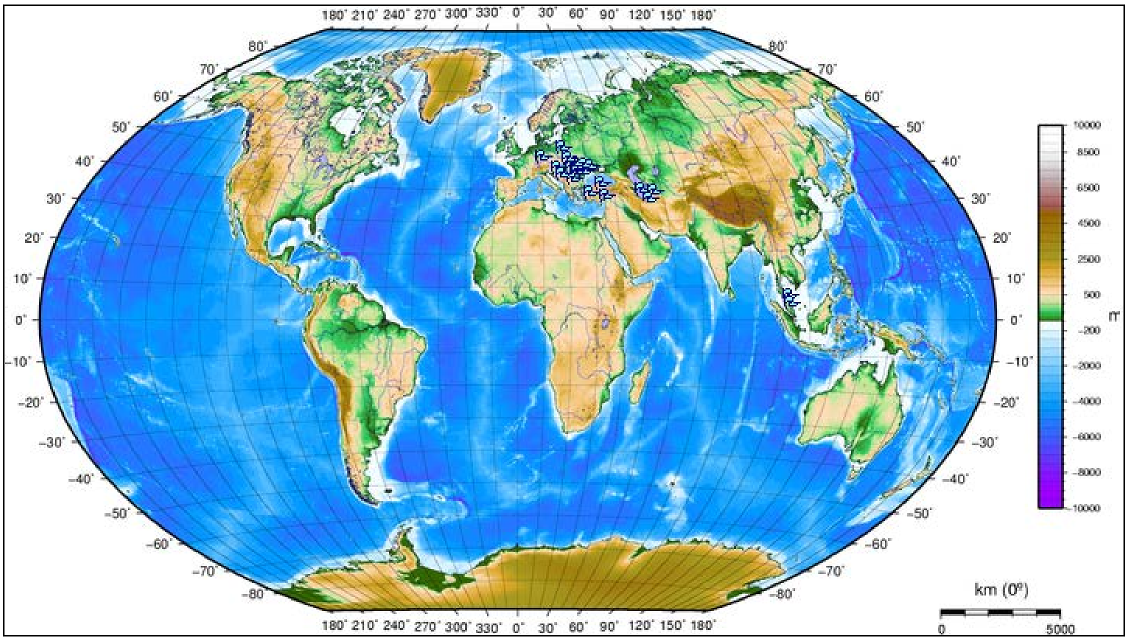
The causes, effects, trends and possibilities of human society to positively intervene to slow down this process or to adapt to it involve a huge variety of aproacess and efforts.

With the fact in mind that these aproaces and efforts shuld be based on genuine scientific understanding, the editors of the *Transylvanian Review of Systematical and Ecological Research* series launch a second annual volumes dedicated to the wetlands, volumes resulted mainly as a results of the *Aquatic Biodiversity International Conference*, Sibiu/Romania, 2007-2013.

The therm wetland is used here in the acceptance of the Convention on Wetlands, signed in Ramsar, in 1971, for the conservation and wise use of wetlands and their resources. **Marine/Coastal Wetlands -** Permanent shallow marine waters in most cases less than six metres deep at low tide, includes sea bays and straits; Marine subtidal aquatic beds, includes kelp beds, sea-grass beds, tropical marine meadows; Coral reefs; Rocky marine shores, includes rocky offshore islands, sea cliffs; Sand, shingle or pebble shores, includes sand bars, spits and sandy islets, includes dune systems and humid dune slacks; Estuarine waters, permanent water of estuaries and estuarine systems of deltas; Intertidal mud, sand or salt flats; Intertidal marshes, includes salt marshes, salt meadows, saltings, raised salt marshes, includes tidal brackish and freshwater marshes; Intertidal forested wetlands, includes mangrove swamps, nipah swamps and tidal freshwater swamp forests; Coastal brackish/saline lagoons, brackish to saline lagoons with at least one relatively narrow connection to the sea; Coastal freshwater lagoons, includes freshwater delta lagoons; Karst and other subterranean hydrological systems, marine/coastal. **Inland Wetlands -** Permanent inland deltas; Permanent rivers/streams/creeks, includes waterfalls; Seasonal/intermittent/irregular rivers/streams/creeks; Permanent freshwater lakes (over eight ha), includes large oxbow lakes; Seasonal/intermittent freshwater lakes (over eight ha), includes floodplain lakes; Permanent saline/brackish/alkaline lakes; Seasonal/intermittent saline/brackish/alkaline lakes and flats; Permanent saline/brackish/alkaline marshes/pools; Seasonal/intermittent saline/brackish/alkaline marshes/pools; Permanent freshwater marshes/pools, ponds (below eight ha), marshes and swamps on inorganic soils, with emergent vegetation water-logged for at least most of the growing season; Seasonal/intermittent freshwater marshes/pools on inorganic soils, includes sloughs, potholes, seasonally flooded meadows, sedge marshes; Non-forested peatlands, includes shrub or open bogs, swamps, fens; Alpine wetlands, includes alpine meadows, temporary waters from snowmelt; Tundra wetlands, includes tundra pools, temporary waters from snowmelt; Shrub-dominated wetlands, shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils; Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils; Forested peatlands; peatswamp forests; Freshwater springs, oases; Geothermal wetlands; Karst and other subterranean hydrological systems, inland. **Human-made wetlands -** Aquaculture (e. g., fish/shrimp) ponds; Ponds; includes farm ponds, stock ponds, small tanks; (generally below eight ha); Irrigated land, includes irrigation channels and rice fields; Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture); Salt exploitation sites, salt pans, salines, etc.; Water storage areas, reservoirs/barrages/dams/impoundments (generally over eight ha); Excavations; gravel/brick/clay pits; borrow pits, mining pools; Wastewater treatment areas, sewage farms, settling ponds, oxidation basins, etc.; Canals and drainage channels, ditches; Karst and other subterranean hydrological systems, human-made.

The editors of the *Transylvanian Review of Systematical and Ecological Research* started and continue this new annual sub-series (*Wetlands Diversity*) as an international scientific debate platform for the wetlands conservation, and not to take in the last moment, some last heavenly "images" of a perishing world …

This seventh volume included variated researches from diverse wetlands around the world.



The subject areas ( ) for the published studies in this volume.

No doubt that this new data will develop knowledge and understanding of the ecological status of the wetlands and will continue to evolve.

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The Editors

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REVISION OF PARASITIC HELMINTHS REPORTED IN FRESHWATER FISH FROM TURKEY WITH NEW RECORDS

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ABSTRACT

This new checklist is an update of helminths of freshwater fish from Turkey. The last publication of a checklist of helminth parasites of freshwater fish in Turkey was over 11 years ago (Öktener, 2003), and there have been a number of new records. This update includes additional records and allows for the correction of errors and omissions that were present in the preceding version. The revision literature indicated the occurrence of 123 parasite species which included 60 monogeneans, 20 digeneans, 20 cestodes, 11 nematodes, seven acanthocephalans, five annelids from 71 different wild fish (64 native, four transitional, three introduced fish) species from freshwater in Turkey. Parasites not identified to species level are listed separately, and not included in the resulting comments, because of reporting different host species. Cyprinidae, with 50 species, is the dominant family among the examined fish with regard to species diversity.

RESUMEN: Revisión de parásitos helmintos reportados en peces de aguadulce en Turquía, con nuevos registros.

Se realizó una actualización del elenco de especies de helmintos parásitos de peces de agua dulce de Turquía. Desde la publicación del último listado de parásitos helmintos de peces dulceacuícolas, hace 11 años (Öktener, 2003), han habido cantidad de nuevos registros. Esta actualización incluye a dichos registros, lo cual permitió la corrección de aquellos errores y omisiones que se cometieron en la versión anterior del listado. La literatura revisada indica la ocurrencia de 123 especies parásitas que incluyen 60 monogeneos, 20 digeneos, 20 céstodos, 11 nemátodos, siete acantocéfalos y cinco anélidos colectados en 71 especies de peces de agua dulce en Turquía (64 especies nativas, cuatro transicionales y tres introducidas). Los parásitos no identificados a nivel especie se enlistan separadamente y no se comentan en los resultados, debido a que son reportados en distintas especies de hospederos. Los ciprínidos, con 50 especies, es la familia dominante entre los peces examinados en cuanto a diversidad específica.

REZUMAT: Revizuire a viermilor paraziți raportați la specii de pești de apă dulce din Turcia, cu noi înregistrări.

Această listă nouă de specii este rezultatul revizuirii parazitării helmintice la speciile de pești de apă dulce din Turcia. De la publicarea primei versiuni în urmă cu peste 11 ani (Öktener, 2003), au mai fost semnalate și alte specii. Prezenta versiune include și semnalările ulterioare și permite corectarea erorilor și omisiunilor din prima versiune. Literatura utilizată a indicat prezența a 123 de specii parazite care au inclus 60 specii monogenee, 20 specii de digenee, 20 de cestode, 11 nematode, șapte acanthocephali, cinci annelide, iar speciile gazdă sunt în număr de 71 (specii sălbatice dulcicole) din care 64 sunt pești autohtoni, patru de tranzit și trei specii introduse. Paraziții care nu au fost identificați la nivel de specie sunt indicați într-o listă separată fără a include comentarii, deoarece se raportează la specii gazdă diferite. Din punct de vedere al diversității speciilor studiate, familia de pești dominantă este cea a Cyprinidaelor cu 50 de specii investigate parazitologic.

INTRODUCTION

The fish-parasite checklist studies are important taxonomic documents in order to obtain the fish-parasite relationships, host selectivity and geographic distribution of fish parasites. They may contribute as a baseline of data in the disciplines of parasitology, zoology, medicine, environmental science in terms of determining biological diversity, treatment and control of parasites, identification of parasite, determining host selectivity and geographic distribution of fish zoonoses, compare of fish parasite fauna of local, regional and worldwide. Research about the helminth parasites of freshwater fish in the world has increased in recent years (Holland and Kennedy, 1997; Arthur and Lumanlan-Mayo, 1997; Palm et al., 1999; Arthur and Ahmet, 2002; Kohn et al., 2006; Salgado-Maldanado, 2006; Luque and Tavares, 2007; Violante-González et al., 2007; Pazooki and Masoumian, 2012).

Turkey is geographically divided into seven regions: the Marmara Region, the Mediterranean Region, the Black Sea Region, the Aegean Region, the Central Anatolia Region, the Eastern Anatolian Region, and the South-Eastern Anatolian Region. These regions have 200 lakes, 206 dam lakes, 953 pond lakes and 33 rivers (Kiliç, 1999). The examination of literature on Turkish freshwater has revealed the report of 248 species (plus 13 introduced) valid freshwater fish species (Frick et al., 2007).

The parasites of Turkey's freshwater fish were poorly known until Paperna (1964) reported the cestode *Caryophyllaeus brachycollis* Janiszewska, in 1951 *Cyprinus carpio*. Articles in different journals, MSc and PhD thesis, symposium, conference proceedings and other reports have been published mentioning parasites of wild, farmed and imported fish by Turkish researchers between 1964 and 2014.

All information about parasites of freshwater fish-parasite have been compiled by Öktener (2003), based on a parasite-host list and host-parasite list, respectively. The author compiled a critical checklist of the metazoan parasites (99 helminths, 12 parasitic crustaceans, one mollusca larvae) of freshwater fish from Turkey. After this checklist, several studies and theses were published by Turkish and foreign scientists. These studies yielded some new distributional records and added new species.

This new checklist was done to update the helminths of freshwater fishes from Turkey. Finally, it was also planned to show and update the parasite richness of fishes of Turkey. It was felt that a critical summary of the freshwater fish parasites known from Turkey to date would help to solve contradictions among researchers, and benefit veterinarians, parasitologists, etc.

MATERIALS AND METHODS

Information from all available references on helminths of freshwater fishes in Turkey (journal publications, reports of research projects, thesis, proceedings of congress, symposium proceedings) from 1964 to 2014 were gathered to provide host-parasite and parasite-host lists.

In the literature dealing with the parasites of freshwater fishes in Turkey, appear many incorrect spellings of parasite names, host names and species author's names, and incorrect attributions of dates of species authorship. The scientific names of all parasites and their synonyms were checked with main electronic sites concerning with the classification (ITIS, 2013; WoRMS Editorial Board, 2014; Gibson et al., 2005). Erroneous spellings of parasite names have been consistently applied, these were noted (Tab. 1).

The scientific names of fishes were checked according to Frick et al. (2007) and the electronic sites Froese and Pauly (2013); WoRMS Editorial Board (2014); Eschmeyer (2014). Similarly, misspellings of host species names, with few exceptions where these have been widely applied, have been corrected without comment using information obtained from Froese and Pauly (2013) (Tab. 2).

Table 1: Change of current valid names and synonymies of helminth species.

Synonyms and incorrect spellings	Valid Name
Diplozoon megan (Nordmann, 1832)	*Paradiplozoon megan* Bykhovskii and Nagibi, 1959
Silurodiscoides vistulensis Gussev, 1985	*Ancylodiscoides vistulensis* Sivak, 1932
Silurodiscoides siluri Gussev, 1976	*Ancylodiscoides siluri* Zandt, 1924
Philometra abdominalis Nybelin, 1928	*Philometra ovate* (Zeder, 1803)
Bothriocephalus gowkonensis (Korting, 1976)	*Bothriocephalus acheilognathi* Yamaguti, 1955
Caryophyllaeus mutabilis Rudolphi, 1802	*Caryophyllaeus laticeps* (Müller, 1781)
Helobdella stagnates Linnaeus, 1758	*Helobdella stagnalis* (Linnaeus, 1758)

Table 2: Change of current valid names and synonymies of fish species.

Synonyms and incorrect spellings	Valid Names
Carassius auratus auratus	*Carassius auratus*
Gobius fluviatilis	*Neogobius fluviatilis*
Cobitis simplicispinna	*Cobitis simplicispina*
Chondostroma regium	*Chondrostoma regium*
Leuciscus cephalus	*Squalius cephalus*
Leuciscus cephalus orientalis	*Squalius cephalus*
Vimba vimba tenella	*Vimba vimba*
Chalcalburnus chalcoides	*Alburnus chalcoides*
Rhodeus sericeus amarus	*Rhodeus amarus*
Rhodeus sericeus	*Rhodeus amarus*
Clarias lazera	*Clarias gariepinus*
Stizostedion lucioperca	*Sander lucioperca*
Nemachilus sp.	*Nemacheilus* sp.
Cyprinion macrostomus	*Cyprinion macrostomum*
Leuciscus lepidus	*Squalius lepidus*
Garra rufa obtusa	*Garra rufa*
Capoeta capoeta bergamae	*Capoeta bergamae*
Barbus plebejus escherichii	*Luciobarbus escherichii*
Barbus rajanorum mystaceus	*Luciobarbus mystaceus*
Barbus rajanorum	*Luciobarbus pectoralis*
Capoeta capoeta umbla	*Capoeta umbla*
Barbus capito pectoralis	*Luciobarbus pectoralis*
Barbus esocinus	*Luciobarbus esocinus*
Pseudophoxinus battalgil	*Pseudophoxinus battalgilae*

RESULTS AND DISCUSSION

This helminth checklist of freshwater fish from Turkey includes only Monogenea, Digenea, Cestoda, Nematoda, Acanthocephala, Annelida and it was compiled with the parasite species arranged by phylum, class and alphabetical, as appropriate. The host-parasite list/parasite-host list are arranged: (1) a list of collected parasite groups and their parasitized fish, the collection site, and author (Tab. 3); (2) a list of parasitized fish with the corresponding species of parasites (Tab. 4).

Table 3: Helminth - Host List.

Phylum Platyhelmintes		
Class Monogenea		
Ancylodiscoides siluri Zandt, 1924		
Silurus glanis	Sapanca Lake	Soylu (1990)
Silurus glanis	İznik Lake	Aydoğdu et al. (1996b)
Silurus glanis	Terkos Lake	Soylu (2005)
Silurus glanis	Almus Dam Lake	Turgut (2005)
Silurus glanis	Siğirci Lake	Çolak (2013)
Ancylodiscoides vistulensis Sivak, 1932		
Silurus glanis	Sapanca Lake	Soylu (1990)
Silurus glanis	Terkos Lake	Soylu (2005)
Silurus glanis	Almus Dam Lake	Turgut (2005)
Silurus glanis	Siğirci Lake	Çolak (2013)
Ancyrocephalus paradoxus Creplin, 1839		
Sander lucioperca	Siğirci Lake	Çolak (2013)
Dactylogyrus affinis Bychowsky, 1933		
Capoeta umbla	Hazar Lake	Aksoy et al. (2006)
Dactylogyrus alatus Linstow, 1878		
Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Chondrostoma regium	Almus Dam Lake	Turgut (2005)
Alburnus alburnus	Mustafakemalpaşa Stream	Aydoğdu and Selver (2006)
Chondostroma regium	Almus Dam Lake	Özgül (2008)
Alburnus heckeli	Murat River	Koyun (2011)

Table 3 (continuing): Helminth - Host List.

Dactylogyrus anchoratus (Dujardin, 1845)		
Cyprinus carpio	Bekteşağa Pond	Özer (1995)
Carassius carassius	Enne Dam Lake	Koyun (2001)
Carassius auratus	Enne Dam Lake	Koyun (2001)
Carassius carassius	Kovada Lake	Özan and Kir (2005)
Carassius gibelio	Seyitler Dam Lake	Öztürk (2010)
Cyprinus carpio	Karacaören II Dam Lake	Samanci (2011)
Carassius carassius	Karacaören II Dam Lake	Samanci (2011)
Carassius auratus	Emre Dam Lake	Öztürk (2011)
Carassius gibelio	Emre Dam Lake	Öztürk (2011)
Carassius gibelio	Siğirci Lake	Çolak (2013)
Dactylogyrus ancylostylus Linstow, 1878		
Luciobarbus pectoralis	Keban Dam Lake	Sağlam (1992)
Luciobarbus esocinus	Keban Dam Lake	Sağlam (1992)
Cyprinus carpio	Keban Dam Lake	Sağlam (1992)
Dactylogyrus asper Linstow, 1878		
Luciobarbus esocinus	Keban Dam Lake	Sağlam (1992)
Luciobarbus mystaceus	Keban Dam Lake	Sağlam (1992)
Dactylogyrus auriculatus (Nordmann, 1832)		
Capoeta umbla	Hazar Lake	Aksoy et al. (2006)
Dactylogyrus baueri Gussev, 1955		
Carassius gibelio	Siğirci Lake	Çolak (2013)
Dactylogyrus bicornis Malevitskaya, 1941		
Rhodeus amarus	Sapanca, Terkos Lakes	Soylu (2009)
Dactylogyrus carpathicus Zakhvatkin, 1951		
Luciobarbus escherichii	Doganci Dam Lake	Aydoğdu (2001)

Table 3 (continuing): Helminth - Host List.

Dactylogyrus chalcalburni Dogiel et Bychow., 1833		
Alburnus chalcoides	Manyas Lake	Öztürk (2000)
Alburnus chalcoides	Terkos Lake	Soylu (2009)
Dactylogyrus cornu Linstow, 1878		
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Vimba vimba	Manyas Lake	Öztürk (2000)
Vimba vimba	Sirakaraağaçlar Stream	Özer and Öztürk (2005)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Dactylogyrus cornoides (Gläser and Gussev, 1971)		
Vimba vimba	Sapanca Lake	Uzunay (2006)
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Dactylogyrus crucifer Wagener, 1857		
Rutilus rutilus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Rutilus frisii	İznik Lake	Aydoğdu et al. (1997b)
Rutilus rutilus	Manyas Lake	Öztürk (2000)
Capoeta tinca	Almus Dam Lake	Turgut (2005)
Rutilus rutilus	Kocadere Stream	Selver (2008)
Capoeta tinca	Almus Dam Lake	Özgül (2008)
Rutilus rutilus	Siğirci Lake	Çolak (2013)
Dactylogyrus difformis Wagener, 1857		
Scardinius erythrophthalmus	Sapanca Lake	Soylu (1990)
Scardinius erythrophthalmus	Manyas Lake	Öztürk (2000)
Scardinius erythrophthalmus	Karacabey Lagoon Lake	Öztürk et al. (2002)
Scardinius erythrophthalmus	Kocadere Stream	Selver (2008)
Scardinius erythrophthalmus	Terkos Lake	Soylu (2009)
Scardinius erythrophthalmus	Siğirci Lake	Çolak (2013)

Table 3 (continuing): Helminth - Host List.

Dactylogyrus difformoides Glaser and Gusev, 1967		
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Scardinius erythrophthalmus	Sapanca Lake	Soylu (2009)
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Scardinius erythrophthalmus	Siğirci Lake	Çolak (2013)
Dactylogyrus distinguendus (Linstow, 1878)		
Abramis brama	Terkos Lake	Karatoy (2004)
Blicca bjoerkna	Kocadere Stream	Selver (2008)
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Dactylogyrus elegantis Gusev, 1966		
Chondrostoma regium	Murat River	Koyun (2011)
Squalius cephalus	Murat River	Koyun (2011)
Dactylogyrus ergensi Molnar, 1964		
Pseudophoxinus antalyae	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2007)
Dactylogyrus extensus Mueller and Cleave, 1932		
Luciobarbus mystaceus	Keban Dam Lake	Sağlam (1992)
Chondrostoma regium	Keban Dam Lake	Sağlam (1992)
Cyprinus carpio	Bekteşağa Pond	Özer (1995)
Cyprinus carpio	Uluabat Lake	Oğuz et al. (1996a)
Cyprinus carpio	İznik Lake	Aydoğdu (1997)
Cyprinus carpio	Manyas Lake	Öztürk (2000)
Cyprinus carpio	Doğanci Dam Lake	Aydoğdu (2001)
Cyprinus carpio	Karacabey Lagoon Lake	Aydoğdu et al. (2001a)
Cyprinus carpio	Karamik Lake	Kutlu (2005)
Cyprinus carpio	Eber Lake	Öztürk (2005)
Cyprinus carpio	Almus Dam Lake	Turgut (2005)
Capoeta umbla	Hazar Lake	Aksoy et al. (2006)
Cyprinus carpio	Hazar Lake	Aksoy et al. (2006)
Squalius cephalus	Hazar Lake	Aksoy et al. (2006)
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Barbus grypus	Atatürk Dam Lake	Dal (2006)

Table 3 (continuing): Helminth - Host List.

Cyprinus carpio	Akşehir Lake	Kartal (2006)
Cyprinus carpio	Selevir Dam Lake	Öztürk and Bulut (2006)
Cyprinus carpio	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2007)
Cyprinus carpio	Terkos Lake	Soylu (2009)
Cyprinus carpio	Emre Dam Lake	Öztürk (2011)
Cyprinus carpio	Tahtali Dam Lake	Karakişi and Demir (2012)
Carassius gibelio	Siğirci Lake	Çolak (2013)
Dactylogyrus falcatus (Wedl, 1857)		
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Dactylogyrus folkmanovae Ergens, 1956		
Squalius cephalus	Doganci Dam Lake	Aydoğdu (2001)
Squalius cephalus	Susurluk River	Gürkan and Özan (2012)
Dactylogyrus fraternus Wagener, 1909		
Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Alburnus alburnus	Mustafakemalpaşa Stream	Aydoğdu and Selver (2006)
Dactylogyrus frisii Bychowsky, 1933		
Rutilus frisii	Terkos Lake	Soylu (2009)
Dactylogyrus inexpectatus Izjumova, 1955		
Carassius gibelio	Siğirci Lake	Çolak (2013)
Dactylogyrus izjumovae Gusev, 1966		
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Dactylogyrus malleus Linstow, 1877		
Barbus plebejus	Almus Dam Lake	Turgut (2005)
Capoeta umbla	Hazar Lake	Aksoy et al. (2006)
Dactylogyrus macrocanthus Wagener, 1857		
Tinca tinca	Sapanca Lake	Soylu (1990)
Tinca tinca	Uluabat Lake	Öztürk (2002)
Tinca tinca	Terkos Lake	Soylu (2003)

Table 3 (continuing): Helminth - Host List.

Dactylogyrus minutus Kulwiec, 1927		
Luciobarbus pectoralis	Keban Dam Lake	Sağlam (1992)
Cyprinus carpio	Keban Dam Lake	Sağlam (1992)
Cyprinus carpio	Karacaören I Dam Lake	Kir (1998)
Cyprinus carpio	Beyşehir Lake	Özan (2005)
Carassius carassius	Kovada Lake	Özan and Kir (2005)
Capoeta umbla	Hazar Lake	Aksoy et al. (2006)
Cyprinus carpio	Kovada Lake	Kir and Özan (2007)
Dactylogyrus naviculoides Ergens, 1960		
Squalius cephalus	Almus Dam Lake	Turgut (2005)
Dactylogyrus nybelini Markewitsch, 1933		
Rutilus frisii	Terkos Lake	Soylu (2009)
Dactylogyrus phoxini (Malevitskaya, 1949)		
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Dactylogyrus prostae Molnar, 1964		
Squalius cephalus	Murat River	Koyun (2011)
Dactylogyrus pulcher Bychowsky, 1957		
Capoeta capoeta	Almus Dam Lake	Turgut (2005)
Dactylogyrus rectotrabus Gussev, Jalal and Molnar, 1993		
Garra rufa	Murat River	Koyun (2011)
Dactylogyrus sphyrna Linstow, 1828		
Rutilus rutilus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Capoeta trutta	Keban Dam Lake	Sağlam (1992)
Chondrostoma regium	Keban Dam Lake	Sağlam (1992)
Blicca bjoerkna	Uluabat Lake	Akinci (1999)
Blicca bjoerkna	Manyas Lake	Öztürk (2000)
Rutilus rubilio	İznik Lake	Aydoğdu et al. (2000)

Table 3 (continuing): Helminth - Host List.

Abramis brama	Terkos Lake	Karatoy (2004)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Pseudophoxinus antalyae	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2007)
Blicca bjoerkna	Kocadere Stream	Selver (2008)
Vimba vimba	Gölbaşi Dam Lake	Aydoğdu et al. (2008)
Scardinius erythrophthalmus	Sapanca Lake	Soylu (2009)
Rutilus rutilus	Siğirci Lake	Çolak (2013)
Dactylogyrus vastator (Nybelin, 1924)		
Cyprinus carpio	Bafa Lake	Geldiay and Balik (1974)
Aphanius sp.	Cigli Stream	Geldiay and Balik (1974)
Capoeta capoeta	Balikliag Stream	Cengizler and Göksu (1994)
Alburnus orontis	Balikliag Stream	Cengizler and Göksu (1994)
Cyprinus carpio	Bekteşağa Pond	Özer (1995)
Cyprinus carpio	Seyhan River	Cengizler et al. (2001)
Carassius carassius	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2005)
Silurus glanis	Yamula Dam Lake	Kilinçaslan (2007)
Cyprinus carpio	Adana DSI	Güleç and Şahan (2010)
Carassius gibelio	Siğirci Lake	Çolak (2013)
Dactylogyrus vistulae Prost, 1957		
Squalius cephalus	Doganci Dam Lake	Aydoğdu (2001)
Squalius cephalus	Almus Dam Lake	Turgut (2005)
Chondrostoma regium	Almus Dam Lake	Turgut (2005)
Rutilus rutilus	Sapanca Lake	Karabiber (2006)
Squalius cephalus	Örenler Dam Lake	Kurupinar (2009)
Squalius cephalus	Susurluk River	Gürkan and Özan (2012)
Chondrostoma regium	Murat River	Koyun (2011)
Squalius cephalus	Murat River	Koyun (2011)
Dactylogyrus wunderi Bykhovskii, 1931		
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Diplozoon homoion Bykhovskii and Nagibi, 1959		
Rutilus rutilus	Manyas Lake	Öztürk (2000)

Table 3 (continuing): Helminth - Host List.

Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Alburnus alburnus	Mustafakemalpaşa Stream	Aydoğdu and Selver (2006)
Cyprinus carpio	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2007)
Pseudophoxinus antalyae	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2007)
Diplozoon paradoxum Nordman, 1832		
Rhodeus amarus	Simav, Nif Brooks	Geldiay and Balik (1974)
Rutilus rutilus	Uluabat Lake	Geldiay and Balik (1974)
Acantobrama marmid	Tigem Reservoirs	Zeren (2008)
Alburnus chalcoides	Tödürge Lake	Yildirim and Ünver (2006)
Diplozoon barbi Nordman, 1832		
Capoeta trutta	Keban Dam Lake	Sağlam (1992)
Luciobarbus pectoralis	Keban Dam Lake	Sağlam (1992)
Dogielius forceps Bychowsky, 1936		
Capoeta damascina	Murat River	Koyun (2011)
Gyrodactylus arcuatus Bychowsky, 1933		
Gasterosteus aculeatus	Sirakaraağaçlar Stream	Özer et al. (2004)
Gyrodactylus cobitis Bychowsky, 1933		
Cobitis simplicispina	Akşehir Lake	Kartal (2006)
Gyrodactylus elegans Nordmann, 1832		
Cyprinus carpio	Eski Gediz Stream	Geldiay and Balik (1974)
Cyprinus carpio	Seyhan River	Cengizler et al. (2001)
Luciobarbus pectoralis	Seyhan River	Şahan and Cengizler (2003)
Barbus plebejus	Almus Dam Lake	Turgut (2005)
Chondrostoma regium	Almus Dam Lake	Turgut (2005)
Cyprinus carpio	Karamik Lake	Kutlu (2005)
Cyprinus carpio	Eber Lake	Öztürk (2005)
Cyprinus carpio	Akşehir Lake	Kartal (2006)
Cyprinus carpio	Selevir Dam Lake	Öztürk and Bulut (2006)

Table 3 (continuing): Helminth - Host List.

Gyrodactylus gobii Shul’man, 1953		
Neogobius fluviatilis	Uluabat Lake	Öztürk et al. (2002)
Gyrodactylus hemibarbi (Ergens, 1980)		
Barbus plebejus	Almus Dam Lake	Turgut (2005)
Gyrodactylus katharineri Malmberg, 1964		
Carassius carassius	Enne Dam Lake	Koyun (2001)
Carassius auratus	Enne Dam Lake	Koyun (2001)
Gyrodactylus macrocornis Ergens, 1963		
Chondrostoma regium	Almus Dam Lake	Turgut (2005)
Chondrostoma regium	Almus Dam Lake	Özgül (2008)
Gyrodactylus medius Kathariner, 1894		
Tinca tinca	Kovada Lake	Kir and Özan (2005)
Gyrodactylus narzikulovi Ergens and Dzhalilov 1979		
Capoeta tinca	Almus Dam Lake	Turgut (2005)
Capoeta tinca	Almus Dam Lake	Özgül (2008)
Gyrodactylus proterorhini Ergens, 1967		
Neogobius melanostomus	Sirakaraağaçlar Stream	Özer (2007)
Gyrodactylus scardinii Malmberg, 1956		
Cyprinus carpio	Manyas Lake	Öztürk (2000)
Carassius gibelio	Seyitler Dam Lake	Öztürk (2010)
Onchocleidus similis Mueller, 1936		
Lepomis gibbosus	Siğirci Lake	Çolak (2013)

Table 3 (continuing): Helminth - Host List.

Quadriacanthus clariadis (Paperna, 1961)		
Clarias gariepinus	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2005)
Paradiplozoon megan Bykhovskii and Nagibi, 1959		
Squalius cephalus	Doganci Dam Lake	Aydoğdu (2001)
Squalius cephalus	Susurluk River	Gürkan and Özan (2012)
Alburnus chalcoides	Tödürge Lake	Yildirim and Ünver (2006)
Tetraonchus monenteron Diesing, 1858		
Esox lucius	Sapanca Lake	Soylu (1990)
Esox lucius	Uluabat Lake	Öztürk (1995)
Esox lucius	Doganci Dam Lake	Aydoğdu 2001
Esox lucius	Gölbaşi Dam Lake	Aydoğdu et al. (2008)
Esox lucius	Siğirci Lake	Çolak (2013)
Phylum Platyhelminthes		
Class Digenea		
Allocreadium isoporum Looss, 1894		
Luciobarbus escherichii	Doganci Dam Lake	Aydoğdu (2001)
Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Barbus plebejus	Enne Dam Lake	Koyun (2001)
Squalius cephalus	Enne Dam Lake	Koyun (2001)
Barbus plebejus	Murat River, Aras River	Aslan (2009)
Aspidogaster limacoides Diesing, 1835		
Rutilus rutilus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Asymphylodora imitans (Mühling, 1898)		
Blicca bjoerkna	Sapanca Lake	Soylu (2006)

Table 3 (continuing): Helminth - Host List.

Asymphylodora markewitschi Kulakovskaya, 1947		
Scardinius erythrophthalmus	Uluabat Lake	Oğuz and Öztürk (1993)
Scardinius erythrophthalmus	Kocadere Stream	Selver (2008)
Asymphylodora tincae (Mooder, 1790)		
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Barbus sp.	Çifteler-Sakaryabaşi Fish Production Station, Sariyar Dam Lake	Burgu et al. (1988)
Esox lucius	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station	Burgu et al. (1988)
Tinca tinca	Sapanca Lake	Soylu (1990)
Tinca tinca	Uluabat Lake	Aksakal (1992)
Tinca tinca	İznik Lake	Aydoğdu et al. (1996a)
Tinca tinca	Terkos Lake	Soylu (2003)
Tinca tinca	Kapulukaya Dam Lake	Yildiz (2003)
Tinca tinca	Beyşehir Lake	Özan (2005)
Tinca tinca	Kovada Lake	Kir and Özan (2005)
Bucephalus polymorphus Baer, 1827		
Esox lucius	Sapanca Lake	Soylu (1990)
Silurus glanis	Sapanca Lake	Soylu (1990)
Sander lucioperca	Egirdir Lake	Yildirim et al. (1996)
Sander lucioperca	Beyşehir Lake, Kovada Lake	Kara (1997)
Knipowitschia caucasica	Eğirdir Lake	Diler et al. (2001)
Clinostomum complanatum Rudolphi, 1819		

Table 3 (continuing): Helminth - Host List.

Cyprinus carpio	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook, Hirfanli Dam Lake, Çankiri-Günerdiğin Pond	Burgu et al. (1988)
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Chondrostoma sp.	Kizilcahamam Brook, Nallihan Brook	Burgu et al. (1988)
Varicorhinus sp.	Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Çankiri-Günerdiğin Pond, Kizilcahamam Brook, Nallihan Brook	Burgu et al. (1988)
Luciobarbus escherichii	Kirmir Stream	Öge and Sarimehmetoğlu (1996)
Capoeta tinca	Kirmir Stream	Öge and Sarimehmetoğlu (1996)
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Scardinius erythrophthalmus	Siğirci Lake	Çolak (2013)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Sander lucioperca	Siğirci Lake	Çolak (2013)
Lepomis gibbosus	Siğirci Lake	Çolak (2013)
Crepidostomum farionis (O. F. Muller, 1780)		
Salmo trutta abanticus	Abant Lake	Caira (1989)
Diplostomum spathaecum (Rudolphi, 1819)		
Rutilus rutilus	Sapanca Lake	Soylu (1990)
Scardinius erythrophthalmus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Esox lucius	Sapanca Lake	Soylu (1990)
Silurus glanis	Sapanca Lake	Soylu (1990)

Table 3 (continuing): Helminth - Host List.

Tinca tinca	Sapanca Lake	Soylu (1990)
Tinca tinca	Terkos Lake	Soylu (2003)
Abramis brama	Terkos Lake	Karatoy (2004)
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Esox lucius	Gölbaşi Dam Lake	Aydoğdu et al. (2008)
Blicca bjoerkna	Kocadere Stream	Selver (2008)
Rutilus rutilus	Kocadere Stream	Selver (2008)
Scardinius erythrophthalmus	Kocadere Stream	Selver (2008)
Diplodiscus subclavatus Diesing, 1836		
Esox lucius	Uluabat Lake	Öztürk et al. (2000)
Opisthorchis felinus (Rivolta, 1884)		
Rutilus rutilus	Uluabat, Manyas Lakes	Geldiay and Balik (1974)
Orientocreadium siluri Bykhovski and Dubi., 1954		
Silurus glanis	Sapanca Lake	Soylu (1990)
Orientocreadium batrachoides Tubangui, 1931		
Clarias gariepinus	Asi River	Tepe et al. (2013)
Phyllodistomum elongatum Nybelin, 1926		
Luciobarbus pectoralis	Karacaören I Dam Lake	Kir (1998)
Posthodiplostomum cuticola Nordmann, 1832		
Scardinius erythrophthalmus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Uluabat Lake	Akinci (1999)
Cyprinus carpio	Eber Lake	Öztürk (2005)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Alburnus chalcoides	Tödürge Lake	Yildirim and Ünver (2006)
Scardinius erythropthalmus	Siğirci Lake	Çolak (2013)
Posthodiplostomum minimum Maccallum, 1921		
Salmo trutta fario	Munzur Stream	Ekingen (1976)

Table 3 (continuing): Helminth - Host List.

Pygidiopsis genata Looss, 1907		
Neogobius melanostomus	Sirakaraağaçlar Stream	Özer (2007)
Rhipidocotyle fennica Taskinen, 1991		
Esox lucius	Uluabat Lake	Öztürk et al. (2000)
Tylodelphys clavata Nordmann, 1832		
Rutilus rutilus	Sapanca Lake	Soylu (1990)
Scardinius erythrophthalmus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Esox lucius	Sapanca Lake	Soylu (1990)
Silurus glanis	Sapanca Lake	Soylu (1990)
Tinca tinca	Sapanca Lake	Soylu (1990)
Tinca tinca	Terkos Lake	Soylu (2003)
Abramis brama	Terkos Lake	Karatoy (2004)
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Atherina boyeri	İznik Lake	Çolak (2013)
Scardinius erytrophthalmus	Siğirci Lake	Çolak (2013)
Sander lucioperca	Siğirci Lake	Çolak (2013)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Lepomis gibbosus	Siğirci Lake	Çolak (2013)
Rutilus rutilus	Siğirci Lake	Çolak (2013)
Esox lucius	Siğirci Lake	Çolak (2013)
Silurus glanis	Siğirci Lake	Çolak (2013)
Tetracotyle percae-fluviatilis (Linstow, 1856)		
Abramis brama	Terkos Lake	Karatoy (2004)
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)

Table 3 (continuing): Helminth - Host List.

Phylum Platyhelminthes		
Class Cestoda		
Bathybothrium rectangulum (Bloch, 1782)		
Esox lucius	Işikli Dam Lake	Dişçi (2002)
Biacetabulum appendiculatum Szidat, 1937		
Luciobarbus escherichii	Enne Dam Lake	Koyun (2001)
Bothriocephalus acheilognathi Yamaguti, 1955		
Cyprinus carpio	İznik Lake	Türkmen (1990)
Rutilus frisii	İznik Lake	Türkmen (1990)
Cyprinus carpio	Karasu Brook, Bendimahi Brook, Engil Brook, Zernek Dam Lake	Topçu (1993)
Capoeta umbla	Hazar Lake	Aksoy (1996)
Tinca tinca	Mogan Lake	Erkul (1997)
Cyprinus carpio	Mogan Lake, Hirfanli Dam Lake, Kirmir Brook	Erkul (1997)
Cyprinus carpio	Karacaören I Dam Lake	Kir (1998)
Cyprinus carpio	Manyas Lake	Öztürk (2000)
Alburnus mossulensis	Manyas Lake	Öztürk (2000)
Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Luciobarbus escherichii	Doganci Dam Lake	Aydoğdu (2001)
Squalius cephalus	Doganci Dam Lake	Aydoğdu (2001)
Neogobius fluviatilis	Uluabat Lake	Öztürk et al. (2002)
Silurus glanis	Hirfanli Dam Lake	Aydin (2003)
Capoeta umbla	Karakaya Dam Lake	Örün et al. (2003)
Chondrostoma regium	Karakaya Dam Lake	Örün et al. (2003)
Cyprinus carpio	Karakaya Dam Lake	Örün et al. (2003)
Acanthobrama marmid	Karakaya Dam Lake	Örün et al. (2003)
Alburnus mossulensis	Karakaya Dam Lake	Örün et al. (2003)
Squalius cephalus	Karakaya Dam Lake	Örün et al. (2003)
Cyprinus carpio	Karamik Lake	Kutlu (2005)
Tinca tinca	Beyşehir Lake	Özan (2005)
Cyprinus carpio	Beyşehir Lake	Özan (2005)
Cyprinus carpio	Eber Lake	Öztürk (2005)
Tinca tinca	Kovada Lake	Kir and Özan (2005)

Table 3 (continuing): Helminth - Host List.

Capoeta trutta	Keban Dam Lake	Dörücü and İspir (2005)
Capoeta umbla	Keban Dam Lake	Dörücü and İspir (2005)
Chondrostoma regium	Keban Dam Lake	Dörücü and İspir (2005)
Cyprinus carpio	Keban Dam Lake	Dörücü and İspir (2005)
Tinca tinca	Sapanca Lake	Akbeniz (2006)
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Blicca bjoerkna	Sapanca Lake	Soylu (2006)
Alburnus alburnus	Mustafakemalpaşa Stream	Aydoğdu and Selver (2006)
Cyprinus carpio	Selevir Dam Lake	Öztürk and Bulut (2006)
Cyprinus carpio	Kovada Lake	Kir and Özan (2007)
Rutilus rutilus	Kocadere Stream	Selver (2008)
Cyprinus carpio	Murat River, Aras River	Aslan (2009)
Squalius cephalus	Örenler Dam Lake	Kurupinar (2009)
Cyprinus carpio	Karacaören II Dam Lake	Samanci (2011)
Alburnus chalcoides	Tödürge Lake	Yildirim and Ünver (2006)
Atherina boyeri	İznik Lake	Çolak (2013)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Caryophyllaeides fennica (Schneider, 1902)		
Rutilus rutilus	Manyas Lake	Öztürk (2000)
Scardinius erythrophthalmus	Manyas Lake	Öztürk (2000)
Caryophyllaeus brachycollis Janiszewska, 1951		
Cyprinus carpio	Antakya Lake	Paperna (1964)
Caryophyllaeus fimbriceps Annenkova-Khlopina, 1919		
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Caryophyllaeus laticeps (Müller, 1781)		
Cyprinus carpio	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook, Hirfanli Dam Lake, Çankiri-Günerdiğin Pond	Burgu et al. (1988)

Table 3 (continuing): Helminth - Host List.

Cyprinus carpio	İznik Lake	Türkmen (1990)
Cyprinus carpio	Karasu Brook, Bendimahi Brook, Engil Brook, Zernek Dam Lake	Topçu (1993)
Rutilus frisii	İznik Lake	Aydoğdu et al. (1997b)
Capoeta umbla	Hazar Lake	Aksoy (1996)
Cyprinus carpio	Karacaören I Dam Lake	Kir (1998)
Cyprinus carpio	Kovada Lake	Becer and Kara (1998)
Blicca bjoerkna	Manyas Lake	Öztürk (2000)
Vimba vimba	Manyas Lake	Öztürk (2000)
Cyprinus carpio	Manyas Lake	Öztürk (2000)
Cyprinus carpio	Karacabey Lagoon Lake	Aydoğdu et al. (2001a)
Luciobarbus escherichii	Doğanci Dam Lake	Aydoğdu (2001)
Cyprinus carpio	Seyhan River	Şahan and Cengizler (2003)
Luciobarbus pectoralis	Seyhan River	Şahan and Cengizler (2003)
Abramis brama	Terkos Lake	Karatoy (2004)
Cyprinus carpio	Beyşehir Lake	Özan (2005)
Tinca tinca	Beyşehir Lake	Özan (2005)
Tinca tinca	Kovada Lake	Kir and Özan (2005)
Tinca tinca	Sapanca Lake	Akbeniz (2006)
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Blicca bjoerkna	Sapanca Lake	Soylu (2006)
Cyprinus carpio	Selevir Dam Lake	Öztürk and Bulut (2006)
Cyprinus carpio	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2007)
Vimba vimba	Gölbaşi Dam Lake	Aydoğdu et al. (2008)
Blicca bjoerkna	Kocadere Stream	Selver (2008)
Capoeta capoeta	Murat River, Aras River	Aslan (2009)
Acanthobrama marmid	Murat River, Aras River	Aslan (2009)
Cyprinus carpio	Karacaören II Dam Lake	Samanci (2011)
Khawia armeniaca Cholodkovskii, 1878		
Luciobarbus pectoralis	Keban Dam Lake	Özdemir and Sarieyyüboğlu (1993)
Capoeta umbla	Hazar Lake	Aksoy (1996)
Acanthobrama marmid	Karakaya Dam Lake	Örün et al. (2003)
Squalius cephalus	Karakaya Dam Lake	Örün et al. (2003)
Capoeta trutta	Karakaya Dam Lake	Örün et al. (2003)
Cyprinus carpio	Karakaya Dam Lake	Örün et al. (2003)
Capoeta umbla	Karakaya Dam Lake	Örün et al. (2003)
Capoeta umbla	Keban Dam Lake	Dörücü and İspir (2005)
Cyprinus carpio	Keban Dam Lake	Dörücü and İspir (2005)

Table 3 (continuing): Helminth - Host List.

Ligula intestinalis Lin., 1758		
Capoeta umbla	Cip Lake	Cantoray and Özcan (1975)
Squalius cephalus	Cip Lake	Cantoray and Özcan (1975)
Luciobarbus escherichii	Cip Lake	Cantoray and Özcan (1975)
Acanthobrama marmid	Devegecidi Dam Lake	Başaran and Kelle (1976)
Alburnus mossulensis	Devegecidi Dam Lake	Başaran and Kelle (1976)
Acanthobrama marmid	Devegecidi Dam Lake	Kelle (1978)
Alburnus mossulensis	Devegecidi Dam Lake	Kelle (1978)
Silurus glanis	Sariyar Dam Lake	Keskin and Erakan (1987)
Chondrostoma regium	Keban Dam Lake	Keskin and Erakan (1987)
Vimba vimba	Kumkaya Dam Lake	Keskin and Erakan (1987)
Capoeta capoeta	Demirkopru Dam Lake	Keskin and Erakan (1987)
Alburnus orontis	Kizilirmak Brook, Yeniköy Stream, Çayirhan Stream, Kumkaya Dam Lake, Enne Dam Lake	Keskin and Erakan (1987)
Garra rufa	Cag-cag Stream	Keskin and Erakan (1987)
Squalius cephalus	Hamidiye, Pazarkavşaği Bridge	Keskin and Erakan (1987)
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Esox lucius	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station	Burgu et al. (1988)
Tinca tinca	Mogan Lake	Burgu et al. (1988)
Vimba vimba	Sariyar Dam Lake	Ekmekçi (1989)
Alburnus orontis	Almus Dam Lake	Cengizler et al. (1991)
Squalius cephalus	Almus Dam Lake	Cengizler et al. (1991)
Luciobarbus pectoralis	Keban Dam Lake	Özdemir and Sarieyyüboğlu (1993)
Alburnus alburnus	Upper Porsuk Basin	Yilmaz et al. (1996)
Cyprinus carpio	Kovada Lake	Becer and Kara (1998)
Cyprinus carpio	Karacaören I Dam Lake	Kir (1998)
Luciobarbus pectoralis	Karacaören I Dam Lake	Kir (1998)
Alburnus alburnus	Kutahya Region Lakes	Koyun et al. (1999)
Squalius cephalus	Yeşilköy Pond	Bulgen (1999)
Alburnus mossulensis	Manyas Lake	Öztürk (2000)
Rutilus rutilus	Manyas Lake	Öztürk (2000)

Table 3 (continuing): Helminth - Host List.

Acanthobrama marmid	Keban Dam Lake	Türk (2000)
Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Tinca tinca	Beyşehir Lake	Yildiz et al. (2003)
Rutilus rutilus	Yenice Pond	Oğuz et al. (2004)
Alburnus orontis	Camkoru Pond	İnnal (2004)
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Squalius cephalus	Gelingüllü Dam Lake	Ekmekçi and Kirankaya (2004)
Tinca tinca	Kovada Lake	Kir and Özan (2005)
Capoeta bergamae	Topcam Dam Lake	Şaşi (2005)
Squalius cephalus	Caparlipatlak Dam Lake	Torcu-Koç et al. (2006)
Chondrostoma regium	Almus Dam Lake	Özgül and Turgut (2006)
Rhodeus amarus	Sapanca Lake	Akmirza (2007)
Alburnus orontis	Camlidere Dam Lake	İnnal et al. (2007)
Alburnus orontis	Kirmir Creek	İnnal et al. (2007)
Alburnus orontis	Bulak Stream	İnnal et al. (2007)
Alburnus orontis	Mogan Lake	İnnal et al. (2007)
Alburnoides bipunctatus	Kirmir Creek	İnnal et al. (2007)
Cyprinus carpio	Camlidere Dam Lake	İnnal et al. (2007)
Cyprinus carpio	Aksu River	İnnal et al. (2007)
Tinca tinca	Abant Lake	İnnal et al. (2007)
Tinca tinca	Yeniçağa Lake	İnnal et al. (2007)
Vimba vimba	Yamansaz Lake	İnnal et al. (2007)
Barbus plebejus	Çildir Lake	İnnal et al. (2007)
Barbus plebejus	Barhal Creek	İnnal et al. (2007)
Barbus plebejus	Almus Dam Lake	Develi (2008)
Chondrostoma nasus	Kunduzlar Dam Lake	Özbek (2009)
Squalius cephalus	Kunduzlar Dam Lake	Özbek (2009)
Alburnus escherichii	Kunduzlar Dam Lake	Özbek (2009)
Squalius cephalus	Örenler Dam Lake	Kurupinar (2009)
Alburnus escherichii	Çamkoru Pond	İnnal et al. (2010)
Gobio gobio	Çamkoru Pond	İnnal et al. (2010)
Squalius cephalus	Çamkoru Pond	İnnal et al. (2010)
Alburnus orontis	Almus Dam Lake	Turgut et al. (2011)
Squalius cephalus	Almus Dam Lake	Turgut et al. (2011)
Cyprinus carpio	Almus Dam Lake	Turgut et al. (2011)
Capoeta tinca	Almus Dam Lake	Turgut et al. (2011)
Capoeta capoeta	Almus Dam Lake	Turgut et al. (2011)
Ligula pavlovskii Dubinina, 1959		
Neogobius fluviatilis	Manyas Lake	Öztürk (2000)
Neogobius fluviatilis	Uluabat Lake	Öztürk et al. (2002)

Table 3 (continuing): Helminth - Host List.

Monobothrium auriculatum Kulakovskaya, 1961		
Capoeta damascina	Hazar Lake	Aksoy (1996)
Paradilepis scolecina Rudolphi, 1935		
Cyrprinus carpio	Akşehir Lake	Buhurcu (2006)
Proteocephalus osculatus (Goeze, 1782)		
Silurus glanis	Gölbaşi Lake, Eymir Lake, Sariyar Dam Lake	Burgu et al. (1988)
Silurus glanis	Hirfanli Dam Lake	Aydin (2003)
Proteocephalus percae (Müler, 1780)		
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Sander lucioperca	Siğirci Lake	Soylu (2013)
Proteocephalus torulosus (Batsch, 1786)		
Tinca tinca	Kovada Lake	Kir and Özan (2005)
Tinca tinca	Beyşehir Lake	Özan (2005)
Polyonchobothrium magnum (Zme'ev, 1936)		
Clarias gariepinus	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2005)
Postgangesia inarmata de Chambrier, Al-Kallak and Mariaux, 2003		
Silurus triostegus	Atatürk Dam Lake	Öktener and Alaş (2009)
Senga mastacembeli Rahemo, 1996		
Mastacembelus mastacembelus	Atatürk Dam Lake	Öktener and Alaş (2009)
Silurotaenia siluri (Batsch, 1786)		
Silurus glanis	Sapanca Lake	Soylu (1990)

Table 3 (continuing): Helminth - Host List.

Triaenophorus crassus Forel, 1880		
Esox lucius	Sapanca Lake	Soylu (1990)
Phylum Nematoda		
Camallanus truncatus (Rudolphi, 1814)		
Esox lucius	Işikli Dam Lake	Dişçi (2002)
Eustrongylides excisus Jagerskiold, 1909		
Neogobius fluviatilis	Manyas Lake	Öztürk (2000)
Neogobius fluviatilis	Uluabat Lake	Öztürk et al. (2002)
Abramis brama	Terkos Lake	Karatoy (2004)
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Silurus glanis	Terkos Lake	Soylu (2005)
Aphanius mento	Kirkgöz Stream	Aydoğdu et al. (2011)
Pseudophoxinus battalgilae	Manavgat River	Aydoğdu et al. (2011)
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Atherina boyeri	İznik Lake	Çolak (2013)
Sander lucioperca	Siğirci Lake	Çolak (2013)
Molnaria intestinalis Dogiel and Bychowsky, 1934		
Squalius lepidus	Atatürk Dam Lake	Dal (2006)
Philometra intestinalis Dogiel and Bykhovs., 1934		
Chondrostoma sp.	Kizilcahamam Brook, Nallihan Brook	Burgu et al. (1988)
Philometra ovate (Zeder, 1803)		
Squalius cephalus	Seydisuyu Stream	Keskin (1988)
Capoeta umbla	Hazar Lake	Aksoy (1996)
Squalius cephalus	Enne Dam Lake	Koyun (2001)
Squalius cephalus	Çamkoru Lake	İnnal and Keskin (2005)
Philometra rischta Skrjabin, 1923		
Capoeta umbla	Hazar Lake	Aksoy et al. (2006)

Table 3 (continuing): Helminth - Host List.

Pseudocapillaria tomentosa (Dujardin, 1843)		
Cyprinus carpio	Manyas Lake	Öztürk (2000)
Raphidascaris acus (Bloch, 1779)		
Esox lucius	Sapanca Lake	Soylu (1990)
Esox lucius	Uluabat Lake	Öztürk (1995)
Esox lucius	Karacabey Lagoon Lake	Öztürk et al. (2002)
Esox lucius	Işikli Dam Lake	Dişçi (2002)
Esox lucius	Gölbaşi Dam Lake	Aydoğdu et al. (2008)
Rhabdochona denudata (Dujardin, 1845)		
Cyprinus carpio	Karasu Brook, Bendimahi Brook, Engil Brook, Zernek Dam Lake	Topçu (1993)
Luciobarbus pectoralis	Karacaören I Dam Lake	Kir (1998)
Squalius cephalus	Doganci Dam Lake	Aydoğdu (2001)
Alburnus alburnus	Mustafakemalpaşa Stream	Aydoğdu and Selver (2006)
Capoeta capoeta	Murat River, Aras River	Aslan (2009)
Barbus plebejus	Murat River, Aras River	Aslan (2009)
Barbus musra	Murat River, Aras River	Aslan (2009)
Capoeta antalyensis	Köprüçay River	Aydoğdu et al. (2011)
Skrjabillanus scardinii Molnár, 1966		
Scardinius erythrophthalmus	Kocadere Stream	Selver (2008)
Spiroxys contortus Rudolphi, 1819		
Aphanius chantrei	Sarikum Lagoon Lake	Öztürk (2005)
Aphanius danfordii	Sarikum Lagoon Lake	Öztürk and Özer (2008a)
Phylum Acanthocephala		
Acanthocephalus anguillae Müller, 1780		
Esox lucius	Uluabat Lake	Öztürk (1995)
Tinca tinca	Beyşehir Lake	Özan (2005)

Table 3 (continuing): Helminth - Host List.

Neoechinorhynchus rutili (Müller, 1780)		
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Barbus sp.	Çifteler-Sakaryabaşi Fish Production Station, Sariyar Dam Lake	Burgu et al. (1988)
Cyprinus carpio	İznik Lake	Türkmen (1990)
Esox lucius	Sapanca Lake	Soylu (1990)
Cyprinus carpio	Karasu Brook, Bendimahi Brook, Engil Brook, Zernek Dam Lake	Topçu (1993)
Cyprinus carpio	İznik Lake	Aydoğdu et al. (1997a)
Rutilus frisii	İznik Lake	Aydoğdu et al. (1997b)
Rutilus rubilio	İznik Lake	Aydoğdu et al. (2000)
Esox lucius	Işikli Dam Lake	Dişçi (2002)
Capoeta trutta	Keban Dam Lake	Sarieyyüboğlu and Sağlam (2002)
Capoeta trutta	Karakaya Dam Lake	Örün et al. (2003)
Capoeta umbla	Karakaya Dam Lake	Örün et al. (2003)
Chondrostoma regium	Karakaya Dam Lake	Örün et al. (2003)
Cyprinus carpio	Karakaya Dam Lake	Örün et al. (2003)
Luciobarbus esocinus	Karakaya Dam Lake	Örün et al. (2003)
Luciobarbus esocinus	Keban Dam Lake	Dörücü and İspir (2005)
Capoeta umbla	Keban Dam Lake	Dörücü and İspir (2005)
Chondrostoma regium	Keban Dam Lake	Dörücü and İspir (2005)
Cyprinus carpio	Keban Dam Lake	Dörücü and İspir (2005)
Aphanius chantrei	Sarikum Lagoon Lake	Öztürk (2005)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Capoeta trutta	Atatürk Dam Lake	Dal (2006)
Neogobius melanostomus	Sirakaraağaçlar Stream	Özer (2007)
Aphanius danfordii	Sarikum Lagoon Lake	Öztürk and Özer (2008a)
Neoechinorhynchus zabensis Amin, Abdullah, and Mhaisen, 2003		
Capoeta barroisi	Murat River	Oğuz et al. (2012)
Pomphorhynchus laevis (Müller, 1776)		

Table 3 (continuing): Helminth - Host List.

Cyprinus carpio	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook, Hirfanli Dam Lake, Çankiri-Günerdiğin Pond	Burgu et al. (1988)
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Silurus glanis	Gölbaşi Lake, Eymir Lake, Sariyar Dam Lake	Burgu et al. (1988)
Esox lucius	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station	Burgu et al. (1988)
Luciobarbus escherichii	Karasu (Sakarya) Büyükcoz Lake	Soylu (1991)
Alburnus alburnus	Enne Dam Lake	Koyun (2001)
Carassius carassius	Enne Dam Lake	Koyun (2001)
Carassius auratus	Enne Dam Lake	Koyun (2001)
Squalius cephalus	Enne Dam Lake	Koyun (2001)
Nemacheilus sp.	Enne Dam Lake	Koyun (2001)
Tinca tinca	Kapulukaya Dam Lake	Yildiz (2003)
Alburnus nasreddini	Akşehir Lake	Buhurcu (2006)
Squalius cephalus	Örenler Dam Lake	Kurupinar (2009)
Pomphorhynchus tereticollis (Rudolphi, 1809)		
Cobitis bilseli	Beyşehir Lake	Smales et al. (2012)
Pseudoechinorhynchus clavula Dujardin, 1845		
Cyprinus carpio	Karasu Brook, Bendimahi Brook, Engil Brook, Zernek Dam Lake	Topçu (1993)
Triaspiron aphanii Smales, Aydoğdu, Emre, 2012		
Aphanius mento	Kirkgöz Springs	Smales et al. (2012)

Table 3 (continuing): Helminth - Host List.

Phylum Annelida		
Cystobranchus respirans (Troschel, 1850)		
Salmo trutta fario	Kaz Daği Brook	Geldiay and Balik (1974)
Hemiclepsis marginata Müller, 1774		
Cyprinus carpio	Marmara Lake, Bafa Lake	Geldiay and Balik (1974)
Cyprinus carpio	Çapali Lake	Ceylan (2002)
Esox lucius	Çapali Lake	Ceylan (2002)
Hirudo medicinalis Linnaeus, 1758		
Esox lucius	Çapali Lake	Ceylan (2002)
Cyprinus carpio	Çapali Lake	Ceylan (2002)
Piscicola geometra Linnaeus, 1761		
Rutilus rutilus	Sapanca Lake	Soylu (1990)
Scardinius erythrophthalmus	Sapanca Lake	Soylu (1990)
Blicca bjoerkna	Sapanca Lake	Soylu (1990)
Tinca tinca	Sapanca Lake	Soylu (1990)
Esox lucius	Sapanca Lake	Soylu (1990)
Luciobarbus mystaceus	Keban Dam Lake	Sağlam (1992)
Tinca tinca	Uluabat Lake	Öztürk (2002)
Abramis brama	Terkos Lake	Karatoy (2004)
Scardinius erythrophthalmus	Terkos Lake	Kahveci (2004)
Cyprinus carpio	Çavuşçu Lake	Öktener et al. (2007)
Carassius gibelio	Uluabat Lake	Emiroğlu and Arslan (2009)
Rutilus rutilus	Uluabat Lake	Ceylan et al. (2011)
Trachelobdella torquata (Grube, 1871)		
Carassius carassius	Kovada Lake	Özan and Kir (2005)

Table 4: Host - Helminth List.

***Silurus glanis* Linnaeus, 1758**
Ancylodiscoides siluri Zandt, 1924
Ancylodiscoides vistulensis Sivak, 1932
Dactylogyrus vastator (Nybelin, 1924)
Bucephalus polymorphus Baer, 1827
Diplostomum spathaecum (Rudolphi, 1819)
Orientocreadium siluri Bykhovski and Dubi.,1954
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Ligula intestinalis Linnaeus, 1758
Proteocephalus osculatus (Goeze, 1782)
Silurotaenia siluri (Batsch, 1786)
Eustrongylides excisus Jagerskiold, 1909
Pomphorhynchus laevis (Müller, 1776)
***Sander lucioperca* (Linnaeus, 1758)**
Ancyrocephalus paradoxus Creplin, 1839
Bucephalus polymorphus Baer, 1827
Clinostomum complanatum Rudolphi, 1819
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus laticeps (Müller, 1781)
Proteocephalus percae (Müler, 1780)
Eustrongylides excisus Jagerskiold, 1909
***Capoeta umbla* (Heckel, 1843)**
Dactylogyrus affinis Bychowsky, 1933
Dactylogyrus auriculatus (Nordmann, 1832)
Dactylogyrus extensus Mueller and Cleave, 1932
Dactylogyrus malleus Linstow, 1877
Dactylogyrus minutus Kulwiec, 1927
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus laticeps (Müller, 1781)
Khawia armeniaca Cholodkovskii, 1878
Ligula intestinalis Linnaeus, 1758
Philometra intestinalis Dogiel and Bykhovs., 1934
Philometra ovata (Zeder, 1803)
Philometra rischta Skrjabin, 1923
Neoechinorhynchus rutili (Müller, 1780)
***Alburnus alburnus* (Linnaeus, 1758)**
Dactylogyrus alatus Linstow, 1878
Dactylogyrus fraternus Wagener, 1909

Table 4 (continuing): Host - Helminth List.

Diplozoon homoion Bykhovskii and Nagibi, 1959
Allocreadium isoporum Looss, 1894
Bothriocephalus acheilognathi Yamaguti, 1955
Ligula intestinalis Linnaeus, 1758
Rhabdochona denudata (Dujardin, 1845)
Pomphorhynchus laevis (Müller, 1776)
***Chondrostoma regium* (Heckel, 1843)**
Dactylogyrus alatus Linstow, 1878
Dactylogyrus elegantis Gusev, 1966
Dactylogyrus extensus Mueller and Cleave, 1932
Dactylogyrus sphyrna Linstow, 1828
Dactylogyrus vistulae Prost, 1957
Gyrodactylus elegans Nordmann, 1832
Gyrodactylus macrocornis Ergens, 1963
Bothriocephalus acheilognathi Yamaguti, 1955
Ligula intestinalis Linnaeus, 1758
Neoechinorhynchus rutili (Müller, 1780)
***Alburnus heckeli* Battalgil, 1943**
Dactylogyrus alatus Linstow, 1878
***Cyprinus carpio* Linnaeus, 1758**
Dactylogyrus anchoratus (Dujardin, 1845)
Dactylogyrus ancylostylus Linstow, 1878
Dactylogyrus extensus Mueller and Cleave, 1932
Dactylogyrus minutus Kulwiec, 1927
Dactylogyrus phoxini (Malevitskaya, 1949)
Dactylogyrus vastator (Nybelin, 1924)
Diplozoon homoion Bykhovskii and Nagibi, 1959
Gyrodactylus elegans Nordmann, 1832
Gyrodactylus scardinii Malmberg, 1956
Clinostomum complanatum Rudolphi, 1819
Posthodiplostomum cuticola Nordmann, 1832
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus brachycollis Janiszewska, 1951
Caryophyllaeus fimbriceps Annenkova-Khlopina, 1919
Caryophyllaeus laticeps (Müller, 1781)
Khawia armeniaca Cholodkovskii, 1878
Ligula intestinalis Linnaeus, 1758
Paradilepis scolecina Rudolphi, 1935
Pseudocapillaria tomentosa (Dujardin, 1843)
Rhabdochona denudata (Dujardin, 1845)

Table 4 (continuing): Host - Helminth List.

Neoechinorhynchus rutili (Müller, 1780)
Pomphorhynchus laevis (Müller, 1776)
Pseudoechinorhynchus clavula Dujardin, 1845
Hemiclepsis marginata Müller, 1774
Hirudo medicinalis Linnaeus, 1758
Piscicola geometra Linnaeus, 1761
***Carassius carassius* (Linnaeus, 1758)**
Dactylogyrus anchoratus (Dujardin, 1845)
Dactylogyrus minutus Kulwiec, 1927
Dactylogyrus vastator (Nybelin, 1924)
Gyrodactylus katharineri Malmberg, 1964
Pomphorhynchus laevis (Müller, 1776)
Carassius auratus* (Linnaeus, 1758)
Dactylogyrus anchoratus (Dujardin, 1845)
Gyrodactylus katharineri Malmberg, 1964
Pomphorhynchus laevis (Müller, 1776)
Carassius gibelio* (Bloch, 1782)
Dactylogyrus anchoratus (Dujardin, 1845)
Dactylogyrus baueri Gussev, 1955
Dactylogyrus extensus Mueller and Cleave, 1932
Dactylogyrus inexpectatus Izjumova, 1955
Dactylogyrus vastator (Nybelin, 1924)
Gyrodactylus scardinii Malmberg, 1956
Piscicola geometra Linnaeus, 1761
***Luciobarbus pectoralis* (Heckel, 1843)**
Dactylogyrus ancylostylus Linstow, 1878
Dactylogyrus minutus Kulwiec, 1927
Diplozoon barbi Nordman, 1832
Gyrodactylus elegans Nordmann, 1832
Phyllodistomum elongatum Nybelin, 1926
Caryophyllaeus laticeps (Müller, 1781)
Khawia armeniaca Cholodkovskii, 1878
Ligula intestinalis Linnaeus, 1758
Rhabdochona denudata (Dujardin, 1845)
***Luciobarbus esocinus* Heckel, 1843**
Dactylogyrus ancylostylus Linstow, 1878
Dactylogyrus asper Linstow, 1878
Neoechinorhynchus rutili (Müller, 1780)

Table 4 (continuing): Host - Helminth List.

***Luciobarbus mystaceus* (Pallas, 1814)**
Dactylogyrus asper Linstow, 1878
Dactylogyrus extensus Mueller and Cleave, 1932
Piscicola geometra Linnaeus, 1761
***Rhodeus amarus* (Bloch, 1782)**
Dactylogyrus bicornis Malevitskaya, 1941
Diplozoon paradoxum Nordman, 1832
Ligula intestinalis Linnaeus, 1758
***Luciobarbus escherichii* (Steindachner, 1897)**
Dactylogyrus carpathicus Zakhvatkin, 1951
Allocreadium isoporum Looss, 1894
Biacetabulum appendiculatum Szidat, 1937
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus laticeps (Müller, 1781)
Ligula intestinalis Linnaeus, 1758
Pomphorhynchus laevis (Müller, 1776)
***Alburnus chalcoides* (Güldenstädt, 1772)**
Dactylogyrus chalcalburni Dogiel and Bychowsky 1833
Diplozoon paradoxum Nordman, 1832
Paradiplozoon megan Bykhovskii and Nagibi, 1959
Posthodiplostomum cuticola Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
***Blicca bjoerkna* (Linnaeus, 1758)**
Dactylogyrus cornu Linstow, 1878
Dactylogyrus cornoides (Gläser and Gussev, 1971)
Dactylogyrus crucifer Wagener, 1857
Dactylogyrus difformoides Glaser and Gusev, 1967
Dactylogyrus distinguendus (Linstow, 1878)
Dactylogyrus falcatus (Wedl, 1857)
Dactylogyrus sphyrna Linstow, 1828
Dactylogyrus wunderi Bykhovskii, 1931
Aspidogaster limacoides Diesing, 1835
Asymphylodora imitans (Mühling, 1898)
Diplostomum spathaecum (Rudolphi, 1819)
Posthodiplostomum cuticola Nordmann, 1832
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus laticeps (Müller, 1781)
Piscicola geometra Linnaeus, 1761

Table 4 (continuing): Host - Helminth List.

***Vimba vimba* (Linnaeus, 1758)**
Dactylogyrus cornu Linstow, 1878
Dactylogyrus cornoides (Gläser and Gussev, 1971)
Dactylogyrus sphyrna Linstow, 1828
Aspidogaster limacoides Diesing, 1835
Posthodiplostomum cuticola Nordmann, 1832
Tylodelphys clavata Nordmann, 1832
Caryophyllaeus laticeps (Müller, 1781)
Ligula intestinalis Linnaeus, 1758
Neoechinorhynchus rutili (Müller, 1780)
***Rutilus frisii* (Nordmann, 1840)**
Dactylogyrus crucifer Wagener, 1857
Dactylogyrus frisii Bychowsky, 1933
Dactylogyrus nybelini Markewitsch, 1933
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus laticeps (Müller, 1781)
Neoechinorhynchus rutili (Müller, 1780)
***Rutilus rutilus* (Linnaeus, 1758)**
Dactylogyrus crucifer Wagener, 1857
Dactylogyrus sphyrna Linstow, 1828
Dactylogyrus vistulae Prost, 1957
Diplozoon homoion Bykhovskii and Nagibi, 1959
Diplozoon paradoxum Nordman, 1832
Aspidogaster limacoides Diesing, 1835
Diplostomum spathaecum (Rudolphi, 1819)
Opisthorchis felinus (Rivolta, 1884)
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeides fennica (Schneider, 1902)
Ligula intestinalis Linnaeus, 1758
Piscicola geometra Linnaeus, 1761
***Capoeta tinca* (Heckel, 1843)**
Dactylogyrus crucifer Wagener, 1857
Gyrodactylus narzikulovi Ergens and Dzhalilov, 1979
Clinostomum complanatum Rudolphi, 1819
Ligula intestinalis Linnaeus, 1758
***Scardinius erythrophthalmus* (Linnaeus, 1758)**
Dactylogyrus difformis Wagener, 1857
Dactylogyrus difformoides Glaser and Gusev, 1967

Table 4 (continuing): Host - Helminth List.

Dactylogyrus izjumovae Gusev, 1966
Dactylogyrus sphyrna Linstow, 1828
Asymphylodora markewitschi Kulakovskaya, 1947
Clinostomum complanatum Rudolphi, 1819
Diplostomum spathaecum (Rudolphi, 1819)
Posthodiplostomum cuticola Nordmann, 1832
Tylodelphys clavata Nordmann, 1832
Tetracotyle percae-fluviatilis (Linstow, 1856)
Caryophyllaeides fennica (Schneider, 1902)
Ligula intestinalis Linnaeus, 1758
Eustrongylides excisus Jagerskiold, 1909
Skrjabillanus scardinii Molnár, 1966
Piscicola geometra Linnaeus, 1761
***Abramis brama* (Linnaeus, 1758)**
Dactylogyrus distinguendus (Linstow, 1878)
Dactylogyrus sphyrna Linstow, 1828
Diplostomum spathaecum (Rudolphi, 1819)
Tylodelphys clavata Nordmann, 1832
Tetracotyle percae-fluviatilis (Linstow, 1856)
***Squalius cephalus* (Linnaeus, 1758)**
Dactylogyrus elegantis Gusev, 1966
Dactylogyrus extensus Mueller and Cleave, 1932
Dactylogyrus folkmanovae Ergens, 1956
Dactylogyrus naviculoides Ergens, 1960
Dactylogyrus prostae Molnar, 1964
Dactylogyrus vistulae Prost, 1957
Paradiplozoon megan Bykhovskii and Nagibi, 1959
Allocreadium isoporum Looss, 1894
Bothriocephalus acheilognathi Yamaguti, 1955
Khawia armeniaca Cholodkovskii, 1878
Ligula intestinalis Linnaeus, 1758
Philometra ovata (Zeder, 1803)
Rhabdochona denudata (Dujardin, 1845)
Pomphorhynchus laevis (Müller, 1776)
***Tinca tinca* (Linnaeus, 1758)**
Dactylogyrus macrocanthus Wagener, 1857
Gyrodactylus medius Kathariner, 1894
Asymphylodora tincae (Mooder, 1790)
Diplostomum spathaecum (Rudolphi, 1819)
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955

Table 4 (continuing): Host - Helminth List.

Caryophyllaeus laticeps (Müller, 1781)
Ligula intestinalis Linnaeus, 1758
Proteocephalus torulosus (Batsch, 1786)
Acanthocephalus anguillae Müller, 1780
Pomphorhynchus laevis (Müller, 1776)
Piscicola geometra Linnaeus, 1761
Barbus plebejus **Bonaparte, 1839**
Dactylogyrus malleus Linstow, 1877
Gyrodactylus elegans Nordmann, 1832
Gyrodactylus hemibarbi (Ergens, 1980)
Allocreadium isoporum Looss, 1894
Ligula intestinalis Linnaeus, 1758
Rhabdochona denudata (Dujardin, 1845)
Pseudophoxinus antalyae **Bogutskaya, 1992**
Dactylogyrus ergensi Molnar, 1964
Dactylogyrus sphyrna Linstow, 1828
Diplozoon homoion Bykhovskii and Nagibi, 1959
Eustrongylides excisus Jagerskiold, 1909
Barbus grypus **Heckel, 1843**
Dactylogyrus extensus Mueller and Cleave, 1932
Capoeta capoeta **(Güldenstädt, 1773)**
Dactylogyrus pulcher Bychowsky, 1957
Dactylogyrus vastator (Nybelin, 1924)
Caryophyllaeus laticeps (Müller, 1781)
Ligula intestinalis Linnaeus, 1758
Rhabdochona denudata (Dujardin, 1845)
Esox lucius **Linnaeus, 1758**
Tetraonchus monenteron Diesing, 1858
Asymphylodora tincae (Mooder, 1790)
Bucephalus polymorphus Baer, 1827
Diplostomum spathaecum (Rudolphi, 1819)
Diplodiscus subclavatus Diesing, 1836
Rhipidocotyle fennica Taskinen, 1991
Tylodelphys clavata Nordmann, 1832
Bathybothrium rectangulum (Bloch, 1782)
Ligula intestinalis Linnaeus, 1758
Triaenophorus crassus Forel, 1880
Camallanus truncatus (Rudolphi, 1814)

Table 4 (continuing): Host - Helminth List.

Raphidascaris acus (Bloch, 1779)
Acanthocephalus anguillae Müller, 1780
Neoechinorhynchus rutili (Müller, 1780)
Pomphorhynchus laevis (Müller, 1776)
Hemiclepsis marginata Müller, 1774
Hirudo medicinalis Linnaeus, 1758
Piscicola geometra Linnaeus, 1761
***Garra rufa* (Heckel, 1843)**
Dactylogyrus rectotrabus Gussev, Jalali and Molnar, 1993
Ligula intestinalis Linnaeus, 1758
Capoeta trutta (Heckel, 1843)
Diplozoon barbi Nordman, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Khawia armeniaca Cholodkovskii, 1878
Neoechinorhynchus rutili (Müller, 1780)
Rutilus rubilio (Bonaparte, 1837)
Dactylogyrus sphyrna Linstow, 1828
Neoechinorhynchus rutili (Müller, 1780)
***Aphanius* sp.**
Dactylogyrus vastator (Nybelin, 1924)
Alburnus orontis Sauvage, 1882
Dactylogyrus vastator (Nybelin, 1924)
Ligula intestinalis Linnaeus, 1758
***Acantobrama marmid* Heckel, 1843**
Diplozoon paradoxum Nordman, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Caryophyllaeus laticeps (Müller, 1781)
Khawia armeniaca Cholodkovskii, 1878
Ligula intestinalis Linnaeus, 1758
***Capoeta damascina* (Valenciennes, 1842)**
Dogielius forceps Bychowsky, 1936
Monobothrium auriculatum Kulakovskaya, 1961
Gasterosteus aculeatus* Linnaeus, 1758
Gyrodactylus arcuatus Bychowsky, 1933

Table 4 (continuing): Host - Helminth List.

***Cobitis simplicispina* Hankó, 1925**
Gyrodactylus cobitis Bychowsky, 1933
Neogobius fluviatilis* (Pallas, 1814)
Gyrodactylus gobii Shul'man, 1953
Bothriocephalus acheilognathi Yamaguti, 1955
Ligula pavlovskii Dubinina, 1959
Eustrongylides excisus Jagerskiold, 1909
Neogobius melanostomus* (Pallas, 1814)
Gyrodactylus proterorhini Ergens, 1967
Pygidiopsis genata Looss, 1907
Neoechinorhynchus rutili (Müller, 1780)
Lepomis gibbosus* (Linnaeus, 1758)
Onchocleidus similis Mueller, 1936
Clinostomum complanatum Rudolphi, 1819
Tylodelphys clavata Nordmann, 1832
***Clarias gariepinus* (Burchell, 1822)**
Quadriacanthus clariadis (Paperna, 1961)
Orientocreadium batrachoides Tubangui, 1931
Polyonchobothrium magnum (Zme'ev, 1936)
***Alburnus* sp.**
Asymphylodora tincae (Mooder, 1790)
Clinostomum complanatum Rudolphi, 1819
Ligula intestinalis Linnaeus, 1758
Neoechinorhynchus rutili (Müller, 1780)
Pomphorhynchus laevis (Müller, 1776)
***Barbus* sp.**
Asymphylodora tincae (Mooder, 1790)
Neoechinorhynchus rutili (Müller, 1780)
***Knipowitschia caucasica* (Berg, 1916)**
Bucephalus polymorphus Baer, 1827
***Chondrostoma* sp.**
Clinostomum complanatum Rudolphi, 1819
Philometra intestinalis Dogiel and Bykhowsky, 1934

Table 4 (continuing): Host - Helminth List.

***Varcorhinus* sp.**
Clinostomum complanatum Rudolphi, 1819
***Perca fluviatilis* Linnaeus, 1758**
Clinostomum complanatum Rudolphi, 1819
Tylodelphys clavata Nordmann, 1832
Proteocephalus percae (Müler, 1780)
Eustrongylides excisus Jagerskiold, 1909
***Salmo trutta abanticus* Tortonese, 1954**
Crepidostomum farionis (Muller, 1780)
***Salmo trutta fario* Linnaeus, 1758**
Posthodiplostomum minimum Maccallum, 1921
Cystobranchus respirans (Troschel, 1850)
Atherina boyeri* Risso, 1810
Tylodelphys clavata Nordmann, 1832
Bothriocephalus acheilognathi Yamaguti, 1955
Eustrongylides excisus Jagerskiold, 1909
***Alburnus mossulensis* Heckel, 1843**
Bothriocephalus acheilognathi Yamaguti, 1955
Ligula intestinalis Linnaeus, 1758
***Capoeta bergamae* Karaman, 1969**
Ligula intestinalis Linnaeus, 1758
***Alburnoides bipunctatus* (Bloch, 1782)**
Ligula intestinalis Linnaeus, 1758
***Chondrostoma nasus* (Linnaeus, 1758)**
Ligula intestinalis Linnaeus, 1758
***Alburnus escherichii* Steindachner, 1897**
Ligula intestinalis Linnaeus, 1758
***Gobio gobio* (Linnaeus, 1758)**
Ligula intestinalis Linnaeus, 1758
***Aphanius mento* (Heckel, 1843)**
Eustrongylides excisus Jagerskiold, 1909
Triaspiron aphanii Smales, Aydoğdu and Emre, 2012

Table 4 (continuing): Host - Helminth List.

***Pseudophoxinus battalgilae* Bogutskaya, 1997**
Eustrongylides excisus Jagerskiold, 1909
***Squalius lepidus* Heckel, 1843**
Molnaria intestinalis Dogiel and Bychowsky, 1934
Capoeta antalyensis (Battalgil, 1943)
Rhabdochona denudata (Dujardin, 1845)
***Luciobarbus mursa* (Güldenstädt, 1773)**
Rhabdochona denudata (Dujardin, 1845)
***Aphanius chantrei* (Gaillard, 1895)**
Spiroxys contortus Rudolphi, 1819
Neoechinorhynchus rutili (Müller, 1780)
***Aphanius danfordii* (Boulenger, 1890)**
Spiroxys contortus Rudolphi, 1819
Neoechinorhynchus rutili (Müller, 1780)
***Capoeta barroisi* Lortet, 1894**
Neoechinorhynchus zabensis Amin, Abdullah and Mhaisen, 2003
***Nemacheilus* sp.**
Pomphorhynchus laevis (Müller, 1776)
***Alburnus nasreddini* Battalgil, 1943**
Pomphorhynchus laevis (Müller, 1776)
***Cobitis bilseli* Battalgil, 1942**
Pomphorhynchus tereticollis (Rudolphi, 1809)
***Silurus triostegus* Heckel, 1843**
Senga mastacembeli Rahemo, 1996

Atherina boyeri introduced into several western lakes and Beyşehir Lake - *Lepomis gibbosus*, *Carassius gibelio*, *Carassius auratus* are not native to Turkey, they were introduced into the lakes and rivers.

Gasterosteus aculeatus is distributed in the Black Sea, Marmara Sea, Aegean Sea and Mediterranean Sea and adjacent watersheds; *Neogobius fluviatilis* in the Black Sea watersheds; *Neogobius melanostomus* in the Black Sea, Marmara Sea, Aegean Sea and the Caspian Sea watersheds.

Table 5: Unnamed helminth species (at genera level) on freshwater fishes of Turkey.

Phylum Platyhelminthes		
Class Monogenea		
***Ancyrocephalus* sp.**		
Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
***Paradiplozoon* sp.**		
Abramis brama	Terkos Lake	Soylu (2009)
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
***Cleidodiscus* sp.**		
Silurus glanis	Gölbasi Lake	Ekingen (1976)
***Diplozoon* sp.**		
Scardinius erythrophthalmus	Karacabey Lagoon Lake	Öztürk et al. (2002)
***Dactylogyrus* sp.**		
Tinca tinca	Gölbaşi Lake, Eymir Lake	Burgu et al. (1988)
Cyprinus carpio	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook, Hirfanli Dam Lake, Çankiri-Günerdiğin Pond	Burgu et al. (1988)
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Silurus glanis	Gölbaşi Lake, Eymir Lake, Sariyar Dam Lake	Burgu et al. (1988)
Barbus sp.	Çifteler-Sakaryabaşi Fish Production Station, Sariyar Dam Lake	Burgu et al. (1988)
Chondrostoma sp.	Kizilcahamam Brook, Nallihan Brook	Burgu et al. (1988)
Varicorhinus sp.	Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Çankiri-Günerdiğin Pond, Nallihan Brook, Kizilcahamam Brook	Burgu et al. (1988)

Table 5 (continuing): Unnamed helminth species on freshwater fishes of Turkey.

Cyprinus carpio	Kocadere Lake, Uluabat Lake, Ekinli Lagoon Lake	Altin (1989)
Cyprinus carpio	Kocadere Lake, Uluabat Lake, Ekinli Lagoon Lake	Oğuz (1991)
Tinca tinca	İznik Lake	Aydoğdu et al. (1996a)
Tinca tinca	Mogan Lake	Sönmez (1996)
Cyprinus carpio	Mogan Lake	Sönmez (1996)
Alburnus escherichii	Mogan Lake	Sönmez (1996)
Cyprinus carpio	Çifteler-Sakaryabaşi Fish Production Sitation	Atay et al. (1999)
Vimba vimba	Sirakaraağaçlar Stream	Ünsal (2008)
Cyprinus carpio	Halil-ür Rahman Lake	Pişkin and Ütük (2008)
Capoeta capoeta	Almus Dam Lake	Özgül (2008)
***Gyrodactylus* sp.**		
Salmo trutta fario	İstanbul Brook	Soylu (1985)
Cyprinus carpio	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook, Hirfanli Dam Lake, Çankiri-Günerdiğin Pond	Burgu et al. (1988)
Alburnus sp.	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook	Burgu et al. (1988)
Chondrostoma sp.	Kizilcahamam Brook, Nallihan Brook	Burgu et al. (1988)
Varicorhinus sp.	Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Çankiri-Günerdiğin Pond, Kizilcahamam Brook, Nallihan Brook	Burgu et al. (1988)
Barbus sp.	Gölbaşi Lake, Eymir Lake, Sariyar Dam Lake	Burgu et al. (1988)
Cyprinus carpio	Bekteşağa Pond	Özer (1995)
Aphanius chantrei	Sarikum Lagoon Lake	Öztürk (2005)
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Chondrostoma regium	Almus Dam Lake	Özgül and Turgut (2006)

Table 5 (continuing): Unnamed helminth species on freshwater fishes of Turkey.

Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
Aphanius danfordii	Sarikum Lagoon Lake	Öztürk and Özer (2008a)
Aphanius danfordii	Sirakaraağaçlar Stream	Ünsal (2008)
Neogobius melanostomus	Sirakaraağaçlar Stream	Ünsal (2008)
Capoeta capoeta	Almus Dam Lake	Özgül (2008)
Capoeta tinca	Almus Dam Lake	Özgül (2008)
Cyrinus carpio	Emre Dam Lake	Öztürk (2011)
Carassius auratus	Emre Dam Lake	Öztürk (2011)
Carassius carassius	Emre Dam Lake	Öztürk (2011)
Blicca bjoerkna	Sapanca Lake	Soylu (2012)
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Carassius gibelio	Siğirci Lake	Çolak (2013)
Sander lucioperca	Siğirci Lake	Çolak (2013)
Lepomis gibbosus	Siğirci Lake	Çolak (2013)
***Salsuginus* sp.**		
Aphanius chantrei	Sarikum Lagoon Lake	Öztürk (2005)
Aphanius danfordii	Sarikum Lagoon Lake	Öztürk and Özer (2008a)
Aphanius danfordii	Sirakaraağaçlar Stream	Ünsal (2008)
***Tetraonchus* sp.**		
Esox lucius	Mogan Lake	Sönmez (1996)
Acantobrama marmid	Tigem Reservoirs	Zeren (2008)
Phylum Platyhelminthes		
Class Digenea		
***Ascocotyle* sp.**		
Aphanius chantrei	Sarikum Lagoon Lake	Öztürk (2005)
Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
Neogobius melanostomus	Sirakaraağaçlar Stream	Özer (2007)
Aphanius danfordii	Sarikum Lagoon Lake	Öztürk and Özer (2008a)
***Digenea* sp.**		
Tinca tinca	Mogan Lake, Hirfanli Dam Lake, Kizilcahamam Brook	Erkul (1997)
Tinca tinca	Kapulukaya Dam Lake	Yildiz (2003)
Neogobius melanostomus	Sirakaraağaçlar Stream	Özer (2007)
***Diplostomum* sp.**		
Blicca bjoerkna	Uluabat Lake	Akinci (1999)
Acanthobrama marmid	Keban Dam Lake	Dörücü and İspir (2001)
Silurus glanis	Terkos Lake	Soylu (2005)

Table 5 (continuing): Unnamed helminth species on freshwater fishes of Turkey.

Carassius carassius	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2005)
Luciobarbus esocinus	Keban Dam Lake	Dörücü and İspir (2005)
Capoeta umbla	Keban Dam Lake	Dörücü and İspir (2005)
Chondrostoma regium	Keban Dam Lake	Dörücü and İspir (2005)
Squalius cephalus	Keban Dam Lake	Dörücü and İspir (2005)
Blicca bjoerkna	Sapanca Lake	Soylu (2006)
Rutilus rutilus	Sapanca Lake	Karabiber (2006)
Tinca tinca	Sapanca Lake	Akbeniz (2006)
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Vimba vimba	Sapanca Lake	Uzunay (2006)
Cyprinus carpio	Sapanca Lake	Uzunay (2006)
Chondrostoma regium	Almus Dam Lake	Özgül and Turgut (2006)
Alburnus alburnus	Mustafakemalpaşa Stream	Aydoğdu and Selver (2006)
Vimba vimba	Gölbaşi Dam Lake	Aydoğdu et al. (2008)
Capoeta trutta	Keban Dam Lake	Dörücü et al. (2008)
Cyprinus carpio	Almus Dam Lake	Özgül (2008)
Capoeta capoeta	Almus Dam Lake	Özgül (2008)
Capoeta tinca	Almus Dam Lake	Özgül (2008)
Squalius cephalus	Örenler Dam Lake	Kurupinar (2009)
Cyprinus carpio	Keban Dam Lake	Karabulut (2009)
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Atherina boyeri	İznik Lake	Çolak (2013)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Carassius gibelio	Siğirci Lake	Çolak (2013)
Sander lucioperca	Siğirci Lake	Çolak (2013)
Lepomis gibbosus	Siğirci Lake	Çolak (2013)
Scardinius erythropthalmus	Siğirci Lake	Çolak (2013)
Rutilus rutilus	Siğirci Lake	Çolak (2013)
Esox lucius	Siğirci Lake	Çolak (2013)
Silurus glanis	Siğirci Lake	Çolak (2013)
***Diplodiscus* sp.**		
Esox lucius	Uluabat Lake	Öztürk (1995)
***Neascus* sp.**		
Salmo trutta fario	Munzur Stream	Ekingen (1975)
***Orientocreadium* sp.**		
Clarias gariepinus	Kepez I Hydro Electric Power Plant Loading Pond	Soylu and Emre (2005)
***Posthodiplostomum* sp.**		
Aphanius chantrei	Sarikum Lagoon Lake	Öztürk (2005)

Table 5 (continuing): Unnamed helminth species on freshwater fishes of Turkey.

Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
Aphanius danfordii	Sarikum Lagoon Lake	Öztürk and Özer (2008a)
***Rhipidocotyle* sp.**		
Esox lucius	Uluabat Lake	Öztürk (1995)
***Sanguinicola* sp.**		
Cyprinus carpio	Gölbaşi Lake, Eymir Lake, Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Dam Lake, Sariyar Dam Lake, Kizilcahamam Brook, Hirfanli Dam Lake, Çankiri-Günerdiğin Pond	Burgu et al. (1988)
***Tetracotyle* sp.**		
Vimba vimba	Sapanca Lake	Uzunay (2006)
Blicca bjoerkna	Sapanca Lake	Soylu (2006)
Perca fluviatilis	Siğirci Lake	Soylu (2013)
Sander lucioperca	Siğirci Lake	Çolak (2013)
Lepomis gibbosus	Siğirci Lake	Çolak (2013)
***Creptotrema* sp.**		
Salmo trutta fario	Munzur Stream	Ekingen (1975)
Phylum Platyhelminthes		
Class Cestoda		
***Bothriocephalus* sp.**		
Cyprinus carpio	Uluabat Lake	Oğuz et al. (1996a)
Esox lucius	Mogan Lake	Sönmez (1996)
Cyprinus carpio	Mogan Lake	Sönmez (1996)
Alburnus escherichii	Mogan Lake	Sönmez (1996)
Cyprinus carpio	İznik Lake	Aydoğdu (1997)
***Caryophyllaeus* sp.**		
Cyprinus carpio	Porsuk Stream	Yetim (1985)
Cyprinus carpio	Seyhan River	Cengizler et al. (2001)
***Caryophyllaeides* sp.**		
Blicca bjoerkna	Uluabat Lake	Akinci (1999)

Table 5 (continuing): Unnamed helminth species on freshwater fishes of Turkey.

***Cyclophyllidea* sp.**		
	Çifteler-Sakaryabaşi Fish Production Station, Kurtboğazi Lake, Çankiri-Günerdiğin Pond, Nallihan and Kizilcahamam brooks	Burgu et al. (1988)
***Diphyllobothrium* sp.**		
Capoeta umbla	Hazar Lake	Aksoy (1996)
***Ligula* sp.**		
Vimba vimba	Porsuk River	Yetim (1985)
Tinca tinca	Mogan Lake	Öğe and Aydin (1995)
Esox lucius	Mogan Lake	Sönmez (1996)
Cyprinus carpio	Mogan Lake	Sönmez (1996)
Alburnus escherichii	Mogan Lake	Sönmez (1996)
Silurus glanis	İznik Lake	Aydoğdu et al. (1996b)
Tinca tinca	Kapulukaya Dam Lake	Yildiz (2003)
***Proteocephalus* sp.**		
Cyprinus carpio	Porsuk Stream	Yetim (1985)
Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
***Schistocephalus* sp.**		
Cyprinus carpio	Seyhan River	Cengizler et al. (2001)
Luciobarbus pectoralis	Seyhan River	Şahan and Cengizler (2003)
Tinca tinca	Gölbaşi Lake, Eymir Lake	Burgu et al. (1988)
Tinca tinca	Mogan Lake, Hirfanli Dam Lake, Kizilirmak Brook	Erkul (1997)
Cyprinus carpio	Mogan Lake	Erkul (1997)
Alburnus escherichii	Mogan Lake	Erkul (1997)
Esox lucius	Mogan Lake	Erkul (1997)
Tinca tinca	Kapulukaya Dam Lake	Yildiz (2003)
Esox lucius	Siğirci Lake	Çolak (2013)
Silurus glanis	Siğirci Lake	Çolak (2013)
***Philonema* sp.**		
Salmo trutta fario	Munzur Stream	Ekingen (1975)
***Raphidascaris* sp.**		
Esox lucius	Çapali Lake	Ceylan (2002)

Table 5 (continuing): Unnamed helminth species on freshwater fishes of Turkey.

***Rhabdochona* sp.**		
Cyprinion macrostomum	Balikli Thermal	Saygi and Bardakçi (1990)
Gara rufa	Topardic Stream	Saygi and Bardakçi (1990)
Scardinius erythrophthalmus	Uluabat Lake	Oğuz and Öztürk (1993)
Alburnus chalcoides	Tödürge Lake	Yildirim and Ünver (2006)
***Spiroxys* sp.**		
Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
Neogobius melanostomus	Sirakaraağaçlar Stream	Özer (2007)
Phylum Acanthocephala		
***Acanthocephalus* sp.**		
Salmo trutta fario	Munzur Stream	Ekingen (1975)
***Neoechinorhynchus* sp.**		
Salmo trutta fario	Munzur Stream	Ekingen (1976)
Luciobarbus pectoralis	Keban Dam Lake	Özdemir and Sarieyyüpoğlu (1993)
Capoeta capoeta	Murat River, Aras River	Aslan (2009)
Capoeta barroisi	Murat River, Aras River	Aslan (2009)
Barbus plebejus	Murat River, Aras River	Aslan (2009)
Cyprinus carpio	Siğirci Lake	Çolak (2013)
Esox lucius	Siğirci Lake	Çolak (2013)
***Paulisentis* sp.**		
Aphanius chantrei	Sirakaraağaçlar Stream	Özer (2006)
***Pomphorhynchus* sp.**		
Chondrostoma nasus	Porsuk Stream	Yetim (1985)
Luciobarbus escherichii	Porsuk Stream	Yetim (1985)
Capoeta capoeta	Murat River, Aras River	Aslan (2009)
Barbus plebejus	Murat River, Aras River	Aslan (2009)
Squalius cephalus	Murat River, Aras River	Aslan (2009)
Phylum Annelida		
***Actinobdella* sp.**		
Luciobarbus mystaceus	Keban Dam Lake	Sağlam (1992)
***Piscicola* sp.**		
Luciobarbus pectoralis	Keban Dam Lake	Özdemir and Sarieyyüboğlu (1993)

Although parasite at species and genera level were reported from freshwater fish, only the species level will be considered here (Tab. 3). Other parasites at genera level (unnamed species) will be omitted in here.

Because they are reported from different hosts, the fish that will be shown (Tab. 5) may be a new species or the same species.

This revision presents an occurence of 60 monogenean at species level and eight genera level (unnamed), after eleven years (Tab. 3). Other eight unnamed monogenea (genera level) reported from different host fish (*Ancyrocephalus* sp., *Paradiplozoon* sp., *Cleidodiscus* sp., *Diplozoon* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., *Salsuginus* sp., *Tetraonchus* sp.) (Tab. 5). *Dactylogyrus* and *Gyrodactylus* genus are the most abundant among the monogenea. *Dactylogyrus* genus is represented with 38 species, while *Gyrodactylus* with 11 species. *Dactylogyrus* is the dominant genus among the Monogenea with regard to species diversity, host distribution and location. 33 host fish species (32 species of Cyprinidae, one species of Siluridae) were infested with *Dactylogyrus*; 13 host fish species (nine species of Cyprinidae, three species of Gobiidae, one species of Gasterosteidae) with *Gyrodactylus*; 10 different fish species with Paradiploozon and Diplozoon. *Dactylogyrus chalcalburni*, *Ancylodiscoides siluri*, *Ancylodiscoides vistulensis* and *Tetraonchus monenteron* may be considered specific to their hosts. Dominants of some monogeneans selected the following infection sites: *Dactylogyrus* from gill filaments; *Gyrodactylus* from fins, gills, body surface.

This revision presents occurence of 20 digenean at species level and 11 digenean at genera level (unnamed), after eleven years (Tab. 3). Also, 11 unnamed species (genera level) were reported from different host fish (*Ascocotyle* sp., *Digenea* sp., *Diplostomum* sp., *Diplodiscus* sp., *Neascus* sp., *Orientocreadium* sp., *Posthodiplostomum* sp., *Rhipidocotyle* sp., *Sanguinicola* sp., *Tetracotyle* sp., *Creptotrema* sp.). *Digenea* is next-largest group with 20 species. In terms of host distribution, *Digenea* may be ranked as follows: *Diplostomum* (seven hosts), *Tylodelphys* (13 hosts), *Clinostomum* (10 hosts), *Asymphylodora* (four hosts), *Posthodiplostomum* (six hosts), *Bucephalus* (four hosts), *Allocreadium* (four hosts), *Aspidogaster* (five hosts). *Bucephalus polymorphus* may be cosidered specific to carnivorous fish. Adults digeneans were reported from intestine, pyloric caeca, stomach, body cavity, eye lens, liver, spleen, pericard, gall bladder, heart of hosts. Larvaes of some digeneans such as *Centrocestus* sp., *Clinostomum* sp., *Posthodiplostomum* sp., were reported from fins, body surface, operculum, muscle, gills of hosts.

The checklist contains 20 species and eight unnamed species (genera level) of Cestoda. In terms of host distribution, the 10 genera of Cestoda may be ranked as follows: *Ligula* (28 hosts), *Bothriocephalus* (17 hosts), *Caryophyllaeus* (11 hosts), *Proteocephalus* (four hosts) Khawia (six hosts). *Ligula pavlovskii, Triaenophorus crassus, Silurotaenia siluri, Khawia armeniaca* and *Proteocephalus osculatus* may be considered specific to their hosts. *Ligula intestinalis* is the dominant cestode species in terms of host range and location. Cestodes were reported from intestine, body cavity, surfaces of visceral organs, pharynx, external mesenteries of internal organ, pyloric caeca, duodenum, urogenital ducts, liver, gonad of hosts.

The checklist contains 11 species and nine unnamed species (genera level) of Nematoda. In terms of host distribution, the genera of Nematoda may be ranked as follows: *Rhabdochona* (eight hosts), *Eustrongylides* (nine hosts), *Philometra* (three hosts). Adults nematodes were reported from body cavity, pyloric caeca, liver, intestine, mesentery, body surface, gills, coelom, stomach, swimbladder, surfaces of visceral organs, muscle, ovarium, testis of hosts. *Nematoda* sp. larvae were reported from body surface, gills.

The checklist contains seven species and four unnamed species (genera level) of acanthocephala. The genera of Acanthocephala are distributed as follows: *Neoechinorhynchus* (15 hosts), *Pomphorhynchus* (14 hosts), *Acanthocephalus* (two hosts). Acanthocephalans were only reported on intestines of hosts.

The checklist contains five species and two unnamed species (genera level) of hirudinids. Hirudinids were reported on body surface, fins, gills, mouth.

After the checklist of helminths of freshwater fish from Turkey published by Öktener (2003), parasites species number increased significantly to nowadays. Especially, platyhelminth species number reached from 57 to 100 (Tab. 6).

Table 6: Change of number of named and unnamed helminth species reported from fish species occurring after Öktener (2003).

	Öktener (2003)		Present Study	
	Named species	Unnamed species	Named species	Unnamed species
Monogenea	28	5	60	8
Digenea	16	5	20	11
Cestoda	13	6	20	8
Nematoda	8	5	11	9
Acanthocephala	5	3	7	4
Hirudinea	3	2	5	2
	73	26	123	42
Total	99		165	

CONCLUSIONS

This new updated checklist is done to update the helminths of freshwater fish from Turkey.

Finally, it was also planned to show and update the parasite richness of fish of Turkey according to actual literature.

The present publication describes the published literature and thus provides a summary of the currently known freshwater fish parasites in Turkey. It was felt that a critical checklist of the freshwater fish parasites known from Turkey to date would help to solve contradictions among researchers, and benefit veterinarians, parasitologists and zoologists, ecologists.

It is hoped that this compilation will stimulate further parasitological investigations of fish in Turkey.

REFERENCES

1. Akbeniz E., 2006 – Metazoon parasites of tench (Tinca tinca Linnaeus, 1758) in Sapanca Lake, Marmara University, Institute of Science, MSc Thesis, 47.
2. Akinci A. G., 1999 – Studies On Determine The Platyhelminths of Blicca bjoerkna L., 1758 in Uluabat Lake, Uludağ University, Institute of Science, MSc Thesis, 34.
3. Akmirza A., 2007 – The effect of Ligula intestinalis L. plerocercoid on the growth of bitterling (Rhodeus amarus Bloch, 1782), *Journal of the Black Sea/Mediterranean Environment*, 13, 155-160.
4. Aksakal H. N., 1992 – The Parasitological Studies On the Identification of Platyhelminthes Living As A Endoparasites in Tenchs (Tinca tinca) of Uluabat Lake, Uludağ University, Institute of Science, MSc Thesis, 24.
5. Aksoy Ş., 1996 – Endohelminths research in Capoeta capoeta umbla from Hazar Lake, Firat University, Institute of Science, MSc Thesis, 39.
6. Aksoy Ş., Sağlam N. and Dörücü M., 2006 – External Parasites of Three Cyprinid Fish Species from Lake Hazar in Turkey, *Indian Veterinary Journal*, 83, 100-101.
7. Altin H., 1989 – Some Parasites On Carp (Cyprinus carpio L.), Uludağ University, Science Faculty, BSc Thesis, 33.
8. Arthur J. R. and Ahmet A. T. A., 2002 – Checklist of the parasites of fishes of Bangladesh, *FAO Fisheries Technical Paper*, 369, 1, Rome, 77.
9. Arthur J. R. and Lumanlan-Mayo S., 1997 – Checklist of the parasites of fishes of the Philippines, *FAO Fisheries Technical Paper*, 369, Rome, 102.
10. Aslan B., 2009 – Investigations of the endohelminths of some fish from Murat River (Ağri) and Aras River (Erzurum), Atatürk University, Science Institution, Institute of Science, 58.
11. Atay D., Köksal G., Seçer S., Aydin F., Polatsü S. and Yildiz H., 1999 – Impact on the Health Status and some Hematologic Characteristics of Carp Fertilization, *Turkish Journal of Zoology*, 20, 67-72.
12. Aydin Y., 2003 – The Helminths of the Digestive Tract of Catfish (Silurus glanis L., 1758) in Hirfanli Dam Lake, Nigde University, Institute of Science, MSc Thesis, 50.
13. Aydoğdu A., 1997 – Studies on determine the platyhelminth parasites of common carp (Cyprinus carpio L., 1758) in İznik Lake, Uludağ University, Institute of Science, MSc Thesis, 35.
14. Aydoğdu A., 2001 – The Helminthofauna of Some Fishes Living in Doganci Dam Lake, Uludag University, Institute of Science, PhD Thesis, 82.
15. Aydoğdu A., Emence H. and Altunel A., 2008a – Helminth parasites of pike (Esox lucius L.) in Gölbaşi (Bursa) Dam Lake, Turkey, *Pakistan Journal of Zoology*, 40, 3, 221-224.
16. Aydoğdu A., Emence H. and İnnal D., 2008b – The Occurrence of Helminth Parasites in Vimba (Vimba vimba L., 1758) of Golbasi (Bursa) Dam Lake, Turkey, *The Turkish Journal of Parasitology*, 32, 1, 86-90.
17. Aydoğdu A., Emre Y., Emre N. and Altunel F. N., 2011 – The occurrence of helminth parasites (Nemathelminthes) in some freshwater fish from streams discharging into Antalya Bay in Antalya, Turkey: two new host records from Antalya, *Turkish Journal of Zoology*, 35, 6, 859-864.
18. Aydoğdu A., Oğuz M. C., Öztürk M. O. and Altunel F. N., 2001 – Investigations on metazoon parasites of common carp (Cyprinus carpio L., 1758) in Dalyan Lagoon, Karacabey, *Acta Veterinaria*, 51, 5-6, 351-358.
19. Aydoğdu A. and Selver M., 2006 – An Investigation of Helminth Fauna of the Bleak (Alburnus alburnus L.) from the Mustafakemalpasa Stream, Bursa, Turkey, *The Turkish Journal of Parasitology*, 30, 1, 69-72.
20. Aydoğdu A., Yildirimhan H. S. and Altunel F. N., 1996 – An Investigation On Parasites of Catfish (Silurus glanis L., 1758), in Iznik Lake, XIII, National Biology Congress (17-20 September, 1996), Istanbul, 63-70.

21. Aydoğdu A., Yildirimhan H. S. and Altunel F. N., 1996a – An investigation on parasites of tench (Tinca tinca L., 1758) in the İznik Lake, *The Turkish Journal of Parasitology*, 20, 261-270.
22. Aydoğdu A., Yildirimhan H. S. and Altunel F. N., 1997b – An investigation on ecto and endo helminth of roach (Rutilus frisii L.), IX National Aquatic Products Symposium (17-19 September 1997), Isparta, 431-443.
23. Aydoğdu A., Yildirimhan H. S. and Altunel F. N., 1997 – An investigation on some metazoan parasites of common carp (Cyprinus carpio L.) in İznik Lake, *The Turkish Journal of Parasitology*, 21, 4, 442-445.
24. Aydoğdu A., Yildirimhan H. S. and Altunel F. N., 2000 – The Helminth Fauna of Adriatic Roach (Rutilus rubilio) in Iznik Lake, *Bulletin of European Fish Pathology*, 20, 3, 170-172.
25. Başaran A. and Kelle A., 1976 – Distribution of Ligula intestinalis in Some Freshwater Fish Living On the Devegecidi Dam Lake, *Journal of Hacettepe University*, 26, 45-56.
26. Becer Z. A. and Kara D., 1998 – An investigation on population structure and parasites of common carp (Cyprinus carpio L., 1758) which were caught in Kovada Lake, *The Turkish Journal of Parasitology*, 22, 2, 199-203.
27. Buhurcu H. İ., 2006 – An investigation on endoparasite fauna of some fish species (Cyprinus carpio and Alburnus nasreddini) from Lake Akşehir, Afyon Kocatepe University, Institute of Science, MSc Thesis, 42.
28. Bulgen K., 1999 – An investigation of the taxonomic status and biological aspects of the chub (Leuciscus cephalus Linnaeus, 1758), Balikesir University, Institute of Science, MSc Thesis, 48.
29. Burgu A., Oğuz T., Körting W. and Güralp N., 1988 – Parasites of freshwater fishes in some areas of central Anatolia, *Journal of Etlik Veterinary and Microbiology*, 3, 6, 143-165.
30. Caira J. N., 1989 – A revision of the North American papillose Allocreadiidae (Digenea) with independent cladistic analyses of larval and adult forms, *Bulletin of the University of Nebraska State Museum*, Lincoln, 11, 3, 1-58.
31. Cantoray R. and Özcan A., 1975 – La ligulose chez des poissons d’eau douce aux alentours d’Elaziğ, Firat University, *Journal of Veterinary Faculty*, 2, 298-301. (in French)
32. Cengizler İ., Sarihan E. and Çevik C., 1991 – Investigation of Ligulosis on cyprinids in Almus Lake, Symposium of National Aquatic Products, 12-14 Kasim 1991, İzmir, 371-375.
33. Cengizler I. and Göksu L., 1994 – Some Metazoon Parasites Seen in Two Cyprinid Species Lived In Balikliag Stream, XII National Biology Congress (6-8 July 1994, Edirne), Edirne, 362-365.
34. Cengizler İ., Aytaç N., Şahan A., Özak A. A. and Genç E., 2001 – Ecto-Endo Parasite Investigation on Mirror Carp (Cyprinus carpio L., 1758) Captured From the River Seyhan, Turkey, Ege University, *Journal of Fisheries and Aquatic Sciences*, 18, 1-2, 87-90.
35. Ceylan Y., 2002 – Parasitological Research of fishes in Çapali Lake (Dinar-Afyon), Süleyman Demirel University, Institute of Science, MSc Thesis, 54.
36. Ceylan M., Boyaci Y. E., Meke T., İnceoğlu H. and Kara A., 2011 – A Report of Ectoparasite Piscicola geometra (Linnaeus, 1761) (Hirudinea: Rhynchobdellida) on Roach (Rutilus rutilus (Linnaeus, 1758)) from Uluabat Lake, *The Turkish Journal of Parasitology*, 35, 207-209.
37. Çolak H. S., 2013 – Metazoan parasites of fish species from Lake Siğirci (Edirne, Turkey), *Turkish Journal Veterinary Animal Science*, 37, 200-205.
38. Çolak S. Ö., 2013 –The helminth community of the sand smelt (Atherina boyeri Risso, 1810) from Lake Iznik, Turkey, *Journal of Helminthology*, 87, 129-134.
39. Dal A., 2006 – Parasitological research on rainbow trout (Oncorhynchus mykiss) farming in Atatürk Dam Lake, Çukurova University, Institute of Science, MSc Thesis, 52.
40. Develi N., 2008 – Seasonal Distribution of metazoan parasites in fish species found in Almus Dam Lake, Gaziosmanpaşa University, Institute of Science, MSc Thesis, 65.

41. Diler Ö., Yildirim U. G., Küçük F. and Işikli B., 2001 – Parasitological research on cobitid (Knipowitshia caucasica) living in Eğirdir Lake, 11 Symposiyum of National Aquatic Products, Hatay 04-06 Eylül, 2001.
42. Dörücü M., Kan N. İ. and Öztekin Z., 2008 – Investigation of internal parasites of some fish species caught in Keban Dam Lake (Turkey), *Journal of Fisheries Sciences*, 2, 3, 484-488.
43. Dörücü M. and İspir Ü., 2001 – Seasonal Variation of Diplostomum sp. Infection in Eyes of *Acanthobrama marmid* Heckel, 1843 in Keban Dam Lake, Elaziğ, Turkey, Ege University, *Journal of Fisheries and Aquatic Sciences*, 18, 3-4, 301-305.
44. Dörücü M. and İspir Ü., 2005 – A Study on Endo-Parasites of Some Fish Species Caught in Keban Dam Lake, *Journal of Firat University Science and Engineering*, 17, 2, 400-404.
45. Ekingen G., 1975 – Some parasites found on brown trout (Salmo trutta L.) in Munzur Stream, *Journal of Firat University Veterinary Faculty*, 2, 283-301.
46. Ekingen G., 1976 – Some parasites found european catfish (Silurus glanis L.) and brown trout (Salmo trutta L.) in Turkey, *Journal of Firat University Veterinary Faculty*, 3, 112-115.
47. Ekmekçi F. G., 1989 – Examination of fish stocks have economic importance in Sariyar Dam Lake, Hacettepe University, Institute of Science, PhD Thesis, 114.
48. Ekmekçi F. G. and Kirankaya Ş. G., 2004 – Determination of Variations in Fish Growth during Reservoir Ontogeny: a Case Study of the Mirror Carp Population in Geling, ll, Dam Lake (Yozgat, Turkey), *Turkish Journal of Veterinary Animal Science*, 28, 1129-1135.
49. Emiroğlu Ö. and Arslan N., 2009 – First Record of Parasitic Annelida-Hirudinea (Piscicola geometra Linnaeus, 1761) on Carassius gibelio from Lake Uluabat, 11th International Symposium on Aquatic Oligochaeta 2009, Alanya, Türkiye, 62.
50. Erkul S., 1997 – Infection of helminths in freshwater fish seen in the region of Ankara, Ankara University, Institute of Health Science, MSc Thesis, 48.
51. Eschmeyer W. N. (ed.), 2014 – Catalog of fishes: genera, species, references, (http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp), Electronic version (Accessed 13.02.2014).
52. Froese R. and Pauly D. (eds), 2013 – FishBase, World Wide Web electronic publication, www.fishbase.org, Electronic version (Accessed 06.03.2014).
53. Geldiay R. and Balik S., 1974 – Ecto and Endoparasites Found the Freshwater Fish of Turkey, Ege University, *The Science Faculty Monographies*, 14, Ege University Press, Bornova.
54. Gibson D. I., Bray R. A. and Harris E. A., 2005 – Host-Parasite Database of the Natural History Museum, London, available from: http://www.nhm.ac.uk/research-curation/scientific-resources/taxonomy-sytematics/host-parasites (Accessed 06.03.2014).
55. Güleç A. K. and Şahan A., 2010 – Effects to Plasma Glucose, Cortisol and Haemoglobin Levels of Parasite Enfestations in Carp (Cyprinus carpio Linnaeus, 1758), Kafkas University, *Journal of Science*, 3, 1, 1-8.
56. Gürkan Ü. and Özan S. T., 2012 – Helminth fauna of chub (Squalis cephalus L.) in Susurluk Creek (Bursa-Balikesir), Süleyman Demirel University, *Journal of Science*, 7, 2, 77-85.
57. Holland C. V. and Kennedy C. R., 1997 – A checklist of parasitic helminth and crustacean species recorded in freshwater fish from Ireland, *Biology and Environment: Proceedings of the Royal Irish Academy*, 97B, 3, 225-243.
58. ITIS, 2013 – The Integrated Taxonomic Information System, http://www.itis.gov., University, Institute of Science, MSc Thesis, 103.
59. İnnal D., 2004 – Stock assesment of some fish species living in Çamkoru Pond (Çamlidere-Ankara), Hacettepe.
60. İnnal D. and Keskin N., 2005 – *Philometra ovata* (Zeder, 1803) (Philometridae) in European Chub (Leuciscus cephalus L., 1758) living in Çamkoru Lake (Çamlidere), *Journal of Animal and Veterinary Advances*, 4, 12, 959-961.
61. İnnal D., Keskin N. and Erk'akan F., 2007 – Distribution of Ligula intestinalis (L.) in Turkey, *Turkish Journal of Fisheries and Aquatic Sciences*, 7, 19-22.

62. İnnal D., Erk'akan F. and Keskin N., 2010 – The Dynamics of the Ligula intestinalis (Cestoda: Pseudophyllidea) in Three Cyprinid Species (Alburnus escherichii Steindachner, 1897; Gobio gobio (Linnaeus, 1758) and Squalius cephalus (Linnaeus, 1758)) in Çamkoru Pond (Ankara, Turkey), Hacettepe, *Journal of Biology and Chemistry*, 38, 4, 319-324.
63. Kahveci S., 2004 – The metazoon parasites of rud (Scardinius erythrophthalmus Linnaeus, 1758) caught in Lake Durusu (Terkos), Marmara University, Institute of Science, MSc Thesis, 51.
64. Kara D., 1997 – Investigation On Trematodes of Perch (Stizostedion lucioperca L., 1758) in Egirdir, Beysehir Lakes, Suleyman Demirel University, Institute of Science, MSc Thesis, 54.
65. Karabiber F. T., 2006 – Parasite fauna of roach (Rutilus rutilus Linnaeus, 1758) in the Lake Sapanca, Marmara University, Institute of Science, MSc Thesis, 53.
66. Karabulut C., 2009 – Study of endohelminths on carp (Cyprinus carpio L., 1758) caught from four different regions of Keban Dam Lake (Koçkale, Pertek, Çemişgezek, Keban), Firat University, Institute of Science, MSc Thesis, 29.
67. Karakişi H. and Demir S., 2012 – Metazoan Parasites of the Common Carp (Cyprinus carpio L., 1758) from Tahtali Dam Lake (İzmir), *The Turkish Journal of Parasitology*, 36, 174-177.
68. Karatoy E., 2004 – Metazoon parasites of bream (Abramis brama Linnaeus, 1758) in Durusu (Terkos) Lake, Marmara University, Institute of Science, MSc Thesis, 55.
69. Kartal K., 2006 – An investigation on ectoparasite fauna of some fish (Cyprinus carpio and Cobitis simplicispinna) from Lake Akşehir, Afyon Kocatepe University, Institute of Science, MSc Thesis, 5.
70. Kelle A., 1978 – Les Effects de Ligula Intestinalis Sur Les Currelations de Taille Poids et Ces Character Biometriaues des Certain Poissons de Eaux Douces Acanthobrama marmid Heckel, 1843 and Chalcalburnus mossulensis Heckel, 1843, *Journal Ege University Science Faculty*, 7, 1, 95-108.
71. Keskin N., 1988 – Philometra abdominalis Nybelin, 1928 in Leuciscus cephalus in Turkey, *Turkish Journal of Zoology*, 12, 1, 70.
72. Keskin N. and Erakan F., 1987 – Ligulose in the Freshwater Fish in Turkey, *Journal of Hacettepe University Science and Engineer Faculty*, 8, 57-70.
73. Kiliç H., 1999 – Site selection, The case of Turkey, *CIHEAM-Options Mediterraneennes*, 43, 25-33.
74. Kilinçaslan M. O., 2007 – Parasitological Research on economic fishes in Yamula Dam Lake in Kayseri City, Çukurova University, Institute of Science, MSc Thesis, 42.
75. Kir I., 1998 – Investigation of Parasites of Carp (Cyprinus carpio L., 1758) and Barbus (Barbus capito pectoralis L., 1758) and goldfish (Carassius carassius L., 1758) Living in Karacaoren Dam Lake, Suleyman Demirel University, Institute of Science, PhD Thesis, 78.
76. Kir İ. and Özan S. T., 2004 – Occurrence of helminths in tench (Tinca tinca L., 1758) of Kovada (Isparta) Lake, Turkey, *Bulletin of European Fish Pathology*, 25, 2, 75-81.
77. Kohn A., Cohen S. C. and Salgado-Maldanado G., 2006 – Checklist of Monogenea parasites of freshwater and marine fishes, amphibians and reptiles from Mexico, Central America and Caribbean, *Zootaxa*, 1289, 1-114.
78. Koyun M., 2001 –The Helminthofauna of Some Fishes in Enne Dam Lake, Uludağ University, Institute of Science, PhD Thesis, 119.
79. Koyun M., 2011 – First record of Dogielius forceps (Monogenea) on Capoeta umbla (Pisces, Cyprinidae) to Turkey, from Murat River, *International Journal of the Bioflux Society*, 4, 4, 469-473.
80. Koyun M., Yilmaz F. and Alas A., 1999 – Effects On Alburnus alburnus of Pleurocercoids of Ligula intestinalis, X National Aquatic Products Symposium (22-24 September 1999, Adana), Adana, 156-163.
81. Kurupinar E., 2009 – An investigation on parasite fauna of chub (*Leuciscus cephalus* L., 1758) from Dam Lake Örenler (Afyonkarahisar), Afyon Kocatepe University, Institute of Science, MSc Thesis, 63.

82. Kutlu H. L., 2005 – An investigation on anatomy, morphology and ecology of metazoan parasites of Cyprinus carpio Linnaeus, 1758 (common carp) from Lake Karamik (Afyonkarahisar), Afyon Kocatepe University, Institute of Science, MSc Thesis, 64.
83. Luque J. L. and Tavares L. E. R., 2007 – Checklist of Copepoda associated with fishes from Brazil, *Zootaxa*, 1579, 1-39.
84. Öge H. and Sarimehmetoglu H. O., 1996 – The Metacercaria of Clinostomum complanatum (Rudolphi, 1819) in Barbus plebejus escherichii (Steindachner, 1897) and Capoeta tinca (Heckel, 1843), *The Turkish Journal of Parasitology*, 20, 3-4, 429-437.
85. Oğuz M. C., 1991 – An investigation On the Carps (Cyprinus carpio L.) which were caught from some freshwaters of Bursa, *The Turkish Journal of Parasitology*, 15, 2, 103-110.
86. Oğuz M. C. and Özturk M. O., 1993 – A Parasitological Investigation On the Searching of the Endohelminth of the Rudd (Scardinius erythrophthalmus L., 1758), *The Turkish Journal of Parasitology*, 17, 3-4, 130-137.
87. Oğuz M. C., Öztürk M. O., Altunel F. N. and Ay A. D., 1996 – A parasitological investigation on common carp (Cyprinus carpio L., 1758) caught in Uluabat Lake, *The Turkish Journal of Parasitology*, 20, 1, 97-103.
88. Oğuz M. C., Amin O. M., Heckmann R. A., Tepe Y., Johargholizadeh G., Aslan B. and Malek M., 2012 – The discovery of Neoechinorhynchus zabensis (Acanthocephala: Neoechinorhynchidae) from cyprinid fishes in Turkey and Iran, with special reference to new morphological features revealed by scanning electron microscopy, *Turkish Journal of Zoology* 36, 6, 759.
89. Oğuz M. C., Öztürk M. O. and Güre H., 2004 – Seasonal Variation of the Plerocercoid Ligula intestinalis (L.) Observed in Roach (Rutilus rutilus, L) from the Yenice Irrigation Pond, Canakkale, Turkey, *Veterinarski glasnik*, 58, 1-2, 127-130.
90. Öktener A., 2003 – Checklist of Metazoon Parasites Recorded in Freshwater Fish From Turkey, *Zootaxa*, 394, 1-28.
91. Öktener A. and Alaş A., 2009 – A parasitological study of fish from the Ataturk Dam Lake, Turkey, *Bulletin of the European Association Fish Pathologists*, 29, 6, 193-197.
92. Öktener A., Trilles J. P. and Leonardos I., 2007 – Five Ectoparasites from Turkish fishes, *The Turkish Journal of Parasitology*, 31, 2, 154.
93. Örün İ., Dörücü M., Yazlak H. and Öztürk E., 2003 – Research on effects and helminths of fish species from Karakaya Dam Lake, İnönü University, Department of Research Projects, 15.
94. Özan S. T., 2005 – The Investigation of Heavy Metals and Parasites in Carp (Cyprinus carpio L., 1758) and Tench (Tinca tinca L., 1758) Inhabiting Beysehir Lake, Süleyman Demirel University, Institute of Science, PhD Thesis, 93.
95. Özan S. T. and Kir İ., 2005 – An Investigation of Parasites of Goldfish (Carassius carassius L., 1758) in Kovada Lake, *The Turkish Journal of Parasitology*, 29, 3, 200-203.
96. Özbek M., 2009 – Investigations on Ligula sp. infection of fishes from Dam Lake Kunduzlar (Kirka, Eskişehir), Afyon Kocatepe University, Institute of Science, MSc Thesis, 47.
97. Özdemir Y. and Sarieyyupoglu M., 1993 – Some parasites of Barbus capito pectoralis caught in Keban Dam Lake, *Journal of Firat University Sceince and Engineering*, 5, 2, 114-126.
98. Özer A., 1995 – A research on ectoparasites of carp (Cyprinus carpio L., 1758) breeding in Sinop Region, Ondokuz Mayis University, Institute of Science, MSc Thesis, 75.
99. Özer A., 2006 – Parasite Fauna of An Endemic Toothcarp, Aphanius chantrei Gaillard, 1895 in Sinop, Turkey, 11eme Congress International de Parasitologie Glasgow-ecosse du 6 AU 11 Juillet 2006, (a 1544).
100. Özer A., 2007 –Metazoan parasite fauna of the round goby Neogobius melanostomus Pallas, 1811 (Perciformes: Gobiidae) collected from the Black Sea coast at Sinop, Turkey, *Journal of Natural History*, 41, 9-12, 483-492.

101. Özer A. and Öztürk T., 2005 – Dactylogyrus cornu Linstow, 1878 (Monogenea) Infestations on vimba (Vimba vimba tenella (Nordmann, 1840)) Caught in the inop Region of Turkey in Relation to the Host Factors, *Turkish Journal of Veterinary Animal Science*, 29, 1119-1123.
102. Özer A., Öztürk T. and Öztürk M. O., 2005 – Prevalence and intensity of Gyrodactilus arcuatus Bychowsky, 1933 (Monogenea) infestations on the three-spined stickleback, Gasterosteus aculeatus L., 1758, *Turkish Journal of Veterinary Animal Science*, 28, 807-812.
103. Özgül G., 2008 – Seasonal Distribution of parasites on cyprinid fishes in Almus Dam Lake, Gaziosmanpaşa University, Institute of Science, MSc Thesis, 84.
104. Özgül G. and Turgut E., 2006 – Metazoan parasites on Chondrostoma regium caught from Almus Dam Lake, Symposium of Aquaculture Students, Mayis, Muğla, 23-25.
105. Öztürk M. O., 1995 – Studies on determine the endohelminths of Pike (Esox lucius) living in Uluabat Lake, Uludağ University, Institute of Science, MSc Thesis, 53.
106. Öztürk M. O., 2000 – The Helminthofauna of Fishes of Manyas Lake, Uludağ University, Institute of Science, PhD thesis, 134.
107. Öztürk M. O., 2002 – Metazoan parasites of the tench (Tinca tinca L.) from lake Uluabat, Turkey, *Israel Journal of Zoology*, 48, 4, 285-293.
108. Öztürk M. O., 2005 – An Investigation of Metazoan Parasites of Common Carp (Cyprinus carpio L.) in Lake Eber, Afyon, Turkey, *The Turkish Journal of Parasitology*, 29, 3, 204-210.
109. Öztürk T., 2005 – Determination of parasite fauna of flounder, Platichthys flesus L., 1758 and toothcarp Aphanius chantrei Gaillard 1895 present in Sarkum Lagoon Lake, Sinop, Turkey, Ondokuz Mayis University, Institute of Science, PhD Thesis, 327.
110. Öztürk M. O., 2010 – A Research on Plathelminth Parasites of Carassius gibelio (Bloch, 1782) in Lake Dam Seyitler, *Journal of Sciences, AKÜ*, 02, 91-97.
111. Öztürk M. O., 2011 – A research on helminth fauna of three cyprinid fish species in Emre Dam Lake, Afyonkarahisar, AKÜ, *Journal of Sciences*, 11, 23-29.
112. Öztürk T. and Özer A., 2008 – Parasitic fauna of the toothcarp Aphanius danfordii (Boulenger, 1890) (Osteichthyes: Cyprinodontidae), an endemic fish from Sarikum Lagoon Lake in Sinop (Turkey), *Journal of Fisheries Sciences.com*, 2, 3, 388-402.
113. Öztürk M. O. and Bulut S., 2006 – An Investigation on the Metazoan Parasite Fauna of Cyprinus carpio L. (Common Carp) from Lake Selevir Dam (Afyonkarahisar), *Science and Engineering Journal of Firat University*, 18, 2, 143-149.
114. Öztürk M. O., Oğuz M. C. and Altunel F. N., 2000 – Metazoon Parasites of Pike (Esox lucius L.) From Uluabat Lake, *Israel Journal of Zoology*, 46, 119-130.
115. Öztürk M. O, Oguz M. C. and Aydogdu A., 2002 – An investigation of metazoon parasitic fauna of pike (Esox lucius L.) and rudd (Scardinius erytrophthalmus L.) from the Karacabey Lagoon, *The Turkish Journal of Parasitology*, 26, 3, 325-328.
116. Palm H. W., Klimpel S. and Bucher C., 1999 – Checklist of metazoan fish parasite of German coastal waters, Institut für Meereskunde and Christian-Albrechts-Universitat Kiel, 307, 148.
117. Paperna I., 1964 – The Metazoon Parasite Fauna of Israel Inland Water Fishes, *Bamidgeh*, 16, 1-2, 3-66.
118. Pazooki J. and Masoumian M., 2012 – Synopsis of the Parasites in Iranian Freshwater Fishes, *Iranian Journal of Fisheries Sciences*, 11, 3, 570-589.
119. Pişkin F. Ç. and Ütük A. E., 2008 – Dactylogyrus sp. and Trichodina sp. cases in carps of Sanliurfa Balikligol, *Etlik Veteriner Mikrobiyoloji Derg*, 19, 9-12.
120. Sağlam N., 1992 – Investigation of external parasites on fish caught in Lake Keban, Firat University, Institute of Science, MSc Thesis, 50.
121. Sağlam N. and Sarıeyyupoglu M., 2002 –Study of Neoechinorhynchus rutili (Acanthocephala) Found in Fish (Capoeta trutta), *The Turkish Journal of Parasitology*, 26, 3, 328-330.
122. Salgado-Maldanado G., 2006 – Checklist of helminth parasites of freshwater fishes from Mexico, *Zootaxa*, 1324, 1-357.

123. Samanci İ., 2011 – The investigation of parasites in carp (Cyprinus carpio L., 1758) and crucian carp (Carassius carassius L., 1758) inhabiting Karacaören II, Dam Lake, Suleyman Demirel University, Institute of Science, MSc Thesis, 46.
124. Saygi G. and Bardakci F., 1990 – Rhabdochona (Nematod) found in Cyprinion macrostomus and Garra rufa in Thermal Baths Called "Balikli Cermik", *The Turkish Journal of Parasitology*, 14, 1, 95-105.
125. Selver M. M., 2008 – Helminth Fauna Of Some Fish Species Catched From Kocadere Stream, Uludag University, Institute of Health Sciences, PhD thesis, 151.
126. Smales L. R., Aydoğdu A. and Emre Y., 2012 – Pomphorhynchidae and Quadrigyridae (Acanthocephala), including a new genus and species (Pallisentinae), from freshwater fishes, Cobitidae and Cyprinodontidae, in Turkey, *Folia Parasitologica*, 59, 3, 162.
127. Soylu E., 1985 – Studies of Fish diseases in Sapanca Fish Production Station, İstanbul University, College of Aquatic Products, 7, 22.
128. Soylu E., 1990 – Surveys On the Parasite Fauna of the Some Fishes In Sapanca Lake, Istanbul University, Institute of Marine Science, PhD thesis, 85.
129. Soylu E., 1991 – *Pomphorhynchus laevis* (Müller, 1776) (Acanthocephala) in Barbus plebejus escherichi Steindachner 1897 of (Sakarya) Büyükcoz Lake, Anadolu University, *Journal of Science and Literature*, 3, 2, 3.1
130. Soylu E., 2003 – A study on Metazoon parasites of tench (Tinca tinca) in the Lake Durusu (Terkos), XII Symposium of National Aquatic Products, 2-5 Eylül 2003, Elaziğ, 37.
131. Soylu E., 2005 – Metazoan Parasites of catfish (Silurus glanis, Linnaeus, 1758) from Durusu (Terkos) Lake, *Journal of the Black Sea/Mediterranean Environment*, 11, 225-237.
132. Soylu E., 2006 – Some metazoan parasites (Cestoda, trematoda and mollusca) of Blicca bjoerkna Linnaeus, 1758 from Sapanca Lake, *Istanbul University Journal of Fisheries and Aquatic Sciences*, 20, 51-62.
133. Soylu E., 2009 – Monogenean Parasites on the Gills of Some Fish Species from Lakes Sapanca and Durusu, Turkey, Ege University, *Journal of Fisheries and Aquatic Sciences*, 26, 4, 247-251.
134. Soylu E., 2012 – Monogenean Parasites of White Bream (Blicca bjoerkna Linnaeus, 1758) in Lake Sapanca, Turkey, Kafkas University, *Journal of the Faculty of Veterinary Medicine*, 18, A, 23-28.
135. Soylu E., 2013 – Metazoan Parasites of Perch Perca fluviatilis L. From Lake Siğirci, Ipsala, Turkey, *Pakistan Journal of Zoology*, 45, 1, 47-52.
136. Soylu E. and Emre Y., 2005 – Metazoan Parasites of Clarias lazera Valenciennes, 1840 and Carassius carassius (Linnaeus, 1758) from Kepez I Hydro Electric Power Plant Loading Pond, Antalya, Turkey, *Turkish Journal of Fisheries and Aquatic Sciences*, 5, 113-117.
137. Soylu E. and Emre Y., 2007 – Monogenean and cestode parasites of Pseudophoxinus antalyae Bogutskaya, 1992 and Cyprinus carpio Linnaeus 1758 from Kepez Antalya, Turkey, *Bulletin of European Fish Pathology*, 27, 1, 23-28.
138. Sönmez Ş. N., 1996 – Investigation of parasitic fauna of fishes in Mogan Lake, Ankara University Institute of Science, MSc Thesis, 73.
139. Şahan A. and Cengizler İ., 2003 – Seyhan Nehri (Adana Kent İçi Bölgesi)'nde Yaşayan Adi Sazan (Cyprinus carpio) ve Biyikli Balik (Barbus rajanorum)'ta Bazi Hematolojik Parametrelerin Belirlenmesi, XII Ulusal Su Ürünleri Sempozyumu, 2-5 Eylül 2003, Elaziğ, 193. (in Turkish)
140. Tepe Y., Oğuz M. C., Belk M. and Özgen R., 2013 – Orientocreadium batrachoides Tubangui, 1931 (Orientocreadiidae): The only Trematode Parasite of Clarias gariepinus (Burchell, 1822) (Clariidae) from the Asi River (Turkey), *The Turkish Journal of Parasitology,* 37, 203-7.
141. Topçu A., 1993 – The Helminths of the Digestive Tract of the Carps (Cyprinus carpio) in Van Region, Yuzuncu Yil University, Institute of Science, PhD Thesis, 55.

142. Torcu-Koç H., Erdoğan Z. and Coz Rakovac R., 2006 – The occurrence of Ligula intestinalis (L.) observed in chub (Leuciscus cephalus L.) from Caparlipatlak Dam lake, Ivrindi-Balikesir, Turkey, *Periodicum Biologorum*, 108, 2, 183-187.
143. Turgut E., 2005 – Niksar ve Almus Civarindaki Balik Çiftlikleri ile Doğal Ortamdaki Balik Parazitlerinin Su Kalitesi ve Mevsimlere Bağli Olarak Değişimi, Araştirma Projesi, Gaziosmanpaşa Üniversitesi, Almus Meslek Yüksekokulu, Tokat.
144. Turgut E., Develi N., Yeşilayer N. and Buhan E., 2011 – Seasonal Occurrence of Ligula intestinalis Infection in Cyprinids from Almus Dam Lake, Turkey, Kahramanmaras Sutcu Imam University, *Journal Of Natural Sciences*, 14, 3, 9-11.
145. Türk C., 2000 – Ecology of Ligula intestinalis found in Acanthobrama marmid (Heckel, 1843) from Keban Dam Lake and research its in vitro, Firat University, Institute of Science, MSc Thesis, Elaziğ, 45.
146. Türkmen H., 1990 – Prevalence of Digestive Track Helminth Infections in Carps and Roachs in Iznik Lake, İstanbul University, Institute of Heath Sciences, PhD Thesis, 58.
147. Uzunay E., 2006 – Metazoon Parasites of carp (Cyprinus carpio Linnaeus, 1758) and vimba (Vimba vimba Linnaeus, 1758) in the Lake Sapanca, Marmara University, Institute of Science, MSc Thesis, 49.
148. Ünsal G., 2008 – Ectoparasites on some bony fishes. Sinop University, Institute of Science, MSc Thesis, 61.
149. Violante-González J., Aguirre-Macedo L. and Mendoza-Franco E. F., 2007 – A checklist of metazoan parasites of fish from Tres Palos Lagoon, Guerrero, Mexico, *Parasitology Research*, 102, 151-161.
150. WoRMS Editorial Board, 2014 – World Register of Marine Species, Available from http://www.marinespecies.org at VLIZ, Accessed 2014-01-26.
151. Yetim M., 1985 – The Parasites Found the Fish Consuming In Eskişehir, Anadolu University, Institute of Science, MS Thesis, 42.
152. Yildirim M. Z., Kara D. and Becer Z. A., 1996 – Studies on the Bucephalus polymorphus Baer, 1827 which were identified in the pike-perch of Eğirdir Lake, *The Turkish Journal of Parasitology*, 20, 1, 105-112.
153. Yildirim M. and Ünver B., 2006 – Metazoan parasites of Alburnus chalcoides in Tödürge Lake (Zara⁄Sivas, Turkey), *Journal of Applied Ichthyology*, 28, 245-248.
154. Yildiz K., 2003 – Helminth Infections in Tench (Tinca tinca) from Kapulukaya Dam Lake, *Turkish Journal of Veterinary and Animal Science*, 27, 671-675.
155. Yildiz H. Y., Korkmaz A. Ş. and Zencir O., 2003 – The Infection of Tench (Tinca tinca) with Ligula intestinalis Plerocercoids in Lake Beysehir (Turkey), *Bulletin of European Fish Pathology*, 23, 5, 223-227.
156. Yilmaz F., Solak K. and Alaş A., 1996 – A research on Ligula intestinalis L. from Yukari Porsuk, 17-20, Eylül, XIII Congress of National Biology, İstanbul, 71-79.
157. Zeren A., 2008 – Parasitological investigation on some aquatic species collected from the Tigem Reservoirs (Yeniyurt, Dörtyol, Hatay), Mustafa Kemal University, Institute of Science, MSc Thesis, 66.

DE GRUYTER OPEN

SPECIES COMPOSITION OF THE BENTHIC MACROINVERTEBRATES ON THE COASTLINE VEGETATED ROCKY SUBSTRATES OF THE SOUTHERN CASPIAN SEA

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ABSTRACT

For studying benthic macrofaunal composition associated with seagrass rocky beds of the southern Caspian Sea, two time samplings were carried out along the coast line in the winter and summer of 2013. In total, 1,286 specimens of the five species were identified: *Pontogammarus maeoticus*, *Balanus improvisus*, *Mytilaster lineatus*, *Palaemon elegans* and *Alitta succinea*. The total recorded abundance was 5,675 and 755 ind./m^2, with a biomass of 147,271 and 31,238 mg/m^2 in the winter and summer respectively. The collected species in this study are generally non-indigenous (except *P. maeoticus*) and could potentially have an effect on native benthic fauna, as an additional food source could facilitate the commercially exploited fish stocks. Thus further studies are required to monitor their potential interactions on the Caspian Sea fauna.

RÉSUMÉ: La composition spécifique des macroinvertébrés benthiques des fonds rocheux à végétation de la région côtière du sud de la Mer Caspienne.

Pour cette étude, les auteurs ont effectué deux échantillonnages côtiers, durant l'été et l'hiver 2013. Ont été identifiés 1.286 individus de cinq espèces: *Pontogammarus maeoticus*, *Balanus improvisus*, *Mytilaster lineatus*, *Palaemon elegans* et *Alitta succinea*. L'abondance totale a atteint 5.675 ind./m^2 en hiver et 755 ind./m^2 en été, et a correspondu respectivement aux biomasses de 147.271 mg/m^2 et de 31.238 mg/m^2. Bien que les espèces collectées dans cette étude soient allochtones (excepté *P. maeoticus*) et pourraient potentiellement avoit un impact sur la faune indigène, elles sont aussi une source de nourriture supplémentaire qui pourrait faciliter le renouvellement des stocks des poissons dédiés à l'exploitation commerciale. D' autres études sur les interactions de ces espèces avec la faune Caspienne sont nécessaires.

REZUMAT: Compoziția specifică a comunităților de macronevertebrate bentonice de pe substratele costiere pietroase cu vegetație, din sudul Mării Caspice.

Pentru acest studiu s-au efectuat două eșantionări în lungul liniei de coastă în 2013. Au fost identificate 1.286 exemplare din cinci specii: *Pontogammarus maeoticus*, *Balanus improvisus*, *Mytilaster lineatus*, *Palaemon elegans* și *Alitta succinea*. Abundența totală a avut valoarea hivernală de 5.675 ind./m^2, cu o biomasă totală de 14.7271 mg/m^2 și valori estivale de 755 ind./m^2 respectiv 31.238 mg/m^2. Deși, speciile colectate în timpul prezentului studiu sunt în general specii alohtone (cu excepția lui *P. maeoticus*) și ar putea avea impact asupra faunei bentonice indigene, ele constituie și o sursă de hrană suplimentară ce ar putea facilita refacerea stocurilor piscicole exploatate comercial. Sunt necesare studii suplimentare pentru a monitoriza interacțiunile potențiale ale acestor specii cu fauna caspică.

INTRODUCTION

The Caspian Sea is the largest enclosed water body containing 40% of the earth's continental water mass with one of the most unique brackish water ecosystems in the world (Dumont, 1998). Great parts of its fauna are endemic (Dumont, 2000) and they are derived from the origins of the Caspian, the Arctic, and the Atlantic-Mediterranean freshwater. In comparison to the other seas, the biodiversity of the Caspian Sea is three to five times lower than the Black and the Barents seas, respectively (Zenkevich, 1963).

Aquatic ecosystems vegetated substrates usually support higher species abundance and diversity than unvegetated substrates (Everett et al., 1995; Bostrom and Bonsdorf, 1997; Bowden et al., 2001; Lee et al., 2001). Seagrass beds are distributed widely in the coastal areas of temperate and tropical zones, and they are one of the most productive marine ecosystems in the biosphere. These habitats play a key role and are very important in the marine ecological environment, such as improving shallow seawater quality, being the direct food resource of many organisms, providing important habitat and concealment from predation, and a natural barrier resisting against waves and thus protecting the coasts and their associated animals (Orth et al., 1984; Castel et al., 1989; Hemming and Duarte, 2000; Bowden et al., 2001; Boese, 2002; Xiaoping et al., 2006; Novac and Shurova, 2008).

Generally, these habitats, and their associated macrofaunal communities, are poorly known, and for the seagrass patch structures of the Caspian Sea, the information is very limited. This study tries to provide preliminary data on the species composition, abundance, and the biomass of benthic macroinvertebrates associated with vegetated rocky substrates along the coastline of the southern Caspian Sea. Since the frequent supervision of the ecosystem represents a priority task for water resource assessment, the results obtained in this study can help us to monitor and manage these habitats in the future.

MATERIAL AND METHODS

Study area. The Mazandaran Province is located in the middle of the southern beach of the Caspian Sea (Mazandaran Sea) along the Iranian coasts (Fig. 1).

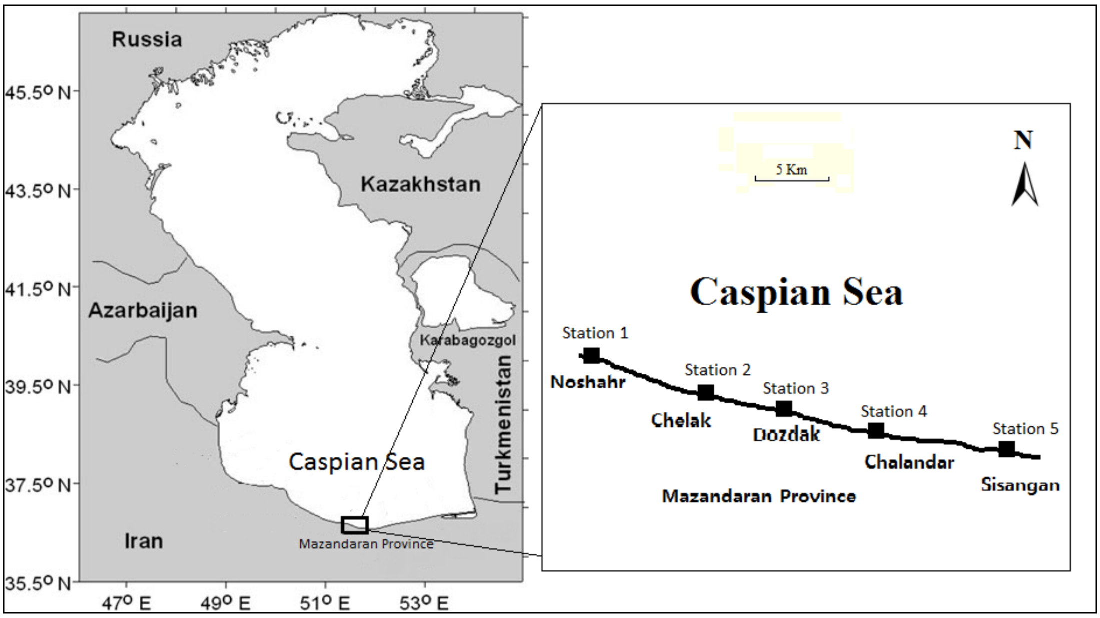

Figure 1: Sampling area map and location of sampling stations in Mazandaran Province.

There is almost no tidal range, and the gradient and structure of the seabed are uniform. The surface salinity and temperature to 20 m depth vary negligibly (Hadjizadeh et al., 2007). No major rivers exist in the vicinity of the sampling sites, but the most important phenomenon in these areas is strong rip currents (Shafiei and Barani, 2011). Besides, floating fishing nets are widely used annually from December to June.

Samples collection. Samplings were carried out along the coast line at five different stations at Mazandaran Province coasts (between Noor and Noshahr cities) within 51°31’11” to 51°49’06”E and 36°35’10” to 36°39’55”N in winter (March) and summer (August) of 2013 (Fig. 1). At each station, five duplicate samples were collected by scraping the surface with a quadrate frame of 80 cm^2 (totally 400 cm^2 at each station).

In the field, the content of each frame was stored in separate plastic containers. In the laboratory, each sample was gently sieved over one millimeter mesh, and the retained material fixed in 4% buffered formalin and stained with Rose Bengal. Then macrofauna separated, identified and counted under an Olympus stereomicroscope and a Carl Zeiss Jena Laboval 4 microscope, and photographed with CCD and Nikon digital cameras. The wet-weight of specimens was determined by a 0.0001 g sensitive balance. The biomass and abundance data were calculated in one square meter separately. The analyses and figures were made using Microsoft Excel.

RESULTS

In total, 1,286 specimens of the five species were identified. Results of the abundances (individuals/m^2) and biomass (wet weight, mg/m^2) of the collected species are given in table 1. Total abundances were recorded 5,675 and 755 ind./m^2 in winter and summer respectively. Among the collected species, *Pontogammarus maeoticus* was the dominant species, with relative abundance of 84.14 and 21.85% in winter and summer respectively. After that *Balanus improvises* with relative abundance of 8.45 and 38.41%, *Mytilaster lineatus* with 5.72 and 33.77%, and *Palaemon elegans* with 1.67 and 3.97% were observed in winter and summer respectively. *Alitta succinea* with 2% abundance was observed only in summer (Fig. 2).

Table 1: Abundance (individuals/m^2) and biomass (wet weight, mg/m^2) of the collected species in this study.

Taxa name	Summer (August 2013)		Winter (March 2013)	
	Abundance	Biomass	Abundance	Biomass
Alitta succinea	15	91.65	0	0
Pontogammarus maeoticus	165	4,950.5	4,775	95,500
Balanus improvises	290	796.65	480	1,232.64
Mytilaster lineatus	255	741.03	325	855.18
Palaemon elegans	30	24,658.22	95	49,683.57
Total	755	31,238.05	5,675	147,271.39

Total biomasses were recorded at 147,271.39 and 31,238.05 mg/m^2 in winter and summer, respectively (Tab. 1). Among the collected species, *P. elegans* had the highest relative biomass, with 33.74 and 78.94% in winter and summer respectively. After that, *P. maeoticus* has a relative biomass of 64.85 and 15.85%, *B. improvises* with 0.84 and 2.85%, and *M. lineatus* with 0.58 and 2.37% were observed in winter and summer respectively. *Alitta succinea* with 0.29% biomass was saw only in summer (Fig. 2).

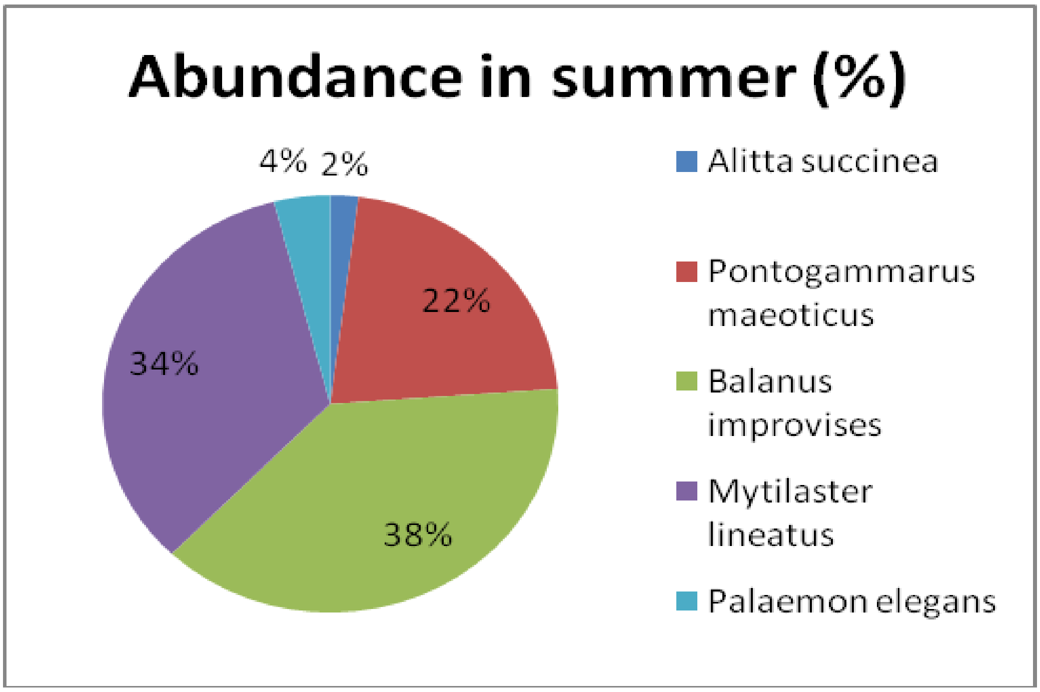

Figure 2a: Percentages of abundance and biomass of the collected species in this study.

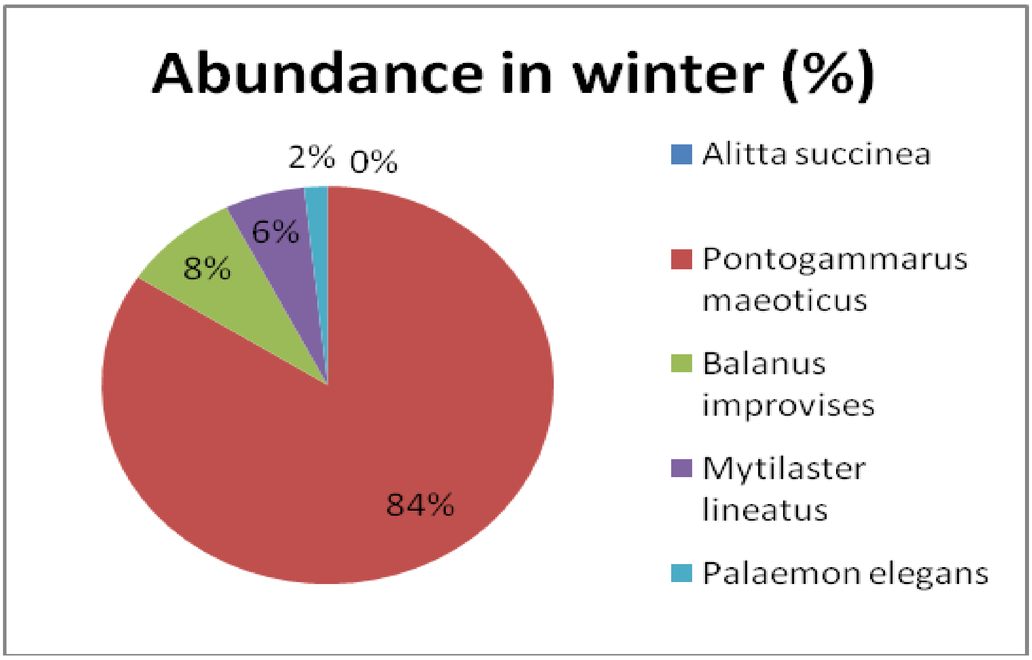

Figure 2b: Percentages of abundance and biomass of the collected species in this study.

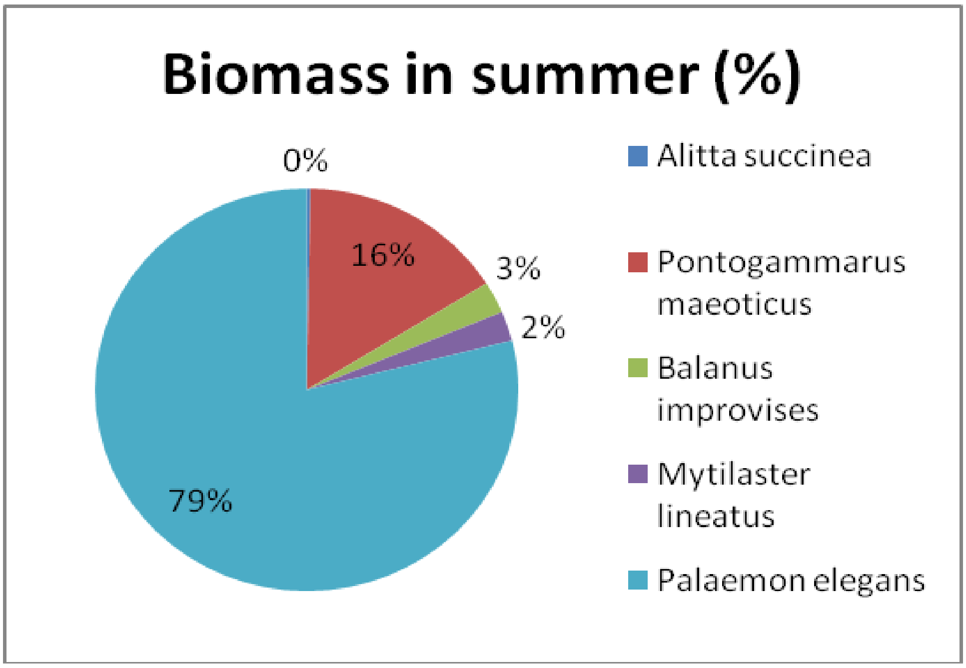

Figure 2c: Percentages of abundance and biomass
of the collected species in this study.

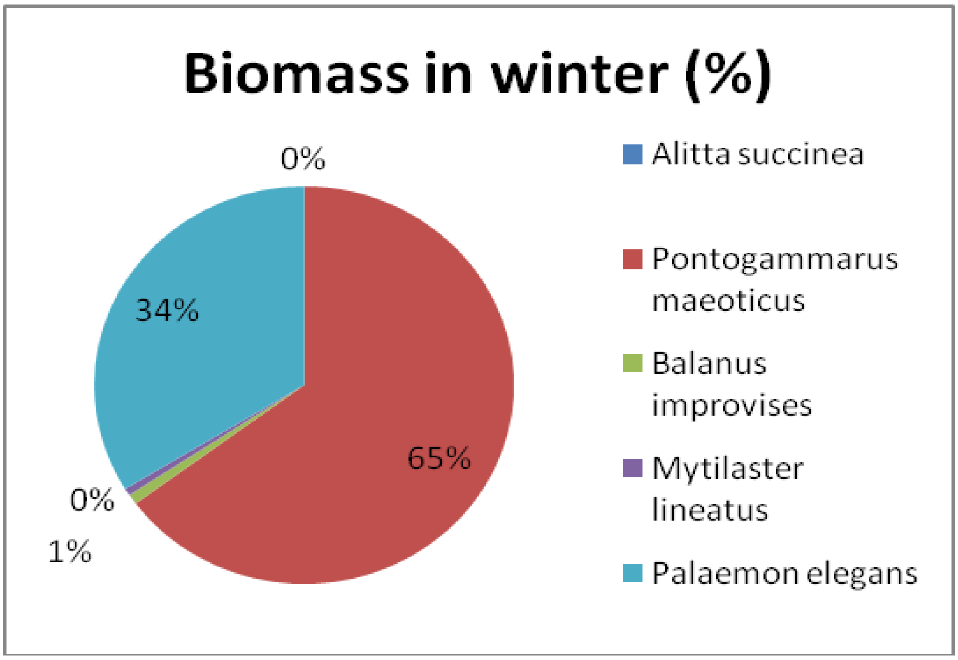

Figure 2d: Percentages of abundance and biomass
of the collected species in this study.

DISCUSSIONS

High productivity (abundance and biomass) and biodiversity of these habitats may result from an arrangement of natural factors and mechanisms (Bostrom and Bonsdorf, 1997; Bowden et al., 2001; Lee et al., 2001). It seems that food availability could be an important factor (Castel et al., 1989). *P. maeoticus* with feeding on suspend plant residues could establish in these habitats very well. Other omnivorous species such as *P. elegans* and *A. succinea* could easily feed on vegetations and small crustaceans (Fauchald and Jumars, 1979; Smaldon, 1993). The wave-generated hydrodynamic force is another factor in determining the abundances and dynamics of communities (Lewis, 1984). In this case, the seagrass beds biota remained more stable than other substrate types and the faunal restoration did not last as long in these habitats by reduction of the wave-generated hydrodynamic force (Lewis, 1984). Due to the vegetated coverage, demersal predatory fish are not able to feed on associated animals efficiently (Orth et al., 1984). The leaves and root-rhizome system of seagrass create habitats of relatively high structural complexity, which by contrast to bare sediments, provide many spatial niches for a variety of fauna (Heck and Wetstone, 1977; Knowles and Bell, 1998).

Other influencing factors on the presence and dynamic of benthic animals include environmental variables related to seasonal changes e.g. salinity, temperature and day length. Due to their effects on the reproduction activity of macrofauna and their predators, affected directly the abundances and dynamics of communities (Yazdani et al., 2010; Taheri and Yazdani, 2010; Ghasemi et al., 2013). Salinity is one of the most important factors influencing distribution of animals in brackish waters (Leppakoski and Olenin, 2000). Within the Caspian Sea, it is the main structuring abiotic factor in species establishment (Aladin and Plotnikov, 2004; Ghasemi et al., 2013).

CONCLUSIONS

In the present study, except *P. maeoticus*, the other collected species are non-indigenous. Although a large number of the Caspian Sea fauna are endemic and adapted to live in waters with low salinity, in the seagrass beds located in fresher waters we have observed two non-indigenous species *Hediste diversicolor* and *Gammarus aequicauda* instead of *A. succinea* and *P. maeoticus*. So it seems that the Caspian native fauna was not well specialized to colonization in the vegetated rocky substrates. These introduced marine origin species with strong competitive abilities may co-exist with Caspian native species and force them out. On the other hand, they may inhabit vacant ecological niches on the poorly colonized vegetated substrates and feed on plants, and suspend residues, practically unlimited food resources. So they could play a key role as a significant food resource for commercially exploited fish, especially sturgeons. Thus, further studies are required to monitor their impacts and interactions on the native fauna of the Caspian Sea.

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REFERENCES

1. Aladin N. V. and Plotnikov I. S., 2004 – The Caspian Sea, Lake Basin Management Initiative, Thematic Paper, 29.
2. Boese B. L., 2002 – Effects of recreational clam harvesting on eelgrass (Zostera marina) and associated infaunal invertebrates: in situ experiments, *Aquatic Botany*, 73, 63-74.
3. Bostrom C. and Bonsdorf E., 1997 – Community structure and spatial variation of benthic invertebrates associated with Zostera marina beds in the northern Baltic Sea, *Journal of Sea Research*, 37, 153-166.
4. Bowden D. A., Rowden A. A. and Attrill M. J., 2001 – Effect of patch size and in-patch location on the infaunal macroinvertebrate assemblages of Zostera marina seagrass beds, *Journal of Experimental Marine Biology and Ecology*, 259, 133-154.
5. Castel J., Labourg P.-J., Escaravage V., Auby I. and Garcia M. E., 1989 – The influence of seagrass beds and oyster parks on the abundance and biomass patterns of meio- and macrobenthos in tidal flats, *Coastal and Shelf Science*, 28, 71-85.
6. Dumont H. J., 1998 – The Caspian Lake: history, biota, structure, and function, *Limnology and Oceanography*, 43, 44-52.
7. Dumont H. J., 2000 – Endemism in the Ponto-Caspian fauna, with special emphasis on the Onychopoda (Crustacea), *Advances in Ecological Research*, 31, 181-196.
8. Everett R. A., Rutz R. M. and Carlton J. T., 1995 – Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific northwest estuary, *Marine Ecology Progress Series*, 123, 205-217.
9. Fauchald K. and Jumars P. A., 1979 – The diet of worms: A study of polychaete feeding guilds, OMBAR, 17, 193-294.
10. Ghasemi A. F., Taheri M. and Jam A., 2013 – Does the introduced polychaete *Alitta succinea* establish in the Caspian Sea? *Helgoland Marine Research*, DOI: 10.1007/s10152-013-0356-1.
11. Hadjizadeh Z. N., Ghafari P. and Jamshidi S., 2007 – Physical study of the southern coastal waters of the Caspian Sea, off Babolsar, Mazandaran in Iran, *Journal of Coastal Research*, 50, 564-569.
12. Heck K. L. and Wetstone G. S., 1977 – Habitat complexity and invertebrate species richness and abundance in tropical seagrass meadows, *Journal of Biogeography*, 4, 135-142.
13. Hemming M. A. and Duarte C. M., 2000 – Seagrass Ecology. Cambridge: Cambridge University Press, 223.
14. Knowles L. L. and Bell S. S., 1998 – The influence of habitat structure in faunal-habitat associations in a Tampa Bay seagrass system, Florida, *Bulletin of Marine Science*, 62, 781-794.
15. Lee S. Y., Fong C. W. and Wu R. S. S., 2001 – The effects of seagrass (Zostera japonica) canopy structure on associated fauna: A study using artificial seagrass units and sampling of natural beds, *Journal of Experimental Marine Biology and Ecology*, 259, 23-50.
16. Leppakoski E. and Olenin S., 2000 – Xenodiversity of the European brackish water seas: the North American contribution. Marine Bioinvasion, *Proceedings of the first National Conferences, Massachusetts Institute of Technology*, 107-119.
17. Lewis III F. G., 1984 – Distribution of macrobenthic crustaceans associated with Thalassia, Halodule and bare sand substrata, *Marine Ecology Progress Series*, 19, 101-113.
18. Novac A. and Shurova N., 2008 – The state of mussel settlements from Agigea, on the Romanian coast of the Black Sea, *Transylvanian Review of Systematical and Ecological Research*, The Wetlands Diversity, Curtean-Bănăduc et al. (eds), 6, 31-40.
19. Orth R. J., Hec K. L. and van Montfrans J., 1984 – Faunal communities in seagrass beds: a review of the influence of plant structure and prey characteristics on predator-prey relationships, *Estuaries*, 7, 339-350.

20. Shafiei S. B. and Barani G. A., 2011 – Field investigation of rip currents along the southern coast of the Caspian Sea, *Scientia Iranica*, 18, 4, 878-884.
21. Smaldon G., 1993 – Coastal shrimps and prawns, *Synopses of the British fauna*, 15.
22. Taheri M. and Yazdani M., 2010 – Community structure and biodiversity of shallow water macrobenthic fauna at Noor coast, South Caspian Sea, Iran, *Journal of the Marine Biological Association of the United Kingdom*, UK, 90, 5, 1-7.
23. Xiaoping H., Liangmin H., Yinghong L., Zhanzhou X., Fong C. W., Daojian H., Quiuying H., Hui H., Yehui T. and Sheng L., 2006 – Main seagrass beds and threats to their habitats in the coastal sea of South China, *Chinese Science Bulletin*, 51, 2, 136-142.
24. Yazdani M., Taheri M. and Seyfabadi J., 2010 – Effect of different salinities on survival and growth of prawn, Palaemon elegans (Palaemonidae), *Journal of the Marine Biological Association of the United Kingdom*, UK, 90, 2, 255-259.

MOLECULAR METHODS FOR THE DETECTION OF NATURAL HYBRIDS IN STURGEON POPULATIONS

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KEYWORDS: Danube, sturgeon populations, natural hybrids, molecular methods.

ABSTRACT

Due to construction of the Iron Gates dams, the Lower Danube has suffered a decrease in sturgeon populations. The dams have decreased sturgeon habitat area, which in turn has caused an overlap of reproduction areas for all sturgeon species. The ease with which sturgeon species can create hybrid offsprings gave rise to an increase in the number of hybrid sturgeon species now found in the Lower Danube area. We propose a set of molecular methods for hybrid species using DNA markers represented by microsatellites and mitochondrial DNA. This identification data and methodology is important for use on sturgeon farms due to the need to correctly identify species of sturgeons. Using the proposed methodologies, it is possible to avoid identification errors that might appear when using only morphological criteria to idenfy sturgeons.

RÉSUMÉ: Méthodes moléculaires pour la détection des hybrides naturelles dans les populations d’esturgeons.

En raison de la construction de barrages aux Portes de Fer, le Danube inférieur a subi une diminution des populations d’esturgeon. La diminution de l’aire géographique a induit le chevauchement des sites de reproduction de toutes les espèces d’esturgeons. La facilité d’hybridation caractéristique de ces espèces a conduit à la situation actuelle qui est une augmentation du nombre d’hybrides d’esturgeons. Nous proposons plusieurs méthodes moléculaires pour l’identification des hybrides utilisant deux types de marqueurs d’ADN. Les données sont importantes pour les fermes d’esturgeons de part la nécessité d’une identification correcte des individus. Ainsi, il est possible de pallier les difficultés potentielles liées à une simple identification morphologique.

REZUMAT: Metode moleculare de detecție a hibrizilor naturali în populații de sturioni.

Datorită construcţiei barajelor de la Porţile de Fier, Dunărea Inferioară a suferit o descreştere a populaţiilor de sturioni. Restrângerea arealului a condus la suprapunerea zonelor de reproducere pentru toate speciile de sturioni. Acest fenomen, împreună cu uşurinţa hibridizării în cazul acestor specii, a condus la situaţia actuală, în care există o creştere a numărului hibrizilor naturali de sturioni. Propunem un set de metode moleculare pentru identificarea hibrizilor de sturioni, folosind două tipuri de markeri ADN. Datele obţinute sunt importante pentru fermele piscicole datorită necesităţii identificării corecte a indivizilor. Astfel, se pot evita eventualele dificultăţi apărute în identificarea indivizilor exclusiv pe baza criteriilor morfologice.

INTRODUCTION

Sturgeons are represented by the order Acipenseriformes, which contains 27 species divided in two families: *Acipenseridae* with 25 species, and *Polyodontidae* with two species (Zhang et al., 2013). This group of "living fossils" is undergoing a dramatic population decline in Eurasia, with fish populations currently at historically low levels (Ludwig, 2006; Ludwig et al., 2009). This decline is due to wrong harvesting, poaching and loss and degradation of habitat, specifically because of dams along rivers (Ludwig et al., 2009; Havelka et al., 2011).

Natural hybridization is one of the effects of habitat degradation and loss, especially in response to hindered migration to spawning areas that occurred in Romania after the construction of the Iron Gates dams. The dam installations, altered parts of the Lower Danube spawning habitats creating favorable conditions for two sturgeon species to overlap. This change in the ecological relationship between the two species left room for "habitat hybridization" (Tranah et al., 2004). Hybridization not only occurs in the wild under natural conditions but also in artificial breeding. Cases of both interspecific and intergeneric hybridization have been observed (Havelka et al., 2011), confirming the rate of this event, especially under the right circumstances.

Cross-breeding sturgeons have the ability to produce fully fertile hybrid offsprings (Havelka et al., 2011) more easily than other vertebrates. Due to possible crossbreeding that may have occurred, using a morphological description to identify sturgeon that may be hybrids is not enough to conclusively identify the sturgeon species. Because first-generation of hybrids are not morphologically intermediate to the genitor morphotypes (Tranah et al., 2004), coupled with the difficulty of identifying sturgeon hybrids in early growth stages such as fry and sub-adults (Zhang et al., 2013), there is a need for molecular hybrid identification and characterization.

One of the techniques for identifying hybrids and pure species sturgeons is PCR-RFLP (Polymerase Chain Reaction - Restriction Fragment Length Polymorphism). This technique is based on the amplification of the region $tRNA^{Glu}$/cytochrome b of 462 bp from the mitochondrial DNA and endonuclease restriction of this fragment. The restriction fragments observed on the electrophoresis gel are analyzed to show the maternal genitor species of an individual sturgeon. This technique is useful for confirming purespecies fish or finding out the maternal genitor of a hybrid because of the small intraspecific variations in sequence for the analyzed region (Wolf et al., 1999). The analysis is based on restriction of species-specific sites resulting in a species-specific band pattern with the use of a single universal primer pair (Ludwig, 2006).

Along with using PCR-RFLP as an identification technique, the DNA barcoding was also used for species identification, respectively for maternal genitor identification in the case of hybrids. The advantage of using DNA barcoding for sturgeon species is that it overcomes the possibility of incorrect identification due to using the phenotype only. Additionally, the DNA method is effective at any life-cycle stage and regardless of gender. From a molecular standpoint, DNA barcoding for the mitochondrial gene COI (Cytochrome Oxidase I) is good because of the haploid mode of inheritance, a lack of introns, and limited exposure for recombination (Hebert et al., 2003; Hubert et al., 2008). The DNA analysis is centered on genes because universal primers are very robust and because changes in the amino-acid sequence change slowly in respect to other mitochondrial genes (Hebert et al., 2003).

In the case of natural sturgeon hybrids, these two techniques lack precision due to the maternal inheritance of mitochondrial DNA (Havelka et al., 2011). For this reason we use nuclear microsatellites markers that are short-tandem repeats of two to nine nucleotides with a high-degree of length polymorphism. Because microsatellites are markers with great variability and due to the fact that they have co-dominant inheritance, unbiased by sex-specific differences (Nelson et al., 2013), microsattelites are used for various types of population studies, and in this case for hybrid identification and characterization. This is possible using the factorial correspondence analysis (FCA) test that shows the relationship of individual samples with respect to a microsatellite dataset of known individual samples.

MATERIAL AND METHODS

Molecular methods were tested using samples harvested without endangering the life of individual fish. Small fin fragments were collected from individual sturgeon captured in the Lower Danube and labeled as either pure species or hybrids based on their morphology. For total genomic DNA extraction from fin tissue we used a standard phenol/chloroform protocol modified from Taggart et al. (1992; 2004).

PCR-RFLP

The PCR reaction was made in a total volume of 25 μL which contained: DNA template, 1X PCR Gold Buffer (AppliedBiosystems), 1.5 mM $MgCl_2$, 200 μM of each dNTP (AppliedBiosystems), 0.48 μM of each primer (forward primer sequence: 5’-AAAAACCACCGTTGTTATTCAACTA-3’, reverse primer sequence 5’-GCCCCTCAG AATGATATTTGTCCTCA-3’), 1U AmpliTaq Gold DNA Polymerase (AppliedBiosystems), and nuclease-free water. The reaction mixes were amplified on GeneAmp 9700 PCR System (AppliedBiosystems) using the following cycling conditions: 95°C for 10 minutes, 40 cycles of 95°C for 30 seconds, 60°C for 45 seconds, 72°C for a minute and a final extension at 72°C for 10 minutes. For the enzymatic restriction we used a total volume of 20 μL with: 2 μL Reaction Buffer, 0.4 μL Bovine Seric Albumine, 16.5 μL PCR product and 1.1 μL restriction enzyme: *Rsa*I or *Ssp*I (Promega). The mix was incubated for three hours at 37°C and then visualized consequently electrophoresis in a 3% agarose gel alongside 50 bp DNA Step Ladder (Promega). Table 1 shows the enzymes we used in this study and the restriction fragment length attributed to the species of sturgeon still found in the Danube River.

Table 1: PCR-RFLP of the amplified cytb gene of four sturgeon species (Wolf et al., 1999).

	Huso huso	*Acipenser gueldenstaedtii*	*Acipenser stellatus*	*Acipenser ruthenus*
*Rsa*I	317 bp	317 bp	462 bp	341 bp
	112 bp	112 bp		88 bp
	33 bp	33 bp		33 bp
*Ssp*I	277 bp	277 bp	462 bp	277 bp
	185 bp	185 bp		185 bp

DNA sequencing

For DNA barcoding we used a PCR mix with a total volume of 25 μL containing 50 ng of DNA template, 1X PCR Gold Buffer (AppliedBiosystems), 1.5 mM $MgCl_2$ 200 μM of each dNTP (AppliedBiosystems), 0.4 μM of each primer (forward: 5’-TCAAGCCAGCCGCATAAC-3’, reverse: 5’-CGCTATTCCCTATTTAGCTTCT-3’), 1U AmpliTaq Gold DNA Polymerase (AppliedBiosystems), nuclease-free water. The cycle conditions were as follows: 95°C for 10 minutes, then 35 cycles of 95°C for 30 seconds, different annealing temperatures for different hybrids for 30 seconds, 72°C for a minute and a final extension at 72°C for 10 minutes. The PCR products were visualized on 2% agarose gel and purified using Wizard SV Gel and PCR Clean-Up System (Promega). The sequencing of amplicons was done with BigDye Terminator v3.1 Cycle Sequencing Kit, the sequencing products were purified using BigDye XTerminator Purification Kit (AppliedBiosystems) and loaded on 3130 Genetic Analyzer (AppliedBiosystems) for capillary electrophoresis. We sequenced the forward and reverse strands for more accurate data; we edited the sequences using BioEdit Sequence Alignment Editor 7.1.9. (Hall, 1999) and then we aligned the resulting data with known sequences from various sturgeon species using the BOLD (Barcode of Life Data) system (Ratnasingham and Hebert, 2007) for identification.

Microsatellite amplification

For microsatellite genotyping, we selected a set of eight microsatellite markers presented in table 2, first isolated from North American sturgeon species and used for native species by cross-amplification. The reaction mixes were prepared in a total volume of 25 µL with: 30 ng of DNA template, 1X PCR Gold Buffer (AppliedBiosystems), 1.5 mM $MgCl_2$, 200 µM of each dNTP (AppliedBiosystems), 0.24 µM of each primer with the forward primer fluorescently labeled, 1U AmpliTaq Gold DNA Polymerase (Applied Biosystems), nuclease free water. The reaction mixes were amplified on GeneAmp 9700 PCR System (AppliedBiosystems) using the following cycling conditions: 95°C for 10 minutes, then 35 cycles of 95°C for 30 seconds, specific annealing temperatures for the different primer pairs due to the different amplified microsatellite markers for 30 seconds, 72°C for a minute and a final extension at 72°C for 60 minutes. The amplified fragments were loaded with the GeneScan-500 LIZ Size Standard into ABI Prism 310 DNA Genetic Analyzer.

The statistical analysis of microsatellite genotype data was performed by FCA implemented in the program GENETIX (Belkhir et al., 2002).

Table 2: Microsatellite genotyping primer sequence.

Locus	Species	Primer sequence from 5' to 3'
LS19	*Acipenser fulvescens*	F: CATCTTAGCCGTCTGTGGTAC R: CAGGTCCCTAATACAATGGC
LS34	*Acipenser fulvescens*	F: TACATACCTTCTGCAACG R: GATCCCTTCTGTTATCAAC
LS39	*Acipenser fulvescens*	F: TTCTGAAGTTCACACATTG R: ATGGAGCATTATTGGAAGG
LS54	*Acipenser fulvescens*	F: CTCTAGTCTTTGTTGATTACAG R: CAAAGGACTTGAAACTAGG
Aox27	*Acipenser oxyrhinchus*	F: AATAACAATAACGGCAGAACCT R: TGTGTTGCTCAAGACAGTATGA
AoxD234	*Acipenser oxyrhinchus*	F: AACTGGCTTTGTGATTGATCC R: TGAAGCAAAGGGTATTATTTGAG
AnacE4	*Acipenser naccari*	F: TCAGCTACAGGGTTCTGGG R: GTTGTTACTCATTGGAACTC
AnacC11	*Acipenser naccari*	F: AAATTTCCATTGGGGTGT R: CTTCGTTTTGAGAACCCG

RESULTS AND DISCUSSION

The FCA statistical interpretation, based on the eight nuclear microsatellite loci, (Fig. 1) shows three clusters of pure-species individuals surrounding and the analyzed hybrids (marked as 203 and 204) which show up between these pure-species clusters. The position occupied by hybrid 204 indicates that this is a hybrid between *Acipenser ruthenus* and *Acipenser gueldenstaedtii*. The maternal genitor species identified by mitochondrial DNA marker analysis is represented by an individual belonging to *Acipenser ruthenus* species, while the paternal genitor is from *Acipenser gueldenstaedtii.*

In the case of hybrid 203, the genitors are represented by *Acipenser gueldenstaedtii* as paternal genitor and *Huso huso* as maternal genitor, this last one being confirmed by mitochondrial DNA marker analysis (Figs. 2, 3 and 4).

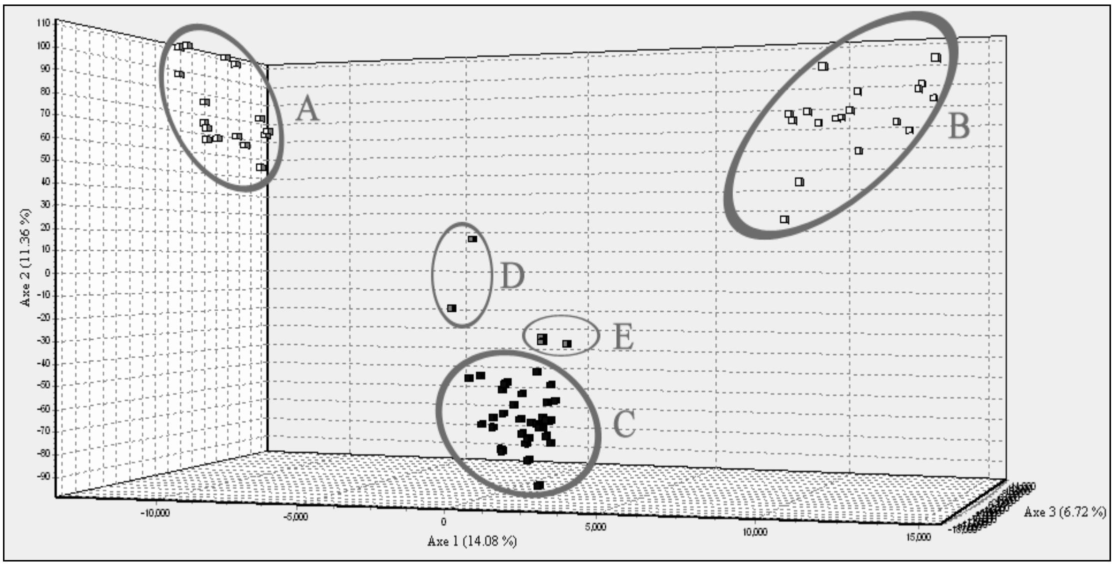


Figure 1: GENETIX - FCA hybrid analysis; A - *Acipenser ruthenus*; B - *Huso huso*; C - *Acipenser gueldenstaedtii*; D - hybrid 204; E - hybrid 203.

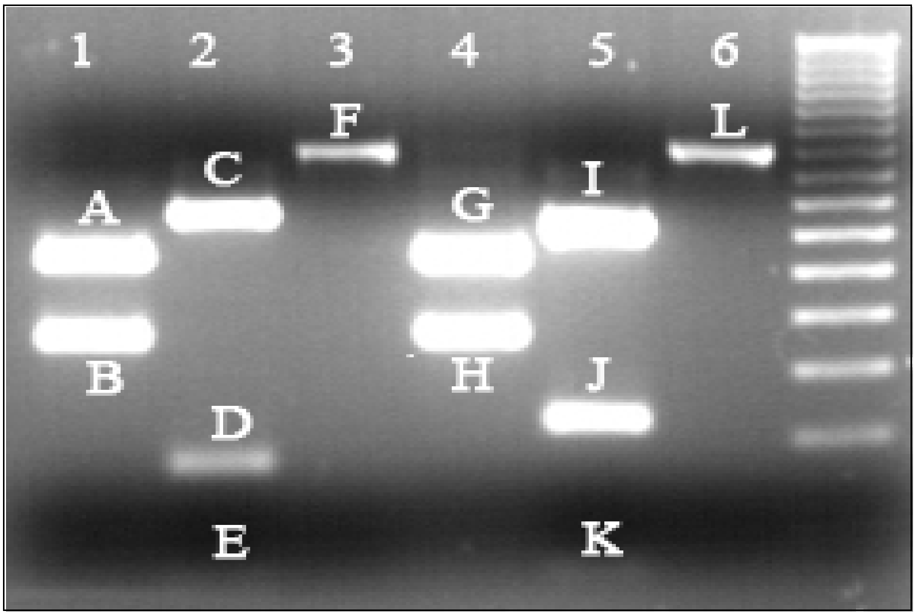


Figure 2: PCR-RFLP electrophoresis gel with 50 bp DNA Step Ladder; 1, 2, 3 - hybrid 204; 4, 5, 6 - hybrid 203; F, L - uncut fragments, 462 bp; A, B - *Ssp.* I restriction fragments, 277 bp and 185 bp; C, D, E - *Rsa*I restriction fragments, 341 bp, 88 bp and 33 bp; G, H - *Ssp*I restriction fragments, 277 bp and 185 bp; I, J, K - *Rsa*I restriction fragments, 317 bp, 112 bp and 33 bp.

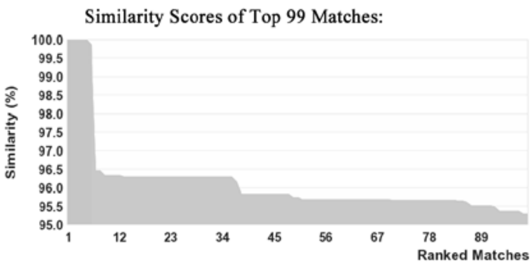
Using maternal genitor identification by PCR-RFLP analysis, the electrophoretic gel (Fig. 2) shows that for hybrid 204 the *Ssp*I digested fragments, 277 bp and 185 bp, are common between *H. huso*, *A. gueldenstaedtii* and *A. ruthenus*, but because of the *Rsa*I digested fragment length the result is pinpointed to *A. ruthenus* with 341 bp, 88 bp, 33 bp fragments. In case of hybrid 203 the *Ssp*I digested fragments show the same patterns as for hybrid 204 but the *Rsa*I band pattern, indicates as maternal genitor species to *H. huso* or *A. gueldenstaedtii*.

The PCR-RFLP analysis showed that hybrid 204 has maternal lineage from *A. ruthenus* yet hybrid 203 has a lineage from *H. huso* or *A. gueldenstaedtii*. The BOLD system was used to confirm the lineage of hybrid 204 and to clarify the origin of hybrid 203. This BOLD system identification showed that the hybrid 204 barcode sequence (Fig. 3) is a 100% match with *A. ruthenus*. Results for hybrid 203 (Fig. 4) showed a 99.9% similarity to the *H. huso* barcode sequence, thereby excluding thus the possibility of *A. gueldenstaedtii* as a paternal genitor as was previously highlighted by PCR-RFLP band pattern. For both hybrids the top five matches are the species to which they are assigned, raising confidence in results.

Using PCR-RFLP and BOLD system sequence alignment we conclude that for hybrid 204 the maternal genitor is *A. ruthenus* while *H. huso* is the maternal genitor for hybrid 203.

Identification Summary:

Taxonomic Level	Taxon Assignment	Probability of Placement (%)
Phylum	Chordata	100
Class	Actinopterygii	100
Order	Acipenseriformes	100
Family	Acipenseridae	100
Genus	Acipenser	100
Species	Acipenser ruthenus	100



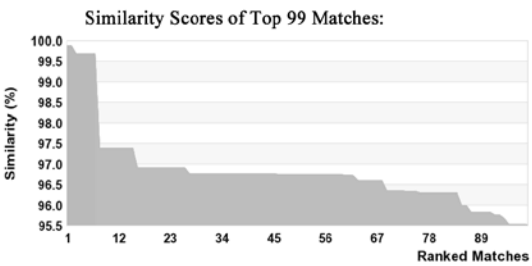
Top 5 Matches:

Phylum	Class	Order	Family	Genus	Species	Similarity (%)	Status
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Acipenser	*ruthenus*	100	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Acipenser	*ruthenus*	100	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Acipenser	*ruthenus*	100	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Acipenser	*ruthenus*	100	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Acipenser	*ruthenus*	100	Published

Figure 3: Hybrid 204, BOLD system sequence alignment.

Identification Summary:

Taxonomic Level	Taxon Assignment	Probability of Placement (%)
Phylum	Chordata	100
Class	Actinopterygii	100
Order	Acipenseriformes	100
Family	Acipenseridae	100
Genus	Huso	100
Species	Huso huso	99.9



Top 5 Matches:

Phylum	Class	Order	Family	Genus	Species	Similarity (%)	Status
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Huso	*huso*	99.88	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Huso	*huso*	99.88	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Huso	*huso*	99.68	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Huso	*huso*	99.68	Published
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	Huso	*huso*	99.68	Published

Figure 4: Hybrid 203, BOLD system sequence alignment.

CONCLUSIONS

Based on our analysis we conclude that the methods used here are particularly effective in hybrid characterization, yielding information not only about the identification of a sturgeon hybrid but also about the maternal and paternal ancestry of the individual sturgeon in question.

With the current difficulty in morphological characterization of natural sturgeon hybrids because of their unknown genitors, we propose the methods shown above provide the most reliable methodologies for identifying hybrids and the pure-stock sturgeon species. The specific application of these methodologies at various fish farms would allow people to identify and then avoid using hybrids in reproduction and repopulation programs that might lead to the alteration of the native populations.

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REFERENCES

1. Belkhir K., Borsa P., Goudet J., Chikhi L. and Bonhomme F., 2002 − Genetix, logiciel sous WindowsTM pour la génétique des populations, Laboratoire Génome et populations, CNRS UPR 9060, Université de Montpellier II, Montpellier, France. (in French)
2. Havelka M., Kašpar V., Hulák M. and Flajšhans M., 2011 – Sturgeon genetics and cytogenetics: a review related to ploidy levels and interspecific hybridization, *Folia Zoologica*, 60, 2, 93-103.
3. Hebert P. D. N., Cywinska A., Ball S. L. and deWaard J. R., 2003 – Biological identifications through DNA barcodes, *Proceedings of the Royal Society B: Biological Sciences*, 270, 313-321.
4. Hubert N., Hanner R., Holm E., Mandrak N., Taylor E., Burridge M., Watkinson D., Dumont P., Curry A., Bentzen P., Zhang J., April J. and Bernatchez L., 2008 – Identifying Canadian Freshwater Fishes through DNA Barcodes, *PLoS ONE*, 3, 6, e2490.
5. Ludwig A., 2006 – A sturgeon view on conservation genetics, *European Journal of Wildlife Research*, 52, 3-8.
6. Ludwig A., Lippold S., Debus L. and Reinartz R., 2009 – First evidence of hybridization between endangered sterlets (Acipenser ruthenus) and exotic Siberian sturgeons (*Acipenser baerii*) in the Danube River, *Biological Invasions*, 11, 753-760.
7. Nelson T. C., Doukakis P., Lindley S. T., Schreier A. D., Hightower J. E., Hildebrand L. R., Whitlock R. E. and Webb M. A. H., 2013 – Research Tools to Investigate Movements, Migrations, and Life History of Sturgeons (Acipenseridae), with an Emphasis on Marine-Oriented Populations, *PLoS ONE* 8, 8, e71552.
8. Ratnasingham S. and Hebert P. D. N., 2007 – BOLD: The Barcode of Life Data System (www.barcodinglife.org), *Molecular Ecology Notes*, 7, 355-364.
9. Taggart J. B., Hynes R. A., Prodohl P. A. and Ferguson A., 1992 – A simplified protocol for routine total DNA isolation from salmonid fishes, *Journal of Fish Biology*, 40, 963-965.
10. Taggart G., Campton D. E. and May B., 2004 – Genetic Evidence for Hybridization of Pallid and Shovelnose Sturgeon, *Journal of Heredity* 95, 6, 474-480.
11. Wolf C., Hubner P. and Luthy J., 1999 – Differentiation of sturgeon species by PCR-RFLP, *Food Research International*, 32, 699-705.
12. Zhang X., Wu W., Li L., Ma X. and Chen J., 2013 – Genetic variation and relationships of seven sturgeon species and ten interspecific hybrids, *Genetics Selection Evolution*, 45, 21.

DE GRUYTER OPEN

THE ASSESSMENT OF COMMUNITY INTEREST FISH SPECIES FROM PROTECTED AREA ROSCI0229

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KEYWORDS: Siriu, protected area, *Cottus gobio*, *Barbus petenyi*, conservation status.

ABSTRACT

In the protected area ROSCI0229 Siriu were named three fish species of community interest: *Gobio uranoscopus frici* Vladykov, 1925, *Barbus petenyi* Heckel, 1847 and *Cottus gobio* Linné, 1758. Out of 193 fish collected in 2010, 49 were *Barbus petenyi* and 37 *Cottus gobio*. In the three monitored rivers (Buzău River, Siriu River, and Crasna River), *Barbus petenyi* was present in two of them and *Cottus gobio* was present in all of them. According to the analytical indices of population, frequency, numerical abundance and density we assessed a favorable population status for *Barbus petenyi* in Buzău River and a medium favorable population status for *Cottus gobio* in Buzău River and its tributaries Crasna River and Siriu River.

ZUSAMMENFASSUNG: Bewertung der Fischarten von gemeinschaftlichem Interesse im Naturschutzgebiet ROSCI0229 Siriu.

Im Naturschutzgebiet ROSCI0229 Siriu wurden drei Fischarten von gemeinschaftlichem Interesse festgestellt und zwar *Gobio uranoscopus frici* Vladykov, 1925, *Barbus petenyi* Heckel, 1847 und *Cottus gobio* Linné, 1758. Von den 193 im Jahr 2010 gesammelten Individuen von Fischen gehörten 49 zu *Barbus petenyi* und 37 zu *Cottus gobio*. In ihrer Verteilung auf die drei untersuchten Fließgewässer (Buzău, Siriu und Crasna) war *Barbus petenyi* in zweien anzutreffen, während *Cottus gobio* in allen drei Gewässern vorkam. Gemäß den analytischen Populations-Indices d. h. Frequenz, numerische Abundanz und Dichte, wurde der Zustand der Population im Buzău-Fluss für *Barbus petenyi* als günstig eingestuft. Für *Cottus gobio* ist der Zustand der Population für den Buzău und seine beiden Zuflüsse Crasna und Siriu als mittelmäßig zu bewerten.

REZUMAT: Distribuția speciilor de pești de interes conservativ din aria naturală protejată ROSCI0229 Siriu.

În aria naturală protejată ROSCI0229 Siriu au fost semnalate trei specii de pești de interes comunitar: *Gobio uranoscopus frici* Vladykov, 1925, *Barbus petenyi* Heckel, 1847 şi *Cottus gobio* Linné, 1758. Dintr-un număr total de 193 exemplare de pești colectate au fost identificate 49 exemplare de *Barbus petenyi* și 37 exemplare de *Cottus gobio*. În cele trei cursuri de apă monitorizate (Buzău, Siriu și Crasna), *Barbus petenyi* a fost prezentă în două cursuri de apă, iar *Cottus gobio* în toate trei cursurile de apă. Conform indicilor analitici ai populației, frecvența, abundența numerică și densitatea am evaluat pentru *Barbus petenyi* statutul populației ca fiind favorabil pentru râul Buzău și pentru *Cottus gobio* statutul populației ca fiind favorabil mediu pentru râul Buzău și afluenții lui Crasna și Siriu.

INTRODUCTION

Biodiversity levels have declined rapidly in Europe over the last few decades (EEA, 2006). The major human pressures upon habitats and species are overexploitation, direct destruction and fragmentation of habitats, changes in abiotic conditions, and introductions of exotic biota (Maiorano et al., 2008; Sax and Gaines, 2008; Thuiller et al., 2005).

To decrease - or better stop - this biodiversity loss, protected areas (PAs) are set aside to conserve habitats and species, and constitute the most widespread instrument used in conservation planning (Margules and Pressey, 2000). Protected areas (PAs) are created for their inherent ecological value (Gaston et al., 2008) and also for their potential to solve social and economic issues faced by local communities (Silva, 2009).

Among the policy instruments that frame the conservation of biodiversity in Europe can be found the European Union's (EU) Habitats Directives (HD) and Birds Directives (BD) (Gaston et al., 2008; Pullin et al., 2009). The Habitats Directive (1992) forms the cornerstone of nature conservation policy in the EU, and together with the older Birds Directive (1979) are the legal base for creating a pan-European protected areas network - the Natura 2000 Network (N2K) - that will facilitate the protection of species and habitats of European conservation interest (Fontaine et al., 2007). This network is composed of all Special Protection Areas (SPAs for the BD) and Sites of Community Importance (SCIs for the HD). All the 5,242 terrestrial SPAs, that coverage 547,819 km^2 of European Union's territory (11.1%) and all the 22,419 terrestrial SCIs, that coverage 719,992 km^2 of European Union's territory (13.6%) form the Natura 2000 (Anonymous, 2009).

A final goal of the HD is to achieve a favourable conservation status for all enlisted habitats and species in the European territory (Article 2 of the HD). The term 'favourable conservation status' is defined in the HD (see also EC 2005, 2006), but has many interpretations (Cantarello and Newton, 2008; Mehtälä and Vuorisalo, 2007; Nielsen et al., 2007).

The assessment of conservation status of habitats and species is a central activity in achieving the final goal of HD. The assessment of conservation status, made by the European Topic Centre on Biological Diversity (ETC/BD), followed the definition given in the HD and was based on four groups of parameters, mentioned in given definition. The HD define conservation status as all the factors that influence habitats or species that may have long-term affect on range, habitat area, population structure and function and their future prospects. Four classes of conservation status were used in the Member State assessments: "favourable", "unfavourable-inadequate", "unfavourable-bad" and "unknown". In 2007, European Union Member States reported on the conservation status of community interest habitats and species for the period 2001-2006. EU analysis, at biogeographical level, shows that only 17% of both habitats and species assessments were deemed favourable (EEA, 2006).

The implementation of European Union biodiversity legislation in Romania through Nature 2000 Network came in force with OUG 57 of 2007 that transposed into Romanian legislation the Habitats Directive and Birds Directive. After that, the Romanian PAs increased from 4.1% prior to 1989 to 19.29% of the national territory due to creation of 27 National and Natural Parks, and recently 382 protected areas as part of the pan-European Natura 2000 network (Iojă et al., 2010). At the next report on the conservation status of habitats and species, to be held in 2013, Romania will take part, which initiated development of the monitoring activities described in this paper.

The Romanian Nature 2000 Network with relevance on the ichthyofauna is represented by 81 SCIs from a total of 273 SCIs (Curtean-Bănăduc and Florescu, 2007; Florea, 2011). Protected Romanian fish species in the normative acts of the Nature 2000 Network are represented by 27 fish species. The number of community interest fish species presented in one Romanian SCI varies quite widely from one species to a maximum of 16 species per SCI. Of the 27 community interest fish species presented in the 81's SCIs, four fish species (*Cottus gobio*, *Barbus petenyi*, *Sabanejewia aurata*, *Cobittis taenia*) have a large spreading area, nine species (*Romanichthys valsanicola*, *Eudontomyzon vladykovi*, *Rutilus pigus*, *Cobitis elongata*, *Leuciscus souffia*, *Eudontomyzon mariae, Alosa caspia*, *Hucho hucho*, *Umbra krameri*) have a small spreading area, being very rare (Bănărescu and Bănăduc, 2007; Florea, 2011).

In the investigation PAs, included in the Romanian Nature 2000 Network, were named three community interest fish species: *Gobio uranoscopus frici* Vladykov, 1925 (Danubian longbarbel gudgeon), *Barbus petenyi* Heckel, 1852 (Danubian rheophilic barb) and *Cottus gobio* Linné, 1758 (bullhead). In the fishing activities during the spring and summer of 2010 we found two of them, *Barbus petenyi* and *Cottus gobio.*

The goal of this study is to evaluate the conservation status of the community interest fish species *Cottus gobio* and *Barbus petenyi* from PAs ROSCI0229 Siriu. The research objectives are: (1) to document the biology and the ecology of *Cottus gobio* and *Barbus petenyi*; (2) to analyze the distribution of *Cottus gobio* and *Barbus petenyi* inside Romania's Natura 2000 net; (3) to analyze the ichthyofauna characteristics of Buzău River and ROSCI0229 Siriu; (4) to document the conservation status and future prospects for species.

The biology and ecology of *Cottus gobio* and *Barbus petenyi*

In Europe the genus *Barbus* includes 34 species (Fauna Europaea, 2011), but in Romania the genus *Barbus* includes only four species: *Barbus barbus* (Linnaeus, 1758), *Barbus petenyi* Heckel, 1852, *Barbus balcanicus* Kotlik, Tsigenopoulous, Rab and Berrebi, 2002 and *Barbus carpathicus* Kotlik, Tsigenopoulous, Rdb and Berrebi, 2002 (Nalbant, 2003). Beside the common barb (*Barbus barbus)*, in the Romanian rivers there are three so-called spotted barb, which characterizes itself by its preference for the colder and more rapid flowing mountain waters. The species *Barbus balcanicus* is present in Banat and in Jiu River basin and the species *Barbus petenyi*, in the basins of the rivers Mureş, Argeş, Vedea and Ialomița. In the basin of the Olt River both of them occur (Iftime, 2004). The species *Barbus carpathicus* is present only in Someş basin, a left tributary of the river Tisa (Nalbant, 2003).

The identification of *Barbus petenyi* must made according to the following morphological criteria: pectorals without spots; dorsal and caudal with small spots, generally randomly disposed; pair one of barbels is relatively long; snout is relatively pointed (Kotlik et al., 2002), simple radius of the dorsal fin is thin and flexible; the insertion of the ventral fins is behind the dorsal fin insertion; the anal fin is long, sometimes reaching the base of the caudal fin; there are dark spots on its back (Bănărescu, 1964; 1968). The *Barbus petenyi* is a medium-sized fish growing to 100-170 mm long; in the river network from PAs ROSCI0229 Siriu it had a total length between 37 and 146 mm.

This fish prefers rivers and streams in mountainous and hilly areas, with stony riverbeds, clear and well oxygenated water and a fast-flowing current. It is benthopelagic, and feeds on small invertebrates. It shows preference for strong current and rocky bottom, in its downstream area the *Barbus petenyi* lives together with *Gobio uranoscopus.* It is strictly sedentary not doing any migration. It is also a species sensitive to pollution and can easily make hybrid species with *B. barbus* and *B. haasi* (Bănărescu, 1964).

While still common in suitable habitats, the decline of its population is suspected and expected to continue gradually due to on-going economic development. Its distribution in Romania is relatively large, but rather fragmented, though in recent decades it has been expanding. In Romania it can be considered to have low vulnerability. The species is included in the IUCN Red List, Bern Convention, Habitats Directive and protected by Law 462/2001.

In Europe the genus *Cottus* include seven species (Fauna Europaea, 2011), but in Romania the genus *Cottus* include only one species *Cottus gobio* Linnaeus, 1758 (Nalbant, 2003). The bullhead is a small almost cylindrical fish, usually measuring 10 cm, in rare cases reaching 12-13 cm total length. The head is relatively large (it represents 26-33% of the total length). The side of the head is armed with spine below the eye, and the preopercula and opercula bones are elongated to form a spine. The lateral line of the body is complete. In Central Europe morphological differences were established between populations from various drainage basins (Riffel at al., 1998). In the Siriu River network the bullhead total length are between seven and 13.5 cm.

The bullhead is a freshwater fish that occurs in cold, clear and fast-flowing shallow water of small stream to medium-sized rivers as well as on gravel or rocky shores of cold lakes (Bănărescu, 1964). Bullhead is a solitary bottom-dwelling fish, each individual defending a territory. Adults do not move between the different stretches of river, but larvae can be passively dispersed downstream after hatching and juveniles actively "explore" neighboring areas before choosing a territory (Chaumota et al., 2006). It feeds mainly on insect larvae, nymphs and other invertebrates, sometimes small fish. The first reproduction occurs when adults are two-years-old or later, length at first maturity being 4.7 to 5 cm. The laying of eggs is in late March-April, after that the male guard the eggs for one month. Larvae become juveniles in fall. Juveniles establish their territory during the first winter of their life.

Investigations linking fish ecology, flow, and physical habitat variability suggest that mesohabitat size, persistence and arrangement may influence fish distribution (Pont et al., 2005; Gosselin et al., 2010). Adults appeared to prefer higher water velocities and coarser substrate and juveniles preferred deeper water and coarser substrate in winter, whereas in summer they appeared to use shallower water (Seeuws et al., 2005). The estimation of the population dynamics was accomplished by using the genetic approach (microsatellite polymorphism) (Knaepkensa et al., 2004; Haenfling et al., 2006), direct field observations (Vlach et al., 2005), or mathematical modeling (Legalle et al., 2005; Chaumota et al., 2006; Charles et al., 2008). There are relatively many multi-scale studies of factors influencing a bullhead distribution allowing integration of patterns observed at different scales and enhancing our understanding of interactions between animals and their environment.

Freshwater fish populations have significantly been reduced and altered due to direct and indirect human activities (Cowx and Welcomme, 1998). Nevertheless, in recent decades, *Cottus gobio* has suffered a considerable decline in Switzerland, Germany, Flanders (Utzinger et al., 1998), and Austria (Fischer and Kummer, 2000). In the latter by human activities such as pollution. Anthropogenic habitat destruction has modified the natural riverine habitat of this species and consequently had a large impact on the size, range and viability of the local bullhead populations (Utzinger et al., 1998; Hanfling and Brandl, 1998; Hanfling and Weetman, 2006; Knaepkens et al., 2002a, b). Consequently, the species is regarded as highly vulnerable and is fully protected by law in Europe Union (Vandelannoote et al., 1998). In Romania it has a relatively wide range, but due to human impact its range has reduced somewhat. In Romania this species has low vulnerability. It is included in the Bern Convention, Habitats Directive and protected by Law 462/2001.

The distribution of *Cottus gobio* and *Barbus petenyi* inside Romania's Natura 2000 Network

From 2007, the total surface of Natura 2000 Network in România represented a significant part of the country's surface. There are 273 SCIs, representing 13.21% of the country surface and 108 SPAs, representing 11.89% of the country surface (MEF/NAE, 2009). From these 273 SCIs only 81 SCIs have fish species which must be protected under the Order 57/2007, Annex 3 – "Species of plants and animals whose conservation requires the designation of SCIs". List of fish species that are found in SCIs, reported in Romania until 2007 (OM. 1964/2007), consist of 26 fish species (Florea, 2010).

Romania possesses five of the ten biogeographic regions officially recognized by the European Union (alpine, continental, panonic, pontic, and steppe), making it one of the most biogeographically diverse country of the EU. The distribution analysis of all 38 SCIs where *Barbus petenyi* was found and of all 39 SCIs where *Cottus gobio* was found, in terms of their belonging to the five major biogeographic regions shows us the following (Fig. 1):

- alpine bioregion has 19 SCIs with *Barbus petenyi* and 24 SCIs with *Cottus gobio*;
- continental bioregion has 16 SCIs with *Barbus petenyi* and 15 SCIs with *Cottus gobio*;
- panonic bioregion has two SCIs with *Barbus petenyi* and no SCIs with *Cottus gobio*;
- steppe bioregion has one SCIs with *Barbus petenyi* and no SCIs with *Cottus gobio*;
- pontic bioregion has no SCIs with *Barbus petenyi* and no SCIs with *Cottus gobio*.

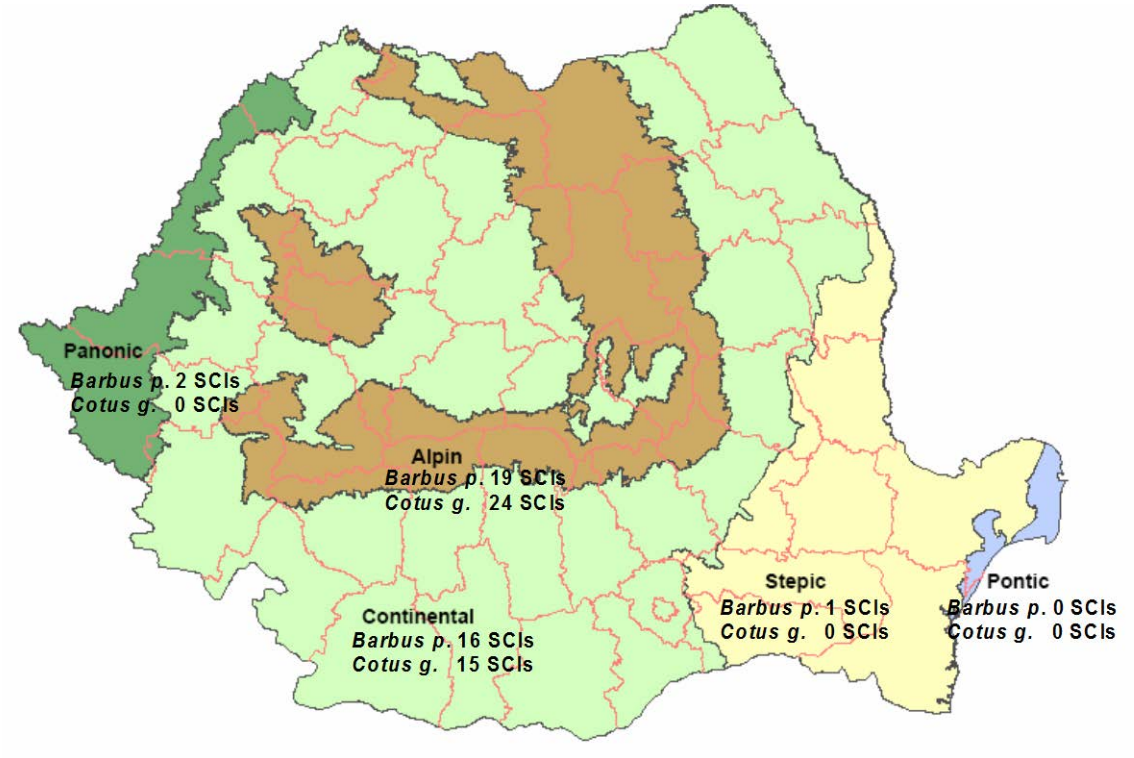

Figure 1: The distribution of SCI-s with *Barbus petenyi* and *Cottus gobio* in biogeographic regions of Romania.

The total number of SCIs where both species are present is 48, of which 29 SCIs have both species, 10 SCIs have only *Cottus gobio* and nine SCIs have only *Barbus petenyi.* The analysis of the protected fish distribution in national Natura 2000 Network show that *Cottus gobio* species is present only in alpine and continental bioregion and *Barbus petenyi* species is present in those regions and also in panonic and steppe bioregion. The medium altitude of SCIs varies significantly for the SCIs with *Cottus gobio* species from the SCIs with *Barbus petenyi* species (Fig. 2). The map of distribution of these species (Fig. 3) was made using the official maps of occurrence of these two species, provided by the Order of Minister of Environment and Sustainable Development no. 1964/2007 (MESD, 2007).

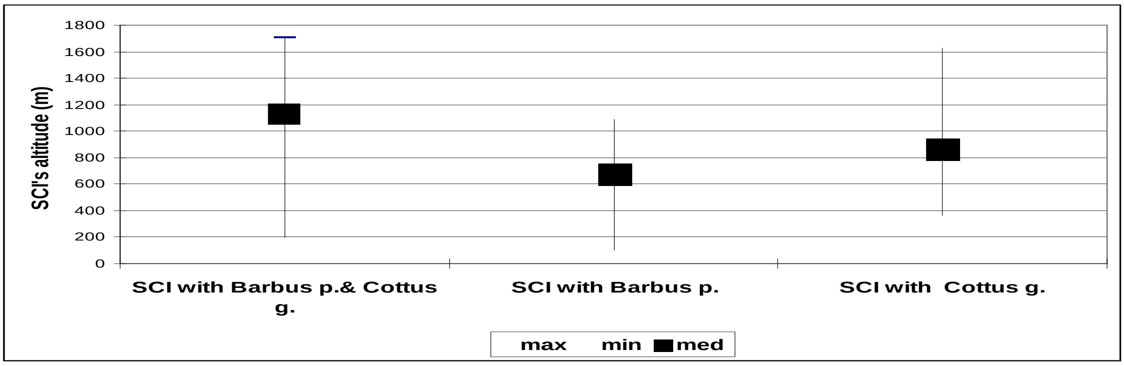

Figure 2: The variation of SCIs medium altitude for SCIs with *B. petenyi*, SCIs with *C. gobio* and SCIs with *B. petenyi* and *C. gobio.*

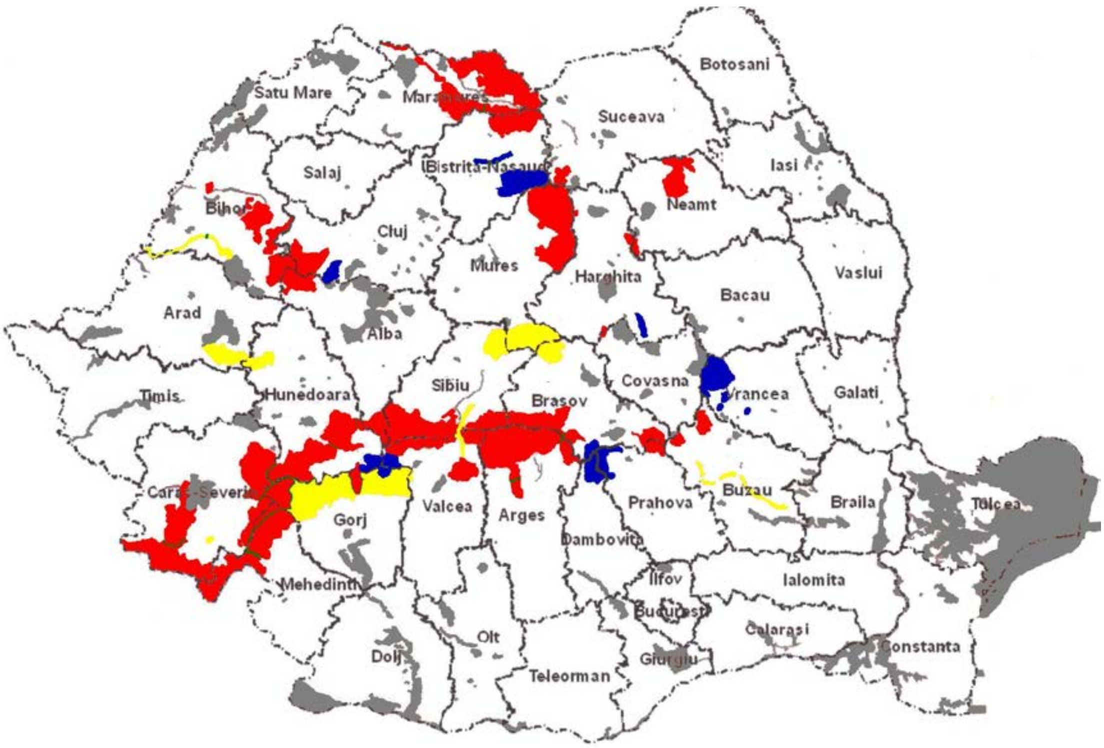

Figure 3: The range of *B. petenyi* and *C. gobio* inside Romania's SCIs network Red - 29 SCIs with *C. gobio* and *B. petenyi* Blue - 10 SCIs with *C. gobio* Yellow - nine SCIs with *B. petenyi.*

The ichthyofauna characteristics of Buzău River and ROSCI0229 Siriu

The past of Buzău River ichthyofauna is presented in the study "R. P. R. Fauna, Pisces: Osteichthyes" by the Romanian ichthyologist Bănărescu P. M., citing for the Buzău River 22 species of fish belonging to six families. The ichthyofauna of the rivers ecosystems from the Buzău hydrographic basin, from its source to its mouth, due to the presence of a large variety of landforms, has been divided into five fish zones (Bănărescu, 1964).

In the mountains: the trout zone (*Salmo fario*), the grayling zone (*Thymallus thymallus*) and the Mediterranean barbel area (*Barbus petenyi*).

In the hills: the sneep zone (*Chondostroma nasus*), the barbel zone (*Barbus barbus*);

In the plains: the carp zone (*Cyprinus carpio*).

Both in the mountains and in the hills and plains, within about 30 years, from 1964 to 1998, major changes in fisheries are highlighted (Figs. 4 and 5). In both periods the trout area is well represented. The mountain area of Buzău offered exceptional conditions for the trout (*Salmo trutta fario*) with whom in the past there has also been observed the minnow (*Phoxinus phoxinus*), the bullhead (*Cottus gobio*), the loach (*Orthrias barbatulus*), the bleak (*Alburnoides bipunctatus*). All these species have been reported in the present too. In contrast, in the 60s the grayling population was well represented on the Buzău River, which was not confirmed by the recent studies (Dimulescu, 1998). In the grayling and the barbel area, the grayling (*Thymallus thymallus*) occupies well individualized and surface limited areas, but the barbel (*Barbus petenyi*) was encountered on more extensive areas, also in the mountains, and downstream, with the chub (*Squalius cephalus*) and the common dace (*Leuciscus leuciscus*) (Bănărescu, 1964) (Fig. 4).

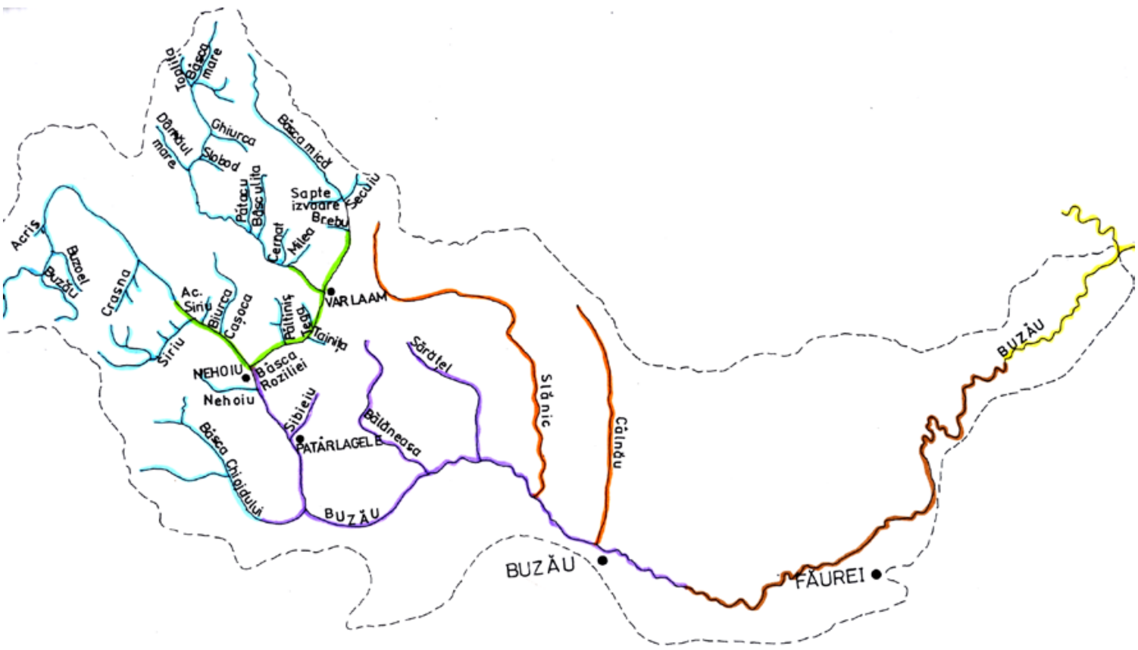

Figure 4: Fish zoning of Buzău's hydrographic basin in 1964, after Bănărescu P. M.; blue - the trout zone; green - the grayling and the barbel zone; purple - thesneep zone; brown - the barbel zone; yellow - the carp zone; orange - zone without fish fauna.

In 1994, the construction of the Siriu Dam was done. The dam is made of rock, tailings and clay core. The purposes of the dam were to supply industrial water supply, to irrigate the agricultural land and, production of electricity by building Nehoiașu hydroelectric power station. The dam also serves as protection against flood. Siriu Lake was formed as a result of daming the Buzău River in the Siriu Village; it has an area of five km^2 and an average depth of 45 m (www.rowater.ro/daBuzău/). After the construction of the Siriu Lake, it was noticed that the grayling zone shrank drastically due to the change of the downstream flow regime and also due to the mining works of the mineral aggregates in the upstream riverbed. In addition, due to the invasion of the sneep populations, the grayling populations have been pushed upstream, and their area was limited to 10 km on the Buzău River, upstream of the confluence with the Crasna River and to 20 km on other left tributary of Buzău (Dimulescu, 1998) (Fig. 5).

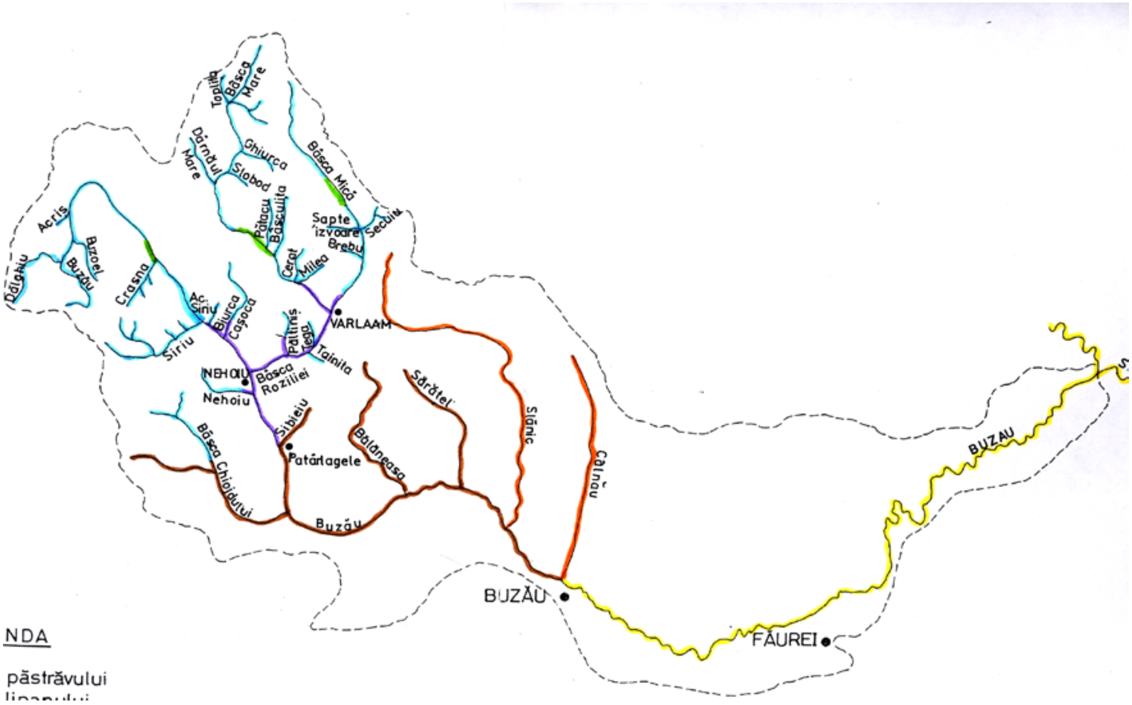

Figure 5: Fish zoning of Buzău's hydrographic basin in 1998 after Dimulescu N.; blue - the trout zone; green - the grayling and barbel zone; purple - the sneep zone; brown - the barbel zone, yellow - the carp zone; orange - zone without fish fauna.

In the present the ichthyofauna of ROSCI0229 Siriu is composed of 10 species of fish caught in June and September 2010, the scientific name being the one that has been recently updated (Nalbant, 2003) (Tab. 1).

The lack of the grayling catch in 2010 confirms the reports from 1998 that pointed to the grayling restriction of the distribution area with about 80% of the area occupied in 1964 and pushing the distribution areal upstream (Dimulescu, 1998). This shrinkage and fragmentation of the grayling distribution area is due to the Siriu dam lake construction and to the change of the flow regime downstream, the grayling populations advancing upstream of the Siriu dam lake. The presence of the rainbow trout, both in the past and in the present, is totally random, being possible because before 1990 in ROSCI 0229 Siriu this new species were populated, but that effort proved totally inefficient.

Table 1: The ROSCI0229 list of fish species from past (1998) and present (2010).

	List of fish species		Common name	
	Past (1998)	Present (2010)	Romanian	English
1.	*Barbus petenyi*	*Barbus petenyi*	moioagă	spotted barbel
2.	*Cottus gobio*	*Cottus gobio*	zglăvoacă	bullhead
3.	*Squalius cephalus*	*Squalius cephalus*	clean	chub
4.	*Alburnoides bipunctatus*	*Alburnoides bipunctatus*	beldiță	sperlin
5.	*Alburnus alburnus*	*Alburnus alburnus*	obleţ	bleak
6.	*Chondrostoma nasus*	*Chondrostoma nasus*	scobar	mackerell
7.	*Salmo fario*	*Salmo fario*	păstrav indigen	river trout
8.	*Rhabdofario mykiss*	*Rhabdofario mykiss*	păstrav curcubeu	rainbow trout
9.	*Phoxinus phoxinus*	*Phoxinus phoxinus*	boiștean	minnow
10.	*Orthrias barbatulus*	*Orthrias barbatulus*	grindel	stone loach
11.	*Thymallus thymallus*		lipan	grayling

The ichthyofauna of the Buzău River and its tributaries within ROSCI0229 is characteristic for the trout zone. The streams from the Siriu Massive offer exceptional conditions for the growth and the development of the river trout, this fact being noticed within the basic fishing activity from September 2010. Thus, in the Crasna station (45.65301 latitude, 26.00877 longitude, 831 m altitude, slope 4.5%), they caught on an area of 220 square meters a total number of 40 specimens of river trout. From the analysis of the catch (Fig. 6) it is observed a balanced structure of the age groups and a favourable average weight of age groups.

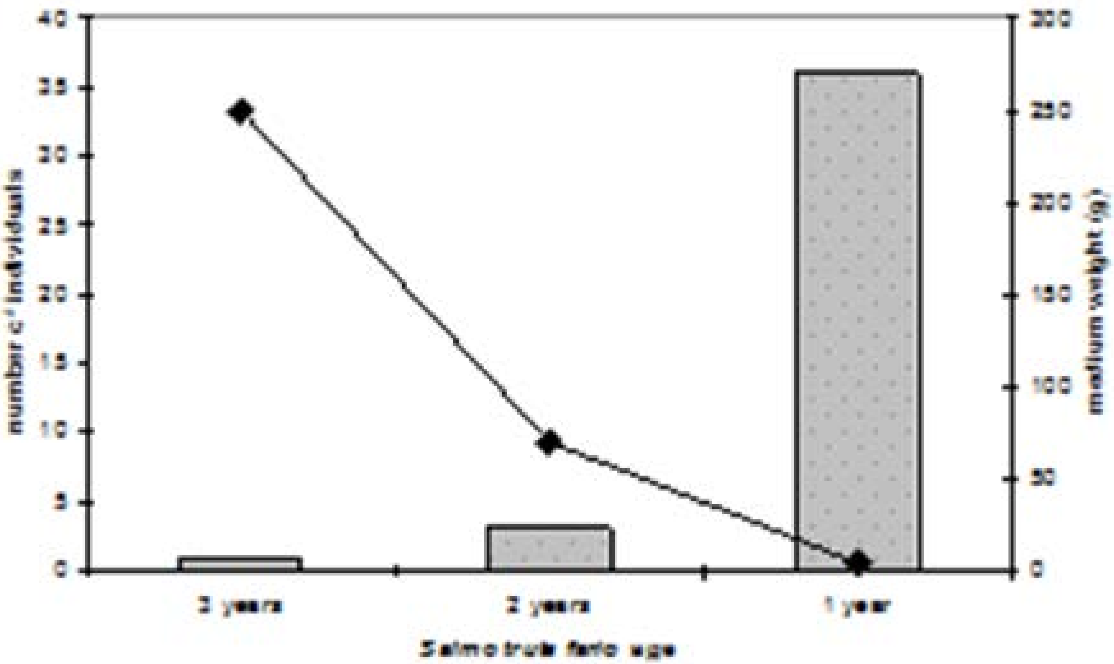

Figure 6: The capture of *Salmo fario*
from Crasna 1 fishing station at 11.09.2010.

MATERIAL AND METHODS

The ROSCI0229 Siriu, part of Buzău River basin, is framed as part of ecoregion 10 - Carpathian Mountains (Ilieș, 1978) and as part of alpine bioregion, with a total surface of 5.747 ha, has the following geographical coordinates: 45º31'28"N, 26º9'43"E, 546 m minimum altitudinal and 1,663 m maximum altitudinal (Fig. 7).

Figure 7: The localization of PAs ROSCI0229 Siriu.

The hydrographic network of PAs ROSCI0229 Siriu, tributary to Buzău River, is a circular network composed by nine streams which descended from the highest peaks, streams that have rather ephemeral flow. In spring (from late April to June) they are more active and formed gradually downstream tumultuous courses carrying large volumes of rock.

We investigated three rivers, Buzău River, Siriu River and Crasna River, which present homogeneous conditions of habitat and which are delimited by confluence (Fig. 8). Investigated rivers were chosen to analyze heterogeneity of environmental conditions of the hydrographic network of PAs ROSCI0229 Siriu. Table 2 reports the main morphological features of these three different rivers according to Management Plan River (NARW, 2009).

The most important parameters which largely influence the habitat conditions from the streams are represented by the slope of the land and the type of the substrate. Of course there are also other environmental factors that influence stream life such as: water chemistry, light, water depth, etc. Minor riverbed morphology is very important and in the case of the fishing stations from ROSCI0229 Siriu this morphology varied within quite wide limits, from waters of two m widths and 20 cm depths to water up to 120 m widths and 120 cm depths (Tab. 2).

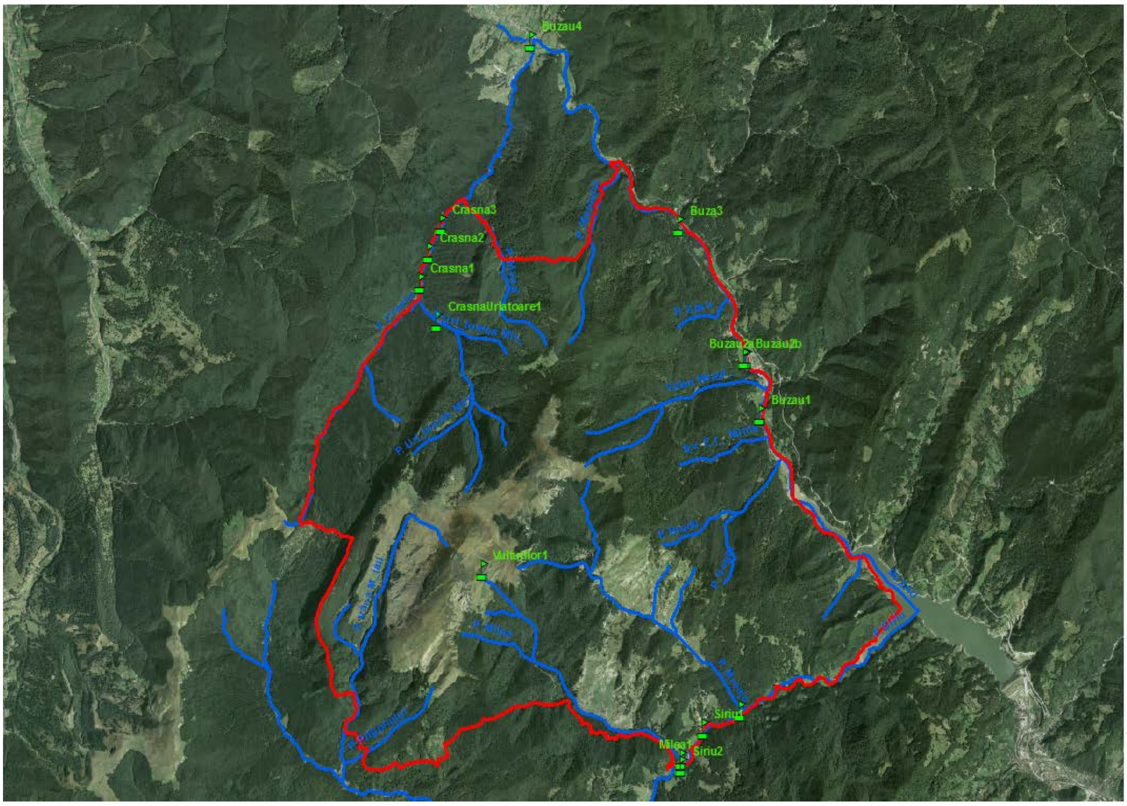

Figure 8: The hydrographic network of PAs ROSCI0229 Siriu and the fishing stations.

Table 2: The morphological features of the investigated river stretches.

Features	Stretches of river		
	Buzău	Siriu	Crasna
hydrographic positioning	order three	order two	order one
sector slope	0.82%	1.3%	5.1%
total length	60 km	30 km	20 km
shading	null	less important	important
substrate type: % boulders % gravel % sand	 25 50 25	 10 65 25	 50 35 15
width	3-15 m	6-8 m	2-4 m
depth	30-120 cm	20-50 cm	20-40 cm
% current area	80	100	100
% shallow area	20	-	-
% monitored sector	25	50	50
no. fishing stations	5	2	3

A total of 14 fishing activities were made in 10 fishing stations in the summer of 2010, in June and September. The fishing stations codes and their localization are: for Buzău River B1, B2a, B2b, B3, B4; for Siriu River: S1, S2; for Crasna River: C1, C2 C3.

The fishing stations were described by hydrographical characteristics (Fig. 9) and hydrological characteristics (Fig. 10). The geographical coordinates of the fishing stations for the rivers have been set by using the GPS that shows the latitude, the longitude and the altitude with an accuracy of 0.8 m. The determination of the land slope was done indirectly through calculation. The width and the depth of the water were measured directly on the field using a ruler and water velocity was measured directly using a flow meter.

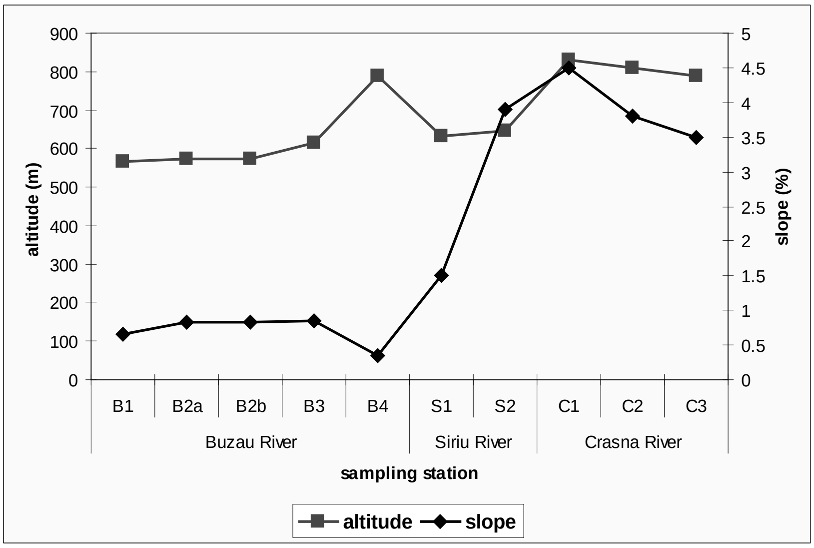

Figure 9: The altitude and the ground slope in the fishing stations.

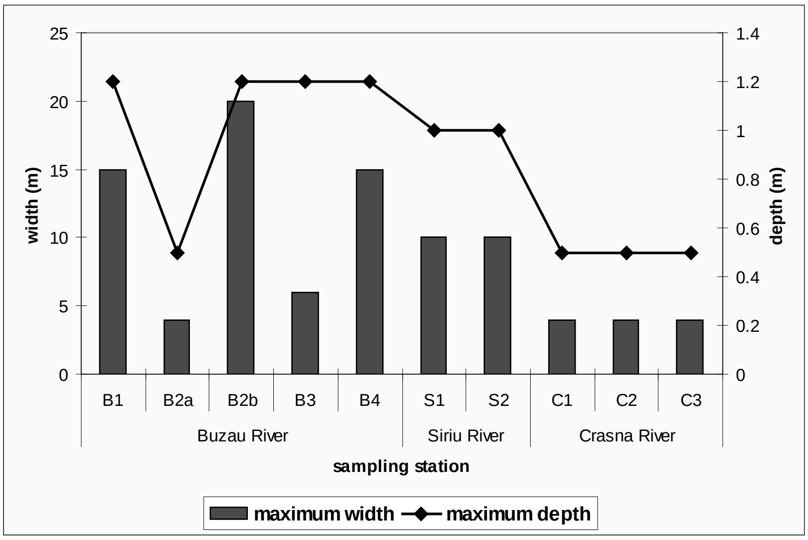

Figure 10: The river width and the depth in the fishing stations.

The sampling of fish was made by electrofishing, according to standard operational procedure (Davideanu, 2005). A portable fishing device, type ELT62II was used. Fishing was done on foot, zigzag from one bank to another over the entire stream, recording the length and the fished area (Fig. 11). Electrofishing was carried out in a river stretch along a distance between a minimum of 80 m and a maximum of 165 m, with a fishing surface between a minimum of 557 m^2 and a maximum of 1,750 m^2 (Fig. 12).

Species identification was carried out according to several morphological characteristics, using determination keys for every systematical unit and species description from the literature (Bănărescu, 1964). The recorded catch for each station is shown in figure 6. On the whole, in the 14 fishing sectors, a total number of 149 fish were collected, of which 49 were *Barbus meridionalis petenyi* and 37 were *Cottus gobio*. For each individual was made the most important somatic measurements, total body length (Tl) and body weight (W). For the body length we use a caliper and for the body weight we use an electronic balance.

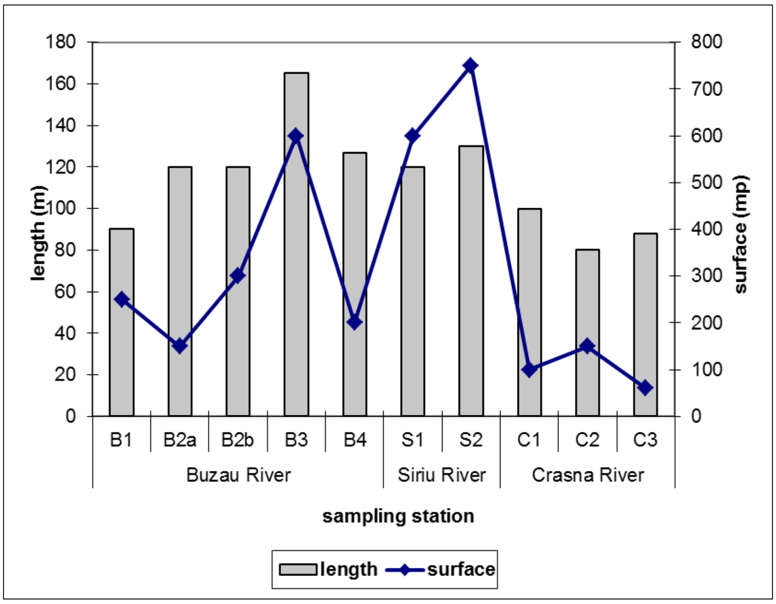

Figure 11: The length and the surface of fishing stations.

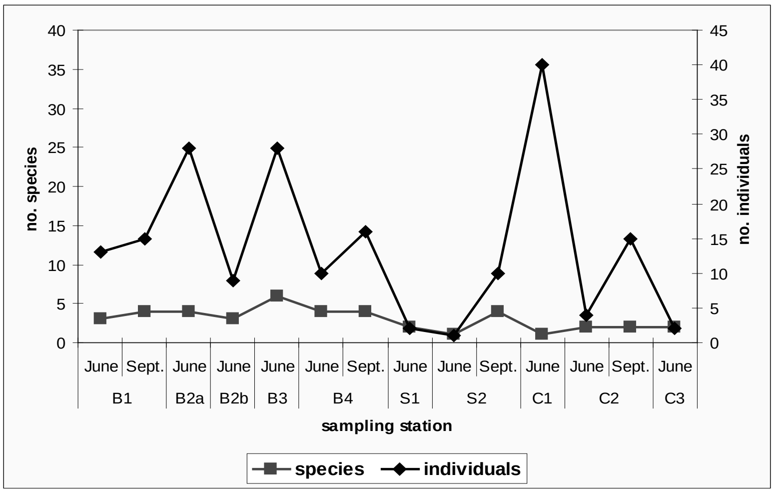

Figure 12: The number of the species and individuals caught in the fishing stations.

RESULTS AND DISCUSSION

The purpose of the fishing activity was to assess the conservation status of these two species of community interest from ROSCI 0229. The results of the fishing activity are listed in tables 3 and 4.

Table 3. Fish capture from PAs ROSCI0229 Siriu in 2010.

Station	Data	Total fish capture		*Barbus m.* no. indiv (An%)	*Cottus g.* no. indiv (An%)
		no. species/ station	no. ind./ station		
B1	05.06	3	13	9 (69%)	0 (0%)
	10.09	4	15	4 (27%)	5 (33%)
B2a	05.06	4	28	21 (75%)	5 (18%)
B2b	05.06	3	9	5 (55%)	0 (0%)
B3	05.06	6	28	4 (14%)	7 (25%)
B4	05.06	4	10	1 (10%)	3 (30%)
	10.09	4	16	3 (19%)	0 (0%)
S1	05.0	2	2	0 (0%)	1 (50%)
S2	07.06	1	1	0 (0%)	1 (100%)
	11.09	4	10	2 (20%)	2 (20%)
C1	05.06	1	40	0 (0%)	0 (0%)
C2	07.06	2	4	0 (0%)	3 (75%)
	11.09	2	15	0 (0%)	9 (60%)
C3	05.06	2	2	0 (0%)	1 (50%)
Total		10 sp.	193 ind.	49 ind. (25%)	37 ind. (19%)

Table 4: Unitary fish capture (ind./100 m^2 and g/100 p) in ROSCI0229 Siriu in 2010.

Station	Unitary fish capture per station		Unitary fish capture per *Barbus m.*		Unitary fish capture per *Cottus g.*	
	ind./100m^2	g/100 m^2	ind./100 m^2	g/100 m^2	ind./100 m^2	g/100 m^2
B1			3.6	284	0	0
	6.0	184	1.6	56	2	24
B2a	18.0	1782.66	14	1550.66	3.33	86.66
B2b	3.0	480	0	130	0	0
B3	4.6	417.5	1.66	70	2.33	85
B4	5.0	585	0.66	35	0.5	120
	8.0	568	0.5	51.5	0	0
S1	3.0	8.33	1.5	15	0.5	11.66
S2	1	1.33	0	0	0.16	1.33
	10	28	0	0	0.26	5.33
C1	40	573	0.26	0	0	0
C2	2.6	120	0	0	3	40
	10	466.66	0	0	6	33.33
C3	3.0	233.33	0	0	0.66	83.33

In order to establish the population status several biological concepts linked to community dynamics may be use. For example, many studies use two analytical indices: frequency and numerical abundance of species.

- **Frequency (F%)** = (p/P) x 100
  p = number of samples in which the species occurs;
  P = total number of samples.

- **The Constant (C)** – is expressed in terms of frequency. Depending on the value of the frequency, species belong to the following classes of constant (Varvara et al., 2001):
  C1 - accidental species - when the frequency is between 1-25%;
  C2 - accessories species - when the frequency is between 25.1-50%;
  C3 - constant species - when the frequency is between 50.1-75%;
  C4 - euconstant species - when the frequency is between 75.1-100%.

- **Numerical abundance (An%)** = (n/N) x 100
  n = number of individuals of a given species from the analyzed sample;
  N = total number of individuals of all species present in the sample.

- **Dominance (D)**:
  D1 - below recendent species - when numerical abundance is below 1.1%;
  D2 - recendent species - when numerical abundance is between 1.1-2%;
  D3 - below dominant species - when numerical abundance is between 2.1-5%;
  D4 - dominant species - when numerical abundance is between 5.1-10%;
  D5 - eudominant species - when numerical abundance is over 10.1%.

- **Ecological significance (W%)** = (F x An)/100:
  W1 - accidental species - when the ecological significance is below 1.1%;
  W2 - accidental - accompanying species - when the ecological significance is between 1.1-2%;
  W3 - accompanying species - when the ecological significance is between 2.1-5%;
  W4 - accompanying - characteristic species - when the ecological significance is between 5.1-10%.
  W5 - characteristic species - when the ecological significance is over 10.1%.

The three classes are used for assessing the population status: favorable, medium favorable and unfavorable (Tab. 5).

Table 5: General evaluation matrix of population status (PS).

		Barbus petenyi			*Cottus gobio*		
No.	indices	favorable "F"	medium favorable "MF"	unfavorable "UF"	favorable "F"	medium favorable "MF"	unfavorable "UF"
1.	(F) frequency	50.1%-100%	25.1%-50%	1%-25%	25.1%-100%	1%-25%	0%
2.	(An) numerical abundance	> 10.1%	5.1%-10%	< 5%	> 5.1%	1%-5%	0%
3.	(W) ecological significance	> 5.1%	1.1%-5%	< 1.1%	> 2.1%	1.1%-2%	< 1.1%
4.	Overall evaluation of PS	All "F"	One/two "MF" but no "UF"	One or two "UF"	All "F"	One/two "MF" but no "UF"	One or two "UF"

The values of frequency (F%) and numerical abundance (An%) (Fig. 13) indicate for the *Barbus petenyi* a favorable status for Buzău River, medium favorable status for Siriu River and unfavorable status for Crasna River. For *Cottus gobio* analytical indices (Fig. 14) indicate a favorable status for Siriu and Crasna rivers and medium favorable status for Buzău River.

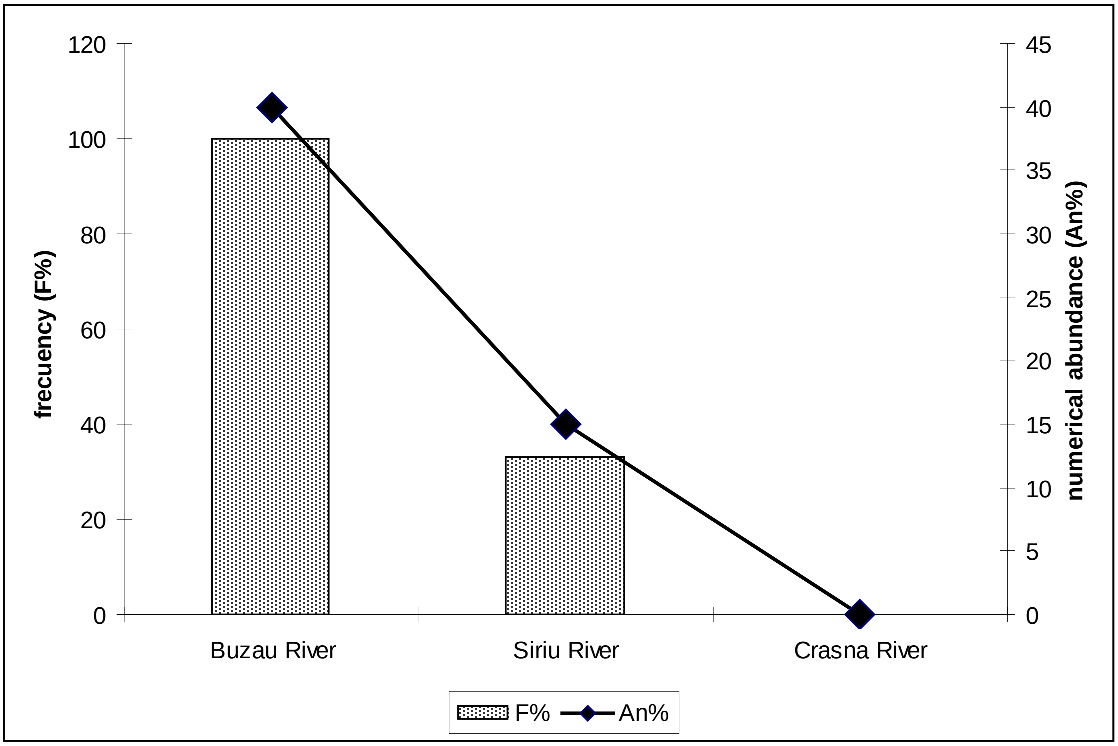

Figure 13: *Barbus petenyi* frequency (F%) and numerical abundance (An%).

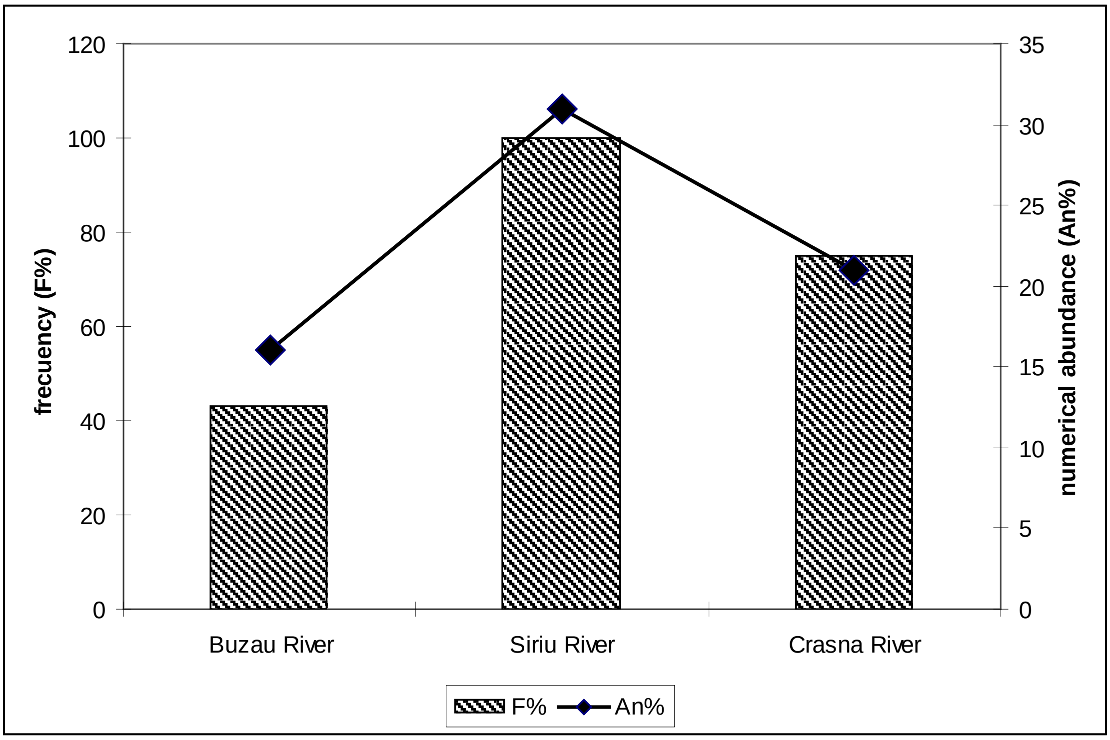

Figure 14: *Cottus gobio* frequency (F%) and numerical abundance (An%).

On the other hand, several studies (Charles et al., 2008; Kotlik et al., 2002) have been published estimating indices for minimum viable populations. So, the population viability of *Barbus petenyi* and *Cottus gobio* species in the investigated rivers are maintained if the criteria described below are met.

Criteria for *Barbus petenyi*'s population viability are:

- Criteria no. 1: the population density (D ind./km) does not decline below a few tens of individuals in each one km length of river;
- Criteria no. 2: the population numerical abundance (An%) is higher than 10.1% for a favorable status;
- Criteria no. 3: the population structure is characterized by at least three year-classes present in significant densities and at least 25% of the population should consist of 2+ fish.

Criteria for *Cottus gobio* population viability are:

- Criteria no. 1: the population density does not decline below one individual per 50 m^2 of the river sector;
- Criteria no. 2: the population numerical abundance (An%) is higher than 5.1% for a favorable status;
- Criteria no. 3: the population structure is characterized by at least three year-classes present in significant densities and at least 75% of the population should consist of 2+ fish.

Table 6: The fulfillment of criteria no. 1 and criteria no. 2 for *Barbus petenyi*’s population viability.

Stations code	Data	The length of fishing stations (m)	(ind./ station)	D (ind./km)	An (%)	Criteria no. 1 fulfill	Criteria no. 2 fulfil
B1	05.06	90	9	100	60.16	yes	yes
	10.09	90	4	44	30.43	yes	yes
B2a	05.06	120	21	175	88.10	yes	yes
B2b	05.06	120	5	42	27.08	yes	yes
B3	05.06	165	4	24	16.76	yes	yes
B4	05.06	127	2	16	5.98	yes	yes
	10.09	127	2	16	9.06	yes	yes
S1	05.0	120	0	0	0	no. specific area	no. specific area
S2	07.06	130	0	0	0	no specific area	no specific area
	11.09	130	2	15	33.33	yes	yes
C1	05.06	100	0	0	0	no. specific area	no specific area
C2	07.06	80	0	0	0	no specific area	no specific area
	11.09	80	0	0	0	no specific area	no. specific area
C3	05.06	88	0	0	0	no specific area	no specific area
Total		1,567	49				
			F = 100% for specific areas	D av. = 59.57 ind./km	An av. = 32.64 %	100% fulfill	100% fulfill

Table 7: The fulfillment of this criteria no. 1 and criteria no. 2 for *Cottus gobio*'s population viability.

Stations code	Data	The surface of fishing stations (m^2)	(ind./ station)	D (ind./ 50 m^2)	An (%)	Criteria no. 1 fulfill	Criteria no. 2 fulfill
B1	05.06	250	0	0	0	no	no
	10.09	250	5	1	13.04	yes	yes
B2a	05.06	150	5	1.66	4.86	yes	no
B2b	05.06	300	0	0	0	no	no
B3	05.06	600	7	1.16	20.35	yes	yes
B4	05.06	200	3	0.25	20.51	no	no
	10.09	200	0	0	0	no	no
S1	05.0	600	1	0.25	50.0	no	no
S2	07.06	750	1	0.08	100.0	no	no
	11.09	750	2	0.13	33.33	no	no
C1	05.06	100	0	0	0	no	no
C2	07.06	150	3	1.5	40.0	yes	yes
	11.09	150	9	3	29.4	yes	yes
C3	05.06	60	1	0.33	35.71	no	no
Total		4,510	37				
			F = 64.28 %	D av. = 0.66 ind./ 50 m^2	An av. = 24.8 %	35.71 % fulfill	28.57 % fulfill

CONCLUSIONS

In a first series of actions, EU member states designated SPAs and SCIs, based on the presence of habitats and species of community interest. They also embedded the BD and HD within their national legislations (Schoukens et al., 2007).

Currently, a second phase in the implementation process has already started. The EU member states assess the conservation status of all enlisted habitats and species to define corresponding conservation objectives and measures in each SCI so that they can be kept or brought into a favourable conservation status, and to set up monitoring schemes (Bottin et al., 2005; Förster et al., 2008). However, this process faces many important practical obstacles.

First, as data on the occurrence and abundance of habitats and species are generally scarce (Gaston et al., 2008), and financial resources to expand these data are limited, assessment of the actual conservation status is a challenging exercise that often leads to different approaches across member states (Opdam et al., 2009). Second, even if detailed data on the present status would be available, formulation of the conservation objectives is not a straightforward procedure. The surface area needed to attain (or maintain) a favourable conservation status for all targeted habitats and species, greatly exceeds the surface area designated by some member states as Natura 2000 sites. Hence, one must decide which habitats and species are of greatest interest in each of the individual

SCIs. In addition, the HD stipulates that conservation objectives only need to be formulated and implemented within the boundaries of every individual SCI. However, the HD requires a favourable conservation status for habitats and species at the national or regional level (EC, 2005, 2006). Therefore, in the absence of a clear framework of national or regional conservation objectives, it will be difficult to estimate whether the aggregation of conservation objectives at the SCI level will meet the conditions for favourable conservation status at the national or regional level (Mehtälä and Vuorisalo, 2007).

Monitoring of conservation status is an obligation arising from Article 11 of the Habitats Directive for all habitats (as listed in Annex I) and species (as listed in Annex II, IV and V) of community interest. The main results of this monitoring have to be reported to the Commission every six years according to Article 17 of the directive. The conservation status of habitats and species should be evaluated at national level and biogeographic level. In the reporting format four classes of Conservation Status are used: Favourable Conservation Status (green), Unfavourable-Inadequate Conservation Status (amber), Unfavourable-Bad Conservation Status (red), Unknown Conservation Status (white).

The evaluation of conservation status of two fish species from the hydrographic network of PAs ROSCI0229 Siriu analyzing the frequency (F%), numerical abundance (An%) and density (D individuals/km or individuals/m) criteria leads to the results show in tables 6 and 7 and synthesized below.

The *Barbus petenyi* species population fulfills the criteria no. 1 and no. 2 having a frequency of 100% for specific areas, an average population density of 59.57 individuals/km and an average numerical abundance of 32.64%. So, overall evaluation of population status is favorable, for areas where the species is characteristic, in this case Buzău River.

The *Cottus gobio* species population fulfills the criteria no. 1 for 35.71% and the criteria no. 2 for 28.57% having a frequency of 64.28% for all investigated areas, an average population density of 0.66 individuals/50 m^2 and an average numerical abundance of 24.8%. So, overall evaluation of population status is medium favorable, for areas where the species is characteristic, in this case Buzău River and its tributaries, river Crasna and river Siriu.

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REFERENCES

1. Bănărescu P., 1964 – Pisces: Osteichthys (Peşti Ganoizi şi Osoşi), Editura R.P.R. Academy, Bucharest, 13, 962. (in Romanian)
2. Bănărescu P., 1968 – Lista revizuită a peştilor din România, Buletinul Institutului de Cercetări și Proiectări Piscicole, XXVII, 3, 53-61. (in Romanian)
3. Bănărescu P. and Bănăduc D., 2007 – Habitats Directive (92/43/EEC) fish species (Osteichthyes) on the Romanian territory, *Acta Ichtiologica Romanica*, II, 43-78.
4. Cantarello E. and Newton A., 2008 – Towards cost-effective indicators to maintain Natura 2000 sites in favourable conservation status. Preliminary results from Cansiglio and New Forest, *Forest*, 1, 75-80.
5. Charles S., Subtil F., Kielbassa J. and Pont D., 2008 – An individual-based model to describe a bullhead population dynamics including temperature variations, *Ecological modelling*, 215, 377-392.
6. Chaumota A., Milionia N., Abdolib A., Pont D. and Charles S., 2006 – First step of a modelling approach to evaluate spatial heterogeneity in a fish (Cottus gobio) population dynamics, *Ecological modelling*, 197, 263-273.
7. Cowx I. G. and Welcomme R. L., 1998 – Rehabilitation of Rivers for Fish, Blackwell Science, Oxford, UK, 204.
8. Curtean-Bănăduc A. and Florescu F. (eds), 2007 – *Romanian NATURA 2000 NGO Coalition contribution for the SCIs designation*, Editura Alma Mater Sibiu, ISBN 978-973-632-402-4, 211.
9. Fischer S. and Kummer H., 2000 – Effects of residual flow and habitat fragmentation on distribution and movement of bullhead (Cottus gobio L.) in an alpine stream, *Hydrobiologia*, 422/423, 305-317.
10. Fish base, 2011.
11. Florea L., 2011 – The distribution of the conservative fish species in the Natura 2000 network from Romania, *Studii şi cercetări ştiinţifice, Seria: Biologie*, XXI, Editura Alma-Mater, Bacău, ISSN 1224-919X, 1-7.
12. Fontaine B., Bouchet P., Van Achterberg K., Alonso-Zarazaga M. A., Araujo R., Asche M., Aspöck U., Audiso P., Aukema B., Bailly N., Balsamo M., Bank R. A., Barnard P., Belfiore C., Bogdanowicz W., Bongers T., Boxshall G., Burckhardt D., Camicas J.-L., Chylarecki P., Crucitti P., Deharveng L., Dubois A., Enghoff H., Faubel A., Fochetti R., Gargominy O., Gibson D., Gibson R., López M. S. G., Goujet D., Harvey M. S., Heller K.-G., Van Helsdingen P., Hoch H., De Jong H., De Jong Y., Karsholt O., Los W., Lundqvist L., Magowski W., Manconi R., Martens J., Massard J. A., Massard-Geimer G., Mcinnes S. J., Mendes L. F., Mey E., Michelsen V., Minelli A., Nielsen C., Nafría J. M. N., Van Nieukerken E. J., Noyes J., Pape T., Pohl H., De Prins W., Ramos M., Ricci C., Roselaar C., Rota E., Schmidt-Rhaesa A., Segers H., Strassen R. Z., Szeptycki A., Thibaud J.-M., Thomas A., Timm T., Van Tol J., Vervoort W. and Willmann R., 2007 – The European Union's 2010 target: putting rare species in focus, *Biological Conservation*, 139, 167-185.
13. Gaston K. J., Jackson S. E., Nagy A., Cantu-Salazar L. and Johnson M., 2008 – Protected areas in Europe – principle and practice, *Annals of the New York Academy of Sciences*, 1134, 97-119.
14. Gosselin M., Petts G. E. and Maddock I. P., 2010 – Mesohabitat use by bullhead (Cottus gobio), *Hydrobiologia*, 652.1 , 299-310.
15. Hanfling B. and Brandl R., 1998 – Genetic variability, population size and isolation of distinct populations in the freshwater fish Cottus gobio L, *Molecular Ecology*, 7, 1625-1632.
16. Hanfling B. and Weetman D., 2006 – Concordant Genetic Estimators of Migration Reveal Anthropogenically Enhanced Source-Sink Population Structure in the River Sculpin, Cottus gobio, *Genetics*, 1487-1501.
17. Iftime A., 2004 – Preliminary data on the distribution of two twin species of the genus Barbus (Pisces: Teleostei: Cyprinidae) in southern Romania, *Travaux du Museum National d'Histoire Naturelle "Grigore Antipa"*, București, XLVlI, 263-268.

18. Iojă C. I., Pătroescu M., Rozylowicz L., PopescuV. D. and Vergheleţ M., 2010 – The efficacy of Romania's protected areas network in conserving biodiversity, *Biological Conservation*, 143, 2468-2476.
19. Knaepkens G., Bruyndoncx L., Bervoets L. and Eens M., 2002a – The presence of artificial stones predicts the occurrence of the European bullhead (Cottus gobio) in a regulated lowland river in Flanders (Belgium), *Ecology of Freshwater Fish*, 11, 203-206.
20. Knaepkens G., Knapen D., Bervoets L., Hanfling B., Verheyen E. and Eens M., 2002b – Genetic diversity and condition factor: a significant relationship in Flemish but not in German populations of the European bullhead (Cottus gobio L.), *Heredity*, 89, 280-287.
21. Knaepkens G., Bervoetsb L., Verheyenc E. and Eens M., 2004 – Relationship between population size and genetic diversity in endangered populations of the European bullhead (Cottus gobio): implications for conservation, *Biological Conservation*, 115, 403-410.
22. Kotlik P., Tsigenopoulos C., Rab P.and Berrebi P., 2002 – Two new Barbus species from the Danube River basin, with redescription of B. petenyi (Teleostei: Cyprinidae), *Folia zoologica*, 51, 3, 227-240.
23. Legalle M., Santoul F., Figuerola J., Mastrorillo S. and Cereghino R., 2005 – Factors influencing the spatial distribution patterns of the bullhead (Cottus gobio L., Teleostei Cottidae): a multi-scale study, *Biodiversity and Conservation*, 14, 1319-1334.
24. Maiorano L., Falcucci A. and Boitani L., 2008 – Size-dependent resistance of protected areas to land-use change, Proceedings of the Royal Society B, 275, 1297-1304.
25. Margules C. R. and Pressey R. L., 2000 – Systematic conservation planning, *Nature*, 405, 243-253.
26. Mehtälä J. and Vuorisalo T., 2007 – Conservation policy and the EU Habitats Directive: Favourable conservation status as a measure of conservation success, *European Environment*, 17, 363-375.
27. Nalbant T., 2003 – Checklist of the Fishes of Romania, Part One: Fresh and Saltwater Fishes, *Research Studies and Biology*, 8, 122-127.
28. Nielsen S. E., Bayne E. M., Schieck J., Herbers J. and Boutin S., 2007 – A new method to estimate species and biodiversity intactness using empirically derived reference conditions, *Biological Conservation*, 137, 403-414.
29. Pont D., Hugueny B. and Oberdorff T., 2005 – Modelling habitat requirement of European fishes: do species have similar responses to local and regional environmental constraints, *Canadian Journal of Fisheries and Aquatic Sciences*, 62, 1, 163-173.
30. Pullin A. S., Baldi A., Can O. E., Dieterich M., Kati V., Livoreil B., Lovei G., Mihok B., Nevin O., Selva N. and Sousa-Pinto I., 2009 – Conservation focus on Europe: major conservation policy issues that need to be informed by conservation science, *Conservation Biology*, 23, 818-824.
31. Sax D. F. and Gaines S. D., 2008 – Species invasions and extinction: The future of native biodiversity on islands, *Proceedings of the National Academy of Sciences of the USA*, 105, 11490-11497.
32. Seeuws P., Meire P. and Verheyen R. F., 2005 – Microhabitat use and preferences of the endangered Cottus gobio in the River Voer, Belgium, *Journal of Fish Biology*, 67, 4 , 897-909.
33. Thuiller W., Lavorel S., Araújo M. B., Sykes M. T. and Prentice I. L., 2005 – Climate change threats to plant diversity in Europe, *Proceedings of the National Academy of Sciences of the USA*, 102, 8245-8250.
34. Utzinger J., Roth C. and Peter A., 1998 – Effects of environmental parameters on the distribution of bullhead (Cottus gobio) with particular consideration of the effects of obstructions, *Journal of Applied Ecology*, 35, 882-892.
35. Vlach P., Dusek J. and Moravec P., 2005 – Fish assemblage structure, habitat and microhabitat preference of five fish species in a small stream, *Folia Zoologica*, 54, 4, 421-431.

36. Anonymous, 2009 – Natura 2000 Barometer - Update November 2009, *Natura 2000 European Commission Nature and Biodiversity Newsletter*, 27, 8-9.
37. EEA (European Environment Agency), 2006 – Progress towards halting the loss of biodiversity by 2010, *EEA report*, 5/2006, Luxembourg.
38. MEF/NAE (Ministry of Environment and Forest/National Agency of Environment), 2009 – Nature conservation and biodiversity, biosafety, National environmental raport, 160-218.
39. MESD (Minister of Environment and Sustainable Development), 2007 – OM 1964 - The constitute of the natural protected area of Community importance as part integral to the European ecological network Natura 2000 Romanian, 1-1315.
40. NARW (National Administration “Romanian Waters”, 2009 – Management Plan River of space - Ialomița Buzău,10-25.
41. http://www.rowater.ro/dabuzau/Planul% Planul de Management al Spațiului Hidrografic Buzău, pdf (accessed at 16.07.2013).

THE EFFECT OF SEASONAL CHANGES ON FRESHWATER FISH ASSEMBLAGES AND ENVIRONMENTAL FACTORS IN BUKIT MERAH RESERVOIR (MALAYSIA)

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KEYWORDS: Malaysia, Bukit Merah Reservoir, seasonal changes, freshwater fish, environmental factors.

ABSTRACT

Seasonal changes of freshwater fish assemblages and environmental factors in Bukit Merah Reservoir were carried out from January-February 2013 (dry season) to March-April 2013 (wet season) by measuring several physico-chemical parameters such as dissolved oxygen (DO), water temperature, pH, water conductivity, total dissolved solids (TDS) and water clarity. 19 fish species comprising of 10 families were collected by using experimental gill nets with different mesh sizes at four different sampling stations. Mean CPUE for total catch and biomass were significantly different between dry and wet season ($p < 0.05$). Based on a T-test analysis, water temperature, pH and conductivity were significantly different ($p < 0.05$) between seasons whereas a one-way ANOVA displayed a significant difference in TDS and water clarity between sampling stations ($p < 0.05$), implicating that those factors did not give major influence towards other parameters in a man-made reservoir. From all fish species studied, only mean CPUE for individuals (CPUEn) of *Osteochilus vittatus* and *Oxygaster anomalura* had a significant difference between seasons ($p < 0.05$); probably an indicator of their migration season.

ZUSAMMENFASSUNG: Auswirkungen saisonaler Schwankungen in Gemeinschaften von Süßwasserfischen und Umweltfaktoren im Bukit Merah Speicher (Malaysia).

Saison gebundene Schwankungen in Gemeinschaften von Süßwasserfischen und Umweltfaktoren wurden im Bukit Merah Speicher von Januar-Februar 2013 (Trockenzeit) bis März-April 2013 (Regenzeit) untersucht. Dabei wurden einige physikalisch-chemische Parameter wie gelöster Sauerstott (DO), Wassertemperatur, pH, Leitfähigkeit, gelöste Feststoffe insgesamt (TDS) und Wassertransparenz gemessen. 19 Fischarten aus 10 Familien wurden mit Kiemennetzen unterschiedlicher Maschenweite an vier Probestellen gesammelt. Der mittlere CPUE-Wert für den Gesamtfang und die Biomasse war signifikant unterschiedlich in der Trocken- und Regenzeit ($p < 0,05$). Auf Grund einer T-Test Analyse zeigten sich bei Wassertemperatur, pH und Leitfähigkeit signifikante Unterschiede ($p < 0,05$)

zwischen Trocken- und Regenzeit, während TDS und Wassertransparenz nur signifikante Unterschiede zwischen den Probestellen ($p < 0,05$) von einem Einweg ANOVA zeigten, woraus sich ergibt, dass diese Faktoren keinen großen Einfluss gegenüber anderen Parametern in einem künstlichen Wasserspeicher haben. Von allen untersuchen Fischarten war allein der mittlere CPUE-Wert für Individuen (CPUEn) bei *Osteochilus vittatus* und *Oxygaster anomalura* signifikant unterschiedlich zwischen den beiden Jahreszeiten ($p < 0,05$), was wohl ein Indikator für deren Migrationszeit ist.

REZUMAT: Efectul schimbărilor sezoniere asupra ihtiocomunităților dulcicole și a factorilor de mediu în lacul de acumulare Bukit Merah (Malaezia).

Prezentul articol se bazează pe cercetări efectuate din lunile ianuarie-februarie 2013 (sezonul secetos) în martie-aprilie 2013 (sezonul umed) prin măsurarea parametrilor fizico-chimici, precum oxigenul dizolvat (DO), temperatura, transparența și conductivitatea apei, pH, materia solidă dizolvată totală (TDS). 19 specii de pești din 10 familii au fost colectate cu ajutorul unor plase experimentale cu diferite mărimi ale ochiurilor în patru stații de eșantionare diferite. CPUE mediu pentru captura totală și biomasa au diferit semnificativ între sezonul secetos și cel umed ($p < 0,05$). Conform analizei T-test, temperatura, conductivitatea și pH-ul au variat semnificativ ($p < 0,05$) de la un sezon la altul în timp ce TDS și transparența au variat semnificativ de la o stație la alta ($p < 0,05$) după ANOVA, ceea ce înseamnă că acești factori nu au avut influență majoră față de alți parametri în acest lac artificial. Dintre toate speciile studiate, doar CPUE mediu individual (CPUEn) la *Osteochilus vittatus* și *Oxygaster anomalura* au variat semnificativ între sezoane ($p < 0,05$), probabil indicând sezonul de migrație.

INTRODUCTION

One of the biggest challenges of conserving or restoring the source of water is to adequately understand the relationship between physico-chemical environment, including seasonal and annual variations, and interactions among species in the reservoir. Generally, the wetland areas in Malaysia are struggling from resource degradation and have negative impacts on the local communities (Ambak and Jalal, 2006; Alang et al., 2010; Aziz and Hashim, 2011).

The conversion of the catchment area for agricultural and urbanization use affects the quality and quantity of water. Water degradation in most lakes is often associated with higher presence of nutrients (phosphorous, nitrogen and ammonia) in the water. Deterioration in water quality directly or indirectly affects fish physiology and growth.

Many countries are facing water shortage due to increasing demand of freshwater as a result of population pressure and water pollution. In a developing country that has limited food production, reservoirs act as a supplemental water source for agriculture (Easton and Petrovic, 2004; Akinbile et al., 2013). Apart from agricultural purposes, they also serve as habitats for wildlife, including endemic and endangered species (Akinbile et al., 2013). Since the demand of water in Malaysia is increasing, about 73 lakes have been created to supply the nation's demand (Sharip and Zakaria, 2008; Akinbile et al., 2013).

However, there are significant anthropogenic interventions occurring such as eutrophication, sedimentation, weed infestation and deterioration in water quality. Seasonal variation and human activities are major factors influencing fish assemblages and abiotic factors in the shallow reservoir. Thus, the objective of the present study is to determine the effect of seasonal changes on fish assemblages and environmental factors in Bukit Merah Reservoir.

MATERIALS AND METHODS

Bukit Merah Reservoir (BMR - 5°01'N 100°39'E), which covers an area of 40 km^2, is a man-made lake and one of the oldest reservoirs located in the district of Kerian, Perak (Ismail and Najib, 2011). BMR is divided into two parts; the north lake and the south lake, by a 4.7 km railway line (Ismail and Najib, 2011). The water sources spring from two main catchment areas, namely Merah and Kurau basins. However, there are several tributaries, including the Ara, Jelutong and Selarong rivers, that link up with the basin. Water from the reservoir is channelled out by gravity flow through six gates into two outlet canals, the Selinsing Canal and Main Canal, for paddy irrigation (Ismail and Najib, 2011; DID, 2012). The main purposes of Bukit Merah Reservoir are to provide irrigation water for double cropping to 24,000 ha of paddy land under the Krian Irrigation Scheme and for domestic water supply. Bukit Merah Reservoir is also well-known as a sanctuary for a species of highly commercially valuable fish, Malayan Golden Arowana (*Scleropages formosus* Müller and Schlegel, 1844) and as a northern lakefront resort and water park (Bukit Merah Laketown Resort) that supports ecotourism.

The reservoir has a storage of 74.98 million cubic meters, maximum spillway discharge of 424.7 m^2 and its length and width are 13.8 km and 4.5 km, respectively (DID, 2012). The reservoir comprises of spillway and intake structures. The spillway structure is used to safely convey discharge or release floods so that the water does not exceed the reservoir limit, while the intake is a structure used to release water for paddy irrigation and domestic water supply. In most parts, the reservoir is quite shallow (about three meters), though at the spillway and intake structures the depth is nearer to five meters. The water level of the reservoir is controlled by two main factors: climatic conditions and the outflow of water to irrigate paddy fields (DID, 2012). The catchment areas of BMR include the virgin and primary forest, agriculture (palm oil plantation) and a breeding farming industry (national boer breeding centre) for economical purposes.

The study area consisted of four sampling sites to represent different ecological conditions within the same system. Site 1 (05°01'56.4"N, 100°40'04.3"E) was located at the outlet of the Kurau River basin, Site 2 (04°59'48.0"N, 100°41'14.5"E) was located in the outlet of the river area that far from the, while Site 3 (05°01'04.2"N, 100°39'20.3"E) and Site 4 (05°01'52.1"N, 100°39'12.3"E) were located at the irrigation canal and gated spillway structures, respectively (Fig. 1).

Sampling was carried out monthly at the four sites from January to April 2013. The sampling months were grouped into two seasons (wet and dry) based on the mean rainfall data of last 10 years (source from the Malaysian Meteorological Department). The season was characterized by monthly rainfall ranging from 150 to 300 mm during wet season and 0 to 150 mm during dry season. Fish sampling was conducted monthly by using experimental mesh gill-nets ranging from 2.5 to 13 cm in size. All of the fish caught were preserved in an ice chest during transportation to the laboratory. In the laboratory, the fish were counted, their body length and weight measured and identified to the lowest taxa possible using standard taxonomic keys (Kottelat et al., 1993; Rainboth, 1996; Ambak et al., 2010) before being preserved in 10% formalin. Voucher specimens were then catalogued and kept at the School of Biological Sciences, University Sains Malaysia. The physico-chemical parameters of the water were measured using YSI 56, and secchi disc. The variables measured were dissolved oxygen (DO, mg/l), temperature (°C), pH, water conductivity (µS/cm), total dissolved solids (TDS, mg/l) and water clarity (cm).

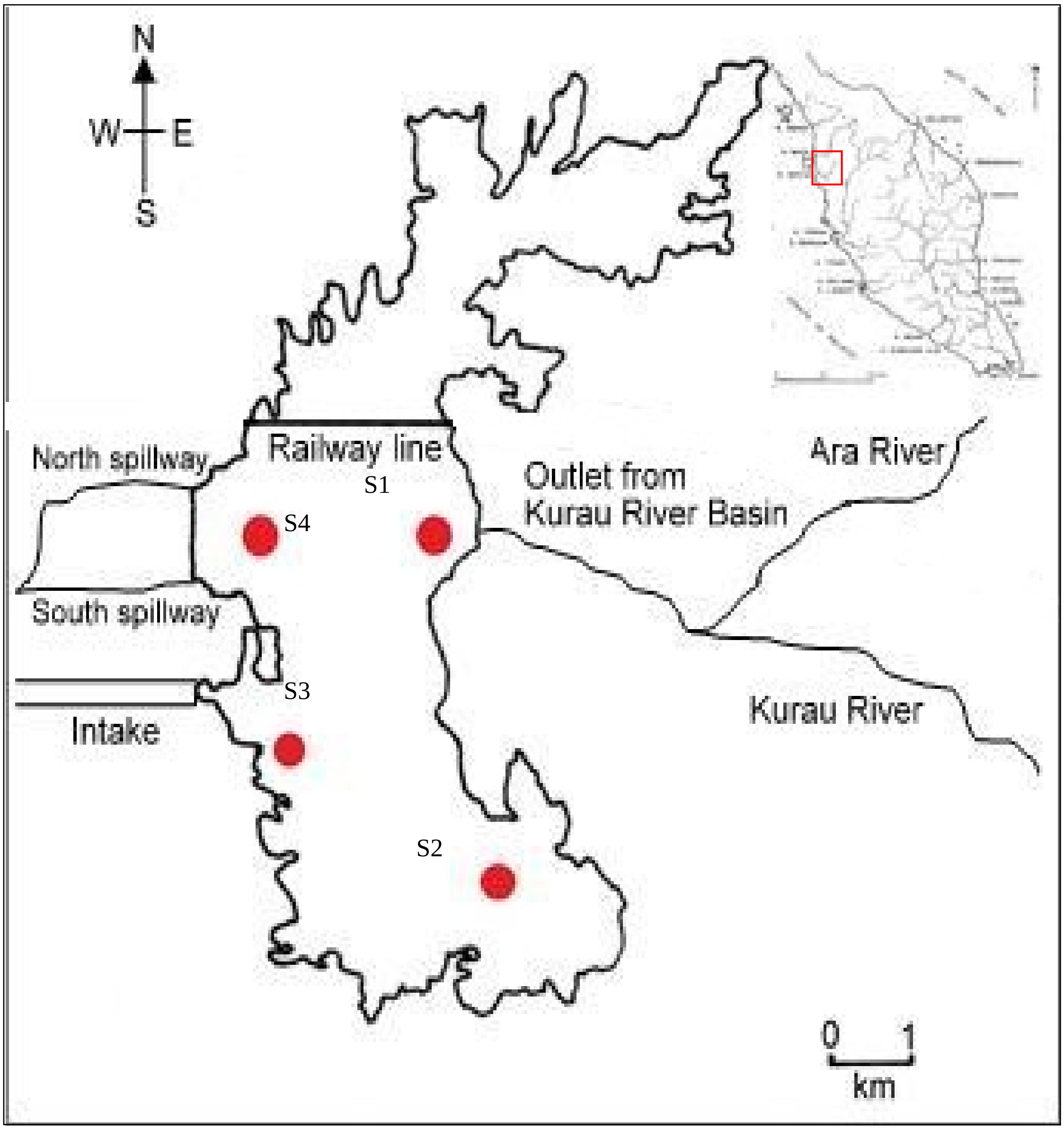

Figure 1: Bukit Merah Reservoir (BMR) system with four sampling sites (S1, S2, S3 and S4).

Catch per Unit Effort (CPUE) was used to estimate fish abundance and biomass from different seasons and sampling sites, which is defined as the sum of the total number (CPUEn) and weight (CPUEb) of captured fish per 24 hours (sampling effort). The values of both CPUE were then transformed into $\log_{10}$ (CPUE + 1) to stabilize the variance for statistical comparison analysis. Species diversity for each sampling site was measured using the Shannon Index while species richness was compared among sampling sites by using rarefaction of individual samples from the program EcoSim 7.0 (Gotelli and Entsminger, 2001). Comparisons among season and sites were made by using a T-test analysis and one-way analysis of variance (ANOVA), respectively.

RESULTS

A total of 19 species belonging to 10 families were recorded during the study (Tab. 1). Eight species that had more than 1% of the numerical abundance contributed 97.08% of the total catch in number of individuals and 89.03% of the total biomass. *Oxygaster anomalura* had the highest abundance of 27.63%, followed by *Notopterus notopterus* (17.34%), *Barbonymus gonoinotus* (16.94%) and *Cyclocheilichthys apogon* (11.75%). While other species were frequent, their numbers collected were very much less. However, the greatest biomass was recorded by *N. notopterus,* which contributed to 30.67% of the total weight.

Table 1: Fish checklist by sampling sites with their percentage of numerical abundance and biomass in Bukit Merah Reservoir, Malaysia; notes: + = present; - = absent.

Family	Species	S1	S2	S3	S4	Numerical abundances (%)	Biomas (%)
Bagridae	*Hemibagrus nemurus*	-	-	+	+	0.24	0.52
Clariidae	*Clarias gariepinus*	+	+	-	-	0.24	1.58
Channidae	*Channa micropeltes*	-	-	+	-	0.08	0.55
Cichlidae	*Oreochromis niloticus*	+	-	-	+	0.49	3.72
Cyprinidae	*Cyclocheilichthys apogon*	+	+	+	+	11.75	4.03
	Barbonymus gonionotus	+	+	+	+	16.94	19.53
	Barbonymus schwanenfeldi	+	+	+	+	9.97	11.30
	Hampala macrolepidota	+	+	+	+	2.43	3.79
	Labiobarbus leptocheilus	-	+	+	-	0.57	1.31
	Osteochilus vittatus	+	+	+	+	7.21	5.18
	Oxygaster anomalura	+	+	+	+	27.63	17.34
	Systomus orphoides	-	-	+	-	0.16	0.23
	Thynnichthys thynnoides	+	-	-	-	0.73	2.72
Eleotridae	*Oxyeleotris marmoratus*	-	-	-	+	0.08	0.09
Helostomatidae	*Helostoma temminckii*	+	+	+	-	3.81	7.19
Notopteridae	*Notopterus notopterus*	+	+	+	+	17.34	20.67
Osphronemidae	*Osphronemus goramy*	+	+	-	-	0.16	0.14
	Trichopodus pectoralis	+	-	-	-	0.08	0.08
Siluridae	*Ompok siluroides*	+	-	-	-	0.08	0.02

Among all sampling sites, S1 had the highest diversity index value of 2.06, and S4 scored the least (1.46), while S2 and S3 had 1.82 and 1.79, respectively. Based on the rarefaction curves, the species richness expected for a standard sample of 191 individuals was 12 for S1, 10 species for S2, 11 species for S3 and 10 species for S4 (Fig. 2). However, species diversity and richness were not significantly different among sites and season ($p > 0.05$).

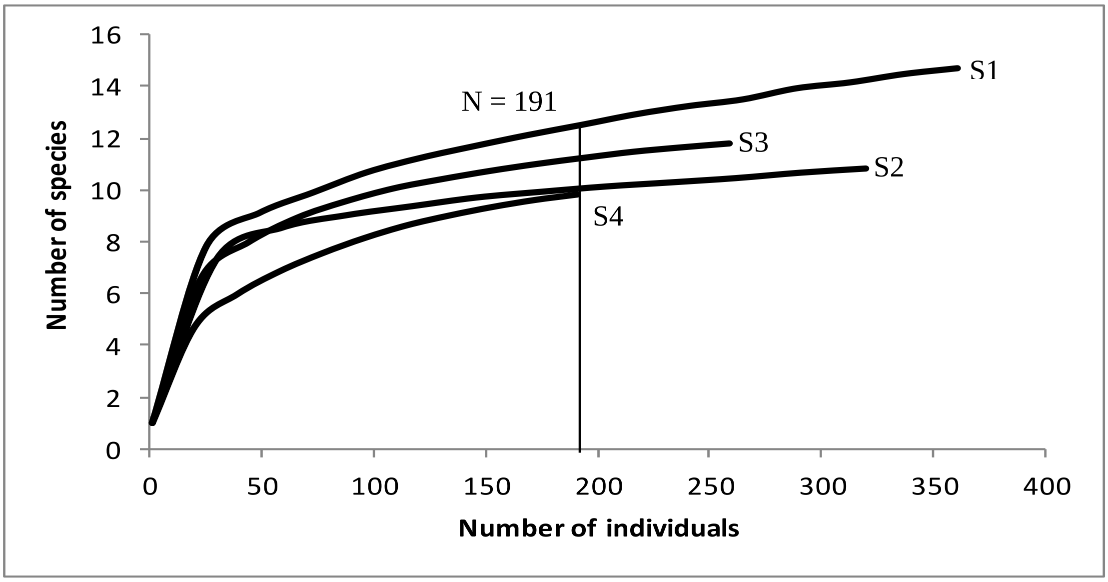

Figure 2: Individual-based rarefaction curves by sites (S1 to S4) for species richness in Bukit Merah Reservoir. Standard sample of individuals was labelled as N = 191.

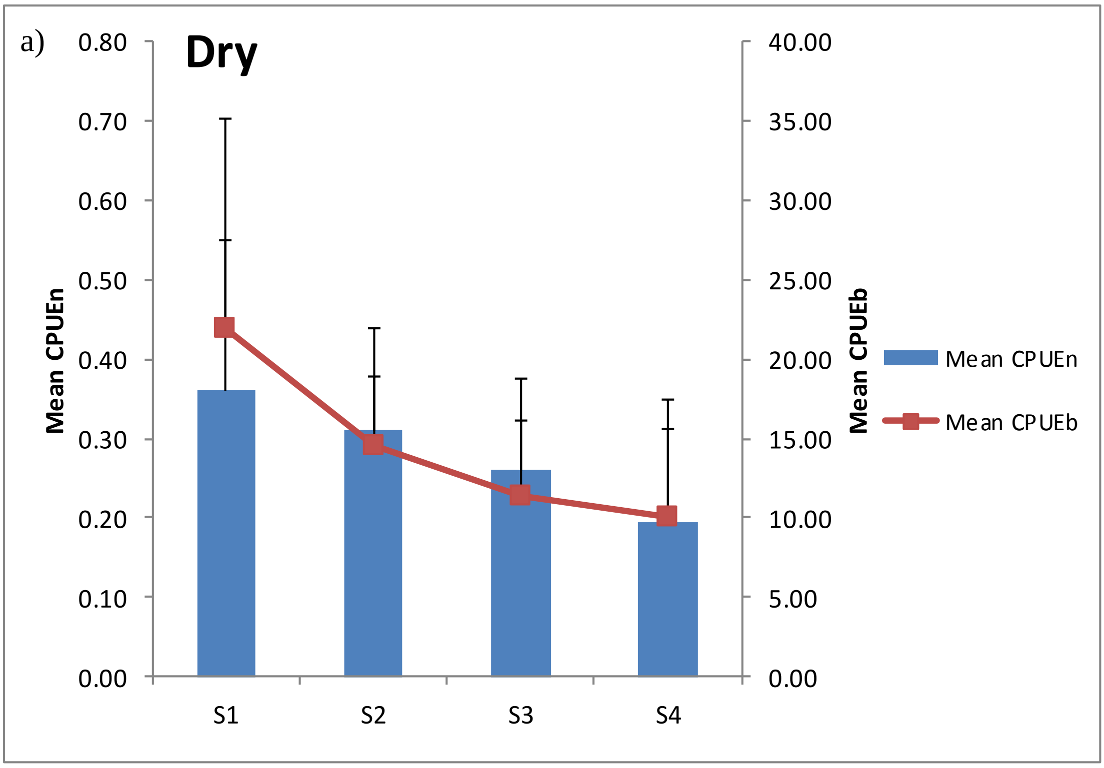

Figure 3a: Mean abundance (CPUEn ± s.e.) and biomass (CPUEb ± s.e.) of spatial and seasonal variations in Bukit Merah Reservoir, Perak, Malaysia.

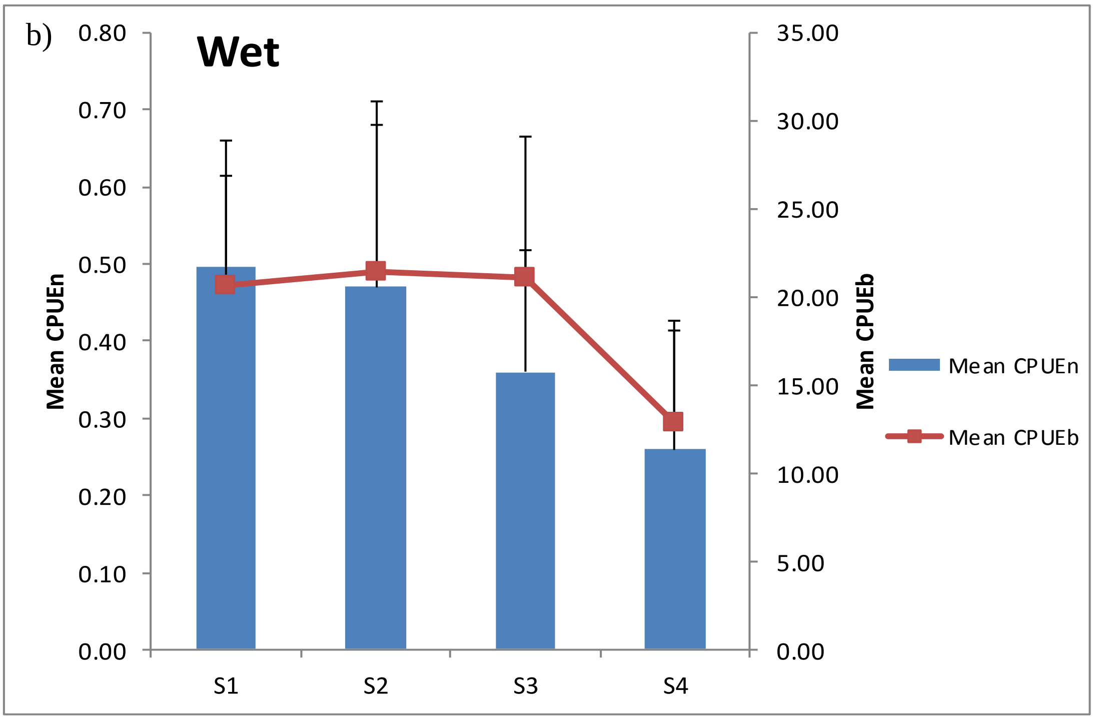

Figure 3b: Mean abundance (CPUEn ± s.e.) and biomass (CPUEb ± s.e.) of spatial and seasonal variations in Bukit Merah Reservoir, Perak, Malaysia.

Changes in mean CPUEn and CPUEb were observed between seasons and sampling sites (Figs. 3a, b). Both seasons showed similar patterns in mean CPUE values, decreasing of mean CPUEn values from S1 to S4. Site 1 recorded the highest mean CPUEn values of 0.36 ± 0.19 during the dry season and 0.50 ± 0.16 during the wet season, while the lowest mean CPUEn were recorded in S4 with the values of 0.2 ± 0.12 and 0.26 ± 1.56 during the dry and wet season, respectively. The CPUEn values for S2 were 0.31 ± 0.13 (dry) and 0.47 ± 0.21 (wet) while the values for S3 were 0.26 ± 0.12 (dry) and 0.36 ± 0.16 (wet). A similar pattern was found for the mean CPUEb during the dry season, with the highest mean being recorded in S1 (21.96 ± 13.14), followed by S2 (14.57 ± 4.36), S3 (11.44 ± 4.75) and S4 (10.01 ± 7.43). However, during the wet season, the mean CPUEb for S1 (20.65 ± 6.25), S2 (21.40 ± 9.7) and S3 (21.07 ± 8.05) were less varied, except for S4 (12.90 ± 5.8). Based on a mean comparison of T-test analysis, there was a significant difference of mean CPUEn (t = 3.77, df = 11, p < 0.05) and CPUEb (t = 2.50, df = 11, p < 0.05) during both seasons. However, there was no significant difference found among sites, although the variation for both mean CPUEn and CPUEb were observed among sites.

Concentration of DO content in the reservoir was less varied, from 5.06 ± 0.52 mg/l (wet season, Site 4) to 6.28 ± 0.55 mg/l (dry season, Site 3) with no significant difference among the seasons and the sampling sites. Water temperature showed an increasing trend from dry to wet seasons, which was statistically significant between both seasons (t = 4.93, df = 14, p = 0.00), ranging from 24.51 ± 1.28°C (dry season, Site 1) to 29.48 ± 0.59°C (wet season, Site 2). However, there were no differences found in water temperature among the sampling sites. The pH values were significantly higher during the wet season compared to the dry season, ranging between 5.73 to 7.19 (t = 2.39, df = 14, p = 0.031). Water conductivity showed a different seasonal pattern, with increasing values from the dry to the wet season (t = 3.22, df = 14, p = 0.013), ranging from 14.67 ± 0.33 µS/cm (dry season, Site 3) to 19.67 ± 2.19 µS/cm (wet season, Site 1). The mean TDS values fell into small range, from 13 ± 0.58 mg/l (dry season, Site 3) to 14.67 ± 0.33 mg/l (wet season, Site 1). The TDS values were significant among sampling sites (F (3.12) = 4.316, p = 0.028). A Tukey post-host test found that only S1 and S3 were significantly different (p < 0.05). Water clarity showed large variations, ranging from 33 ± 0.14 cm (wet season, Site 1) to 93.5 ± 4.37 cm (wet season, Site 2). The large variation of this parameter, leading to a significant different among the sampling sites (F (3.12) = 4.381, p = 0.027), indicates that the clarity of water was significantly different between the outlet of Kurau River basin and the area with high aquatic plants (p < 0.05) (Tab. 2).

Table 2: Physico-chemical parameters (mean ± s.e.) from four sampling sites of Bukit Merah Reservoir during dry and wet season.

Season	Site	DO (mg/l)	Temp. (°C)	pH	Conduct. (µS/cm)	TDS (mg/l)	Water clarity(cm)
Dry	1	5.91 ± 1.21	24.51 ± 1.28	5.98 ± 0.27	16.33 ± 0.33	14.33 ± 0.33	57.67 ± 8.29
	2	5.20 ± 0.76	24.60 ± 0.33	6.79 ± 0.18	16 ± 0.01	14 ± 0.01	92.33 ± 8.54
	3	6.28 ± 0.55	25.21 ± 1.14	5.76 ± 0.31	14.67 ± 0.33	13 ± 0.58	92.67 ± 7.65
	4	6.21 ± 0.91	25.13 ± 0.44	5.73 ± 0.26	17 ± 0.01	14 ± 0.01	77.5 ± 6.06
Wet	1	5.62 ± 0.53	28.34 ± 0.96	6.58 ± 0.42	19.67 ± 2.19	14.67 ± 0.33	33 ± 0.14
	2	5.32 ± 0.36	29.48 ± 0.59	7.19 ± 0.42	19 ± 2.31	13.33 ± 0.33	93.5 ± 4.37
	3	5.97 ± 0.40	29.18 ± 0.49	6.84 ± 0.44	18.67 ± 2.19	14 ± 0.01	81.88 ± 12.70
	4	5.06 ± 0.52	28.88 ± 0.61	6.51 ± 0.43	19 ± 2.52	14.33 ± 0.33	66.25 ± 12.99

DISCUSSION

Based on the numerical abundance, eight species were commonly found in the reservoir, in which six of them (*Oxgaster anomalura*, *Cyclocheilichthys apogon*, *Barbonymus gonionotus*, *Barbonymus schwanenfeldii*, *Hampala macrolepidota* and *Osteochilus vittatus*) were from family Cyprinidae. In Southeast Asia, the Cyprinidae family was the most dominant in both lotic and lentic water bodies, because it consists of many species (Zakaria, 1994). Chong et al., (2010), with about 150 species in Malaysia alone. The dominance of cyprinids in local reservoirs were recorded in Subang Reservoir, Selangor (42%) (Yap, 1992), Temengor Reservoir, Perak (57%) (Zakaria and Lim, 1995), and Kenyir Reservoir, Terengganu (57%) (Yusoff et al., 1995; Kamaruddin et al., 2011). The dominance of *O. anomalura*, *C. apogon*, *B. gonionotus, B. schwanenfeldii, H. macrolepidota* and *O. vittatus, N. notopterus* and *Helostoma temminckii* indicated that they thrive well in lentic water body as they contributed 97.08% of the total catch. These species were also dominant in Chenderoh Reservoir, Malaysia (Kah-Wai and Ali, 2001).

Although there was no significant difference in fish diversity among sites, fish assemblage in the reservoir was different spatially, with greater species richness and diversity observed in the area where the influence of the river is the greatest. The ecotone of river and reservoir, or transitional zone, contributes to the increase of fish diversity due to high abundance of submerged and floating macrophytes that increase spatial heterogeneity and feeding resource availability (Lowe-McConnell, 1991; Aliko et al., 2010; Terra et al., 2010).

The fish community in BMR has distinct seasonal variations. The number of individuals and their biomass caught (CPUEn and CPUEb) during wet season were higher than in dry season. In tropical countries, wet season indicates the main feeding and growing time for the fish (Rainboth, 1996; Meye and Ikomi, 2012). The similar trend was also reported in Kenyir Lake, in which the CPUE was higher during the rainy season compared to the dry season (Kamaruddin et al., 2011). The CPUE data was influenced by the catchability of the gear, location of the sampling and the abundance of the fish in that area (Abiodun and Miller, 2007). The littoral zone had the highest fish catch value, because most of the fish stay close to the shore and were commonly found feeding on the surface of the littoral zone in the reservoir (Fernando and Holčík, 1991; Ali, 1996; Ambak and Jalal, 2006). The inundation of littoral areas that rich the aquatic and terrestrial vegetation during the wet season increase the availability of food resources and thus enables a large number of fish species to occupy those areas. Generally, fish that inhabit reservoirs were formerly riverine species that depended on terrestrial and aquatic vegetation such as ripe fruits, seeds, terrestrial and aquatic insects for food (Ambak and Jalal, 2006). Bishop and Forbes (1991) also found a significant positive correlation between aquatic vegetation and fish diversity. However, the decreasing of CPUEn and CPUEb during the dry season was influenced by the increasing number of fishing occurrences by full and part-time local fishermen hence reducing the fish collection during the sampling. A greater and easier accessibility into the water body due to reduced water volume contributed to the increase of fishermen (Allison et al., 1997). Arcifa and Meschiatti (1993) concluded that the fish population was concentrated in the shallow areas during the wet season and moved to the open area during the dry season.

From the results of physico-chemical parameters, all the parameter values were quite similar with other major reservoirs in Malaysia (Ambak and Jalal, 2006). However, because of the shallowness of the reservoir, the values of those parameters were less varied among sites, although they showed a significant difference spatio-temporally. One possible explanation could be that all sampling sites are located in the same geographical zone and sampling was done in the same environmental conditions. The range of water level did not vary much due to the release of water through spillway to maintain the reservoir level and for paddy irrigation from the Selinsing Canal intake. Dissolved oxygen (DO) showed no significant difference among sites, and seasons indicate that BMR has a uniform reading of oxygen concentration in the water. The concentration of DO in the water lies within the optimum range of fish health (Jain et al., 1977; Alabaster and Lloyd, 1982). Temperature was higher during the wet season than in dry season. The water temperature increasing during the wet season was also recorded in Three Gorges Reservoir, China (Chen et al., 2013) and in Itupararanga Reservoir, Brazil (Pedrazzi et al., 2013). Weather conditions during the sampling influenced the reading of the water temperature (Pedrazzi et al., 2013). The water temperature in BMR provides optimum growth for the fish which ranged between 25-30°C (Afzal Khan et al., 2004).

Pedrazzi et al. (2013) also recorded higher pH values during the wet season, similar with the present study. Photosynthetic activity may increase the pH values in the reservoir (Pedrazzi et al., 2013). Climatic condition, such as rainfall that occurred during the sampling, influenced the values of some parameters. For example, surface runoff that contained large nutrients during the wet season was probably one of the factors that increased the water conductivity in the reservoir (Terra et al., 2010). However, the values were still within the normal range for fresh water (10-1,000 µS/cm) (Offem et al., 2011).

CONCLUSIONS

Increased abundance and biomass during the wet season suggests that new microhabitats become available for fish in the floodplain areas, and fish in both lotic and lentic habitats used littoral habitats within river-reservoir interfaces and migrated through the ecotone during the wet season.

The reservoir showed less variation for its physico-chemical parameters, although there were significant differences during both seasons and sampling sites.

Generally, the reservoir is relatively small, with its depth ranging from three to five meters.

The water fluctuation did not vary much due to the withdrawal of water to maintain its reservoir limit, for paddy irrigation and domestic water supply, resulting in less variation in the mean values of most parameters.

From the result, most of the parameters fell within the suitable range for the aquatic life.

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REFERENCES

1. Abiodun J. A. and Miller J. W., 2007 – Assessment of Gerio Lake fishery for enhancement management and improved fish production, *Journal of Applied Science and Environmental Management*, 11, 4, 11-14.
2. Afzal Khan M., Jafri A. K. and Chadha N. K., 2004 – Growth and body composition of rohu, *Labeo rohita* (Hamilton), fed compound diet: winter feeding and rearing to marketable size, *Journal of Applied Ichthyology*, 20, 265-270.
3. Akinbile C. O., Yusoff M. S., Abu Talib S. H., Abu Hasan Z., Ismail W. R. and Sansudin U., 2013 – Qualitative analysis and classification of surface water in Bukit Merah Reservoir in Malaysia, *Water Science and Technology Water Supply* 13, 4, 1138-1145.
4. Alabaster J. S. and Lloyd R., 1982 – Water quality criteria for freshwater fish, 2nd edition, Food and Agriculture Organization of the United Nations, Butterworth Scientific, London, 361.
5. Alang R. N. N. R., Jusoh W. F. A. W., Nur-Zati A. M. and Hashim N. R., 2010 – Ant diversity on *Sonneratia caseolaris* trees in Rembau-Linggi mangrove forest, Peninsular Malaysia, *Transylvanian Review of Systematical and Ecological Research*, The Wetlands Diversity, Curtean-Bănăduc et al. (eds), 10, 77-82.
6. Ali A. B., 1996 – Chenderoh Reservoir, Malaysia: The conservation and wise use of fish biodiversity in a small flow-through tropical reservoir, *Lakes and Reservoirs: Research and management*, 2, 17-30.
7. Aliko N. G., Da Costa K. S., Konan K. F., Outtara A. and Gourene G., 2010 – Fish diversity along the longitudinal gradient in a man-made lake of West Africa, Taabo Hydroelectric Reservoir, Ivory Coast, *Ribarstvo*, 68, 2, 47-60.
8. Allison M. E., Gabriel U., Inko-Tariah M. B., Davies O. A. and Udeme-Naa B., 1997 – The fish assemblage of Elechi Creek, Rivers State, Nigeria, *Niger Delta Biologia*, 2, 90-96.
9. Ambak M. A. and Jalal K. C. A., 2006 – Sustainability issues of reservoir fisheries in Malaysia, *Aquatic Ecosystem Health and Management*, 9, 2, 165-173.
10. Ambak M. A., Isa M. M., Zakaria M. Z. and Ghaffar M. A., 2010 – *Fishes of Malaysia*, Penerbit University Malaysia Terengganu, 334.
11. Aziz T. N. A. and Hashim N. R., 2011 – Heavy metal concentrations in an important mangrove palm (*Nypa fruticans*), in Rembau-Linggi Mangrove Forest (Peninsular Malaysia), *Transylvanian Review of Systematical and Ecological Research*, The Wetlands Diversity, Curtean-Bănăduc et al. (eds), 12, 111-116.
12. Arcifa M. S. and Meschiatti A. G., 1993 – Distribution and feeding ecology of fishes in a Brazilian Reservoir: Lake Monte Alegre, *Interciencia*, 18, 6, 83-87.
13. Bishop K. A. and Forbes M. A., 1991 – The freshwater fishes of northern Australia, in Haynes C. D., Ridpath M. G. and Williams M. A. J. (eds), *Monsoonal Australia: Landscape, ecology and man in the northern lowlands*, A. A. Balkema, Rotterdam and Brookfield, 79-107.
14. Chen Z., Zhou Z., Peng X., Xiang H., Xiang S. and Jiang Z., 2013 – Effects of wet and dry seasons on the aquatic bacterial community structure of the Three Gorges Reservoir, *World Journal of Microbiology and* Biotechnology, 29, 841-853.
15. Chong V. C., Lee P. K. Y. and Lau C. M., 2010 – Diversity, extinction risk and conservation of Malaysian fishes, *Journal of Fish Biology*, 76, 2009-2066.
16. Department of Irrigation and Drainage, DID, 2012 – Bukit Merah Dam (Online), (Assessed 20th September 2012), Available from World Wide Web: http://www.water.gov.my.
17. Easton Z. M. and Petrovic A. M., 2004 – Fertilizer source effect on ground and surface water quality in drainage from turf grass, *Journal of Environmental Quality*, 33, 2, 645-655.
18. Fernando C. H. and Holčík J., 1991 – Fish in reservoirs, *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, 76, 149-167.
19. Gotelli N. J. and Entsminger G. L., 2001 – EcoSim: Null models software for ecology, Version 7.0., Acquired Intelligence Inc. and Kesey-Bear, http://homepages.together.net/~gentsmin/ecosim.htm

20. Ismail W. R. and Najib S. A. M., 2011 – Sediment and nutrient balance of Bukit Merah Reservoir, Perak (Malaysia), *Lakes and Reservoirs: Research and Management*, 16, 179-184.
21. Jain R. K., Urban L. V. and Stacey G. S., 1977 – *Environmental impact analysis. A new dimension of decision making*, New York: Van Nostrand Reinhold Company.
22. Kah-Wai K. and Ali A., 2001 – Chenderoh Reservoir, Malaysia: Fish community and artisanal fishery of a small mesotrophic tropical reservoir, 167-178, in Sena S. De Silva (ed.), *Reservoir and culture based fisheries: biology and management*, *Australian centre for International Agricultural Research (ACIAR) Proceedings*, 98, 167-178.
23. Kamaruddin I. S., Mustafa Kamal A. S., Christianus A., Daud S. K. and Yu Abit L., 2011 – Fish community in Pengkalan Gawi - Pulau Dula Section of Kenyir Lake, Terengganu, Malaysia, *Journal of Sustainability Science and Management*, 6, 1, 89-97.
24. Kottelat M., Whitten A. J., Kartikasari S. N. and Wirjoatmodjo S., 1993 – *Freshwater fishes of Western Indonesia and Sulawesi*, Singapore: Periplus Editions Limited, 293.
25. Lowe-McConnell R. H., 1991 – Ecological studies in tropical fish communities, Cambridge, Cambridge University Press, 382.
26. Meye J. A. and Ikomi R. B., 2012 – Seasonal fish abundance and fishing gear efficiency in River Orogodo, Niger Delta, Nigeria, *World Journal of Fish and Marine Sciences*, 4, 2, 191-200.
27. Offem B. O., Ayotunde E. O., Ikpi G. U., Ochang S. N. and Ada F. B., 2011 – Influence of seasons on water quality, abundance of fish and plankton species of Ikwori Lake, South-Eastern Nigeria, *Fisheries and Aquaculture Journal*, 1-18.
28. Pedrazzi F. J. D. M., Conceição F. T. D., Sardinha D. D. S., Moschini-Carlos V. and Pompêo M., 2013 – Spatial and temporal quality of water in the Itupararanga Reservoir, Alto Sorocaba Basin (SP), Brazil, *Journal of Water Resource and Protection*, 5, 64-71.
29. Sharip Z. and Zakaria S., 2008 – Lake and Reservoir in Malaysia: Management and Research Challenge, The National Hydraulics Research Institute of Malaysia, Seri Kembangan, Malaysia, 265.
30. Terra B. D. F., Santos A. B., and Araújo F. G., 2010 – Fish assemblage in a dammed tropical river: an analysis along the longitudinal and temporal gradients from river to reservoir, *Neotropical Ichthyology*, 8, 3, 599-606.
31. Yap S. Y., 1992 – Inland capture fishery in Malaysia, in Indo-Pacific Fishery Commission, *FAO Fishery Report*, Baluyut E. A. (ed.), 458 Supplement, FIRI/R458, Rome, 25-46.
32. Yusoff F. M., Zaidi M. Z. and Ambak M. A., 1995 – Fishery and environmental management of Lake Kenyir, Malaysia, in Indo-Pacific Fishery Commision, *FAO Report*, Petr T. and Morris M. (eds), 512 Supplement, FIRI/R512 Supplement, Rome, 112-128.
33. Zakaria I. and Lim K. K. P., 1995 – The fish fauna of Tasik Temengor and its tributaries south of Banding, Hulu Perak, Malaysia, *Malayan Nature Journal*, 48, 318-332.

STRUCTURE OF BIRD COMMUNITIES FROM CEFA NATURE PARK

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ABSTRACT

Cefa Nature Park had, even before its establishment, a protection status directed especially towards the bird fauna, in which varied and vast wetlands, forests, meadows and agricultural lands with low agricultural activity are found. The present paper shows the results of a long period of monitoring (1991-2012) the bird fauna from this area. There are currently 78 identified species, protected and recorded in the Annex I from Birds Directive 79/409/CEE. Another 168 species were identified, that are not found on the above list, thus reaching a total number of 246 species (66% of the total bird fauna of Romania). Quantitative data is also shown with respect to the size of these species population, as well as the belonging to the sedentary or migratory species group. All of the results support the fact that Cefa Nature Park is an area of major importance for bird fauna in the Northwestern territory of Romania, and especially for those species that need wetland habitats for nesting, passage or wintering.

ZUSAMMENFASSUNG: Struktur der Vogelgemeinschaften im Naturpark Cefa.

Der Naturpark Cefa hatte bereits vor seiner Ausweisung als solcher, einen Schutzstatus der insbesondere auf den Vogelbestand dieses Gebietes ausgerichtet war, auf dem sich ausgedehnte, unterschiedliche Feuchtgebietsflächen sowie Wälder, Wiesen und Ackerflächen mit geringer Nutzungsintensität befinden. Die vorliegende Arbeit bringt die Ergebnisse eines langjährigen Monitorings (1991-2012) der Vogelfauna dieses Gebietes. Darunter wurden 78 Arten identifiziert, die einen Schutzstatus haben und im Anhang I der Vogelschutzrichtlinie 79/409/CEE verzeichnet sind. Außerdem wurden weitere 168 Arten identifiziert, die auf obiger Liste nicht enthalten sind, sodass insgesamt 246 Arten festgestellt wurden (66% der in Rumänien vorkommenden Arten). Hinzu kommen quantitative Angaben bezüglich Populationgröße der Arten sowie deren Zugehörigkeit zur Gruppe der Zug- oder Standvögel. Alle diese Ergebnisse bekräftigen die Tatsache, dass der Naturpark Cefa ein Gebiet von großer Bedeutung für die Vogelfauna im Nordwesten Rumäniens darstellt, insbesondere für die Arten, die zur Brutzeit, während des Durchzugs oder zur Überwinterung Feuchtgebietshabitate benötigen.

REZUMAT: Structura comunităților de păsări din Parcul Natural Cefa.

Parcul Natural Cefa, încă înainte de constituire a avut statut de protecție, care viza în special fauna de păsări din această zonă, în care există întinse și variate suprafețe de zone umede, alături de pădure, pajiști și terenuri arabile pe care se practică o agricultură de intensitate slabă. Lucrarea de față prezintă rezultatele unei monitorizări de lungă durată (1991-2012) a faunei de păsări din această zonă. Un număr de 78 de specii identificate până în prezent sunt protejate, fiind prezente în Anexa I a Directivei Păsări 79/409/CEE. Pe lângă acestea, un număr de 168 de specii care nu se află pe lista de mai sus, au fost identificate, ajungându-se la un număr total de 246 specii (66% din totalul faunei de păsări a României). Lucrarea prezintă de asemenea și date cantitative cu privire la mărimea populațiilor acestor specii, precum și apartenența la grupul de specii sedentare sau migratoare.

INTRODUCTION

Cefa Nature Park was established in 2010, in the Northwestern part of Romania, on an area of 5002 ha, in order to preserve the natural values of this region. This rich diversity of the habitat and species (Curtean-Bănăduc et al., 2012) is explained by the varied conditions present here. In this area, there are remains of the vast wetlands supplied in the past by the Crişul Repede River and the numerous plain brooks, vast salting meadows, forests, and not lastly, the largest (size-wise) fish-pond complex from the Northwestern Romania.

One of the most important groups for biodiversity preservation is represented by birds; this is why the area was given a protected area status since 1981. That year, the Bihor County Council declared (Resolution 251/20.06.1981) Rădvani Forest a zoological reserve, having the protection of the heron colony as a main goal. Subsequently, the area was given a status of protected natural area of national interest, being declared by Law 5/2000 as the Bird Colony from Rădvani Forest Nature Reserve, with an area of three ha. Beginning in 1989, the ponds from Cefa and Rădvani Forest were listed as Important Bird Areas - AIA - (Munteanu, 2004; Papp and Sándor, 2007; Papp and Fântână, 2008).

Presently, beside the protection status given by establishing the Cefa Nature Park, the area is also part of two Natura 2000 sites: Cefa - code ROSCI0025, (5.413 ha) and Pescăria Cefa - Pădurea Rădvani - code ROSPA0097 (12,253.9 ha).

The goal of this paper is to present the results of a long period monitoring (1991-2012) of the bird fauna from this area. Also, it shows quantitative data with respect to the size of the population of these species, as well as their belonging to the sedentary or migratory species group.

MATERIAL AND METHODS

Study area. In Cefa Nature Park, on an area of 5002 ha, the following habitats can be found: aquatic habitats (903 ha, 18% of the total park area), meadows (1,825 ha, 36%), forest (238 ha, 5%) and arable land (937 ha, 19%).

Aquatic habitats. The establishment of Cefa fishponds was favored by its location on lowland, subject to flooding which led to marsh forming. After building the Collector Canal (in 1899), the fishponds were created and administrated today by private business. On the fishery area there are 47 basins, with a depth of 1-1.5 m and a total water surface of approximative 663 ha. Besides the fishponds, there can also be found marshes, natural pools, and wet fields networked by canals and ditches.

Meadow habitats. They are used as pastures (1,624 ha, 32% of the total park area) and hayfields (201 ha, 4%). After canalling and draining, they were salinated thus transforming into saltings, scattered all over the park, and covered with halofile secondary vegetation. These saltings have striped characteristics, or a concentric display of the vegetation, according to the salt concentration and the hydric regime of the soil.

Forest habitat. Rădvani Forest is the remnants of the old plain oak forest covering the Crișurilor Plain, alternating with steppe meadows. The average age of the main forest body (Cefa - Ateaş) is between 65-70 years old, with the oldest trees - English oak *Quercus robur* at 80 years old. Cefa’s forest body has an average age of 65 years old, with its oldest trees at 70 years old.

Arable land. Even though the Cefa Nature Park territory is an anthropized habitat, the agricultural surfaces support a rich biodiversity, not being exploited in an intensive system. Many of these surfaces show a high degree of abandonment (because of their high wetness and salting).

The paper was elaborated based on observations made in the Cefa Nature Park area starting in 1991. During this period, there have been numerous bird monitoring actions in the area. For the inventory of bird species, direct observations, and methods of line and point transects have been used (Sutherland et al., 2004). Observation started at 6:30-7:00 a.m. and continued until evening at sunset, around 8:00 p.m.

For inventory and monitoring activities, binoculars (Minox HG 10x52 and Leica Ultravid 10x42 HD), telescopes (Zeiss DiaScope 85, 20-60x85) and bird field guides were used (Bruun et al., 1999; Svensson et al., 2010). All observations were noted in the field. Later, centralization and systematization of the data were performed.

RESULTS AND DISCUSSION

Bird species identified in the Cefa Nature Park are presented within table 1, highlighting the breeding pairs, number of individuals from resident species, as well as wintering and staging species. Binary taxonomy was updated by Avisabe - The world bird database (*).

Table 1: Birds species from Cefa Nature Park, 1991-2012. A: abundant (species existing in over 75% of systematic observations - s.o.), C: common (species existing in over 51-75% of s.o.), RC: relatively common (species existing in over 26-50% of s.o.), R: rare (species existing in over 11-25% of s.o.), VR: very rare (species existing in over 6-10% of s.o.), S: sporadically (species existing in over 1-5% of s.o.), ER: erratic (species existing only exceptionally, under 1% of s.o.).

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
Species from Annex I - Birds Directive 79/409/CEE					
A001	1. *Gavia stellata*				1-3
A002	2. *Gavia arctica*				2-10
A393	3. *Phalacrocorax pygmaeus*				4-25
A020	4. *Pelecanus crispus*				0-1
A021	5. *Botaurus stellaris*		6-10	0-2	10-15
A022	6. *Ixobrychus minutus*		40-50		200-400
A023	7. *Nycticorax nycticorax*		120-150	0-1	600-900
A024	8. *Ardeola ralloides*		3-7		15-40
A026	9. *Egretta garzetta*		5-14		250-400
A027	10. *Egretta alba*		8-15	2-6	400-700
A029	11. *Ardea purpurea*		8-10		80-120
A030	12. *Ciconia nigra*		0-1		12-20
A031	13. *Ciconia ciconia*		2-4		
A032	14. *Plegadis falcinellus*				0-5
A034	15. *Platalea leucorodia*				150-360
A038	16. *Cygnus cygnus*				0-4
A042	17. *Anser erythropus*				0-3
A396	18. *Branta ruficollis*				0-9
A397	19. *Tadorna ferruginea*				0-4

Table 1 (continuing): Birds species from Cefa Nature Park, 1991-2012.

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
A060	20. *Aythya nyroca*		15-35		150-380
A068	21. *Mergus albellus*				25-80
A072	22. *Pernis apivorus*		0-1		15-20
A074	23. *Milvus migrans*		0-1		5-8
A075	24. *Milvus milvus*				0-1
A076	25. *Haliaeetus albicilla*			15-55	
A080	26. *Circaetus gallicus*				0-2
A081	27. *Circus aeruginosus*		8-12	0-2	150-220
A082	28. *Circus cyaneus*			2-4	10-100
A083	29. *Circus macrourus*				0-2
A084	30. *Circus pygargus*		0-2		12-18
A403	31. *Buteo rufinus*				1-3
A089	32. *Aquila pomarina*		0-1		0-2
A090	33. *Aquila clanga*				1
A404	34. *Aquila heliaca*				0-3
A092	35. *Hieraaetus pennatus*				0-1
A094	36. *Pandion haliaetus*				5-12
A097	37. *Falco vespertinus*				0-12
A098	38. *Falco columbarius*			1-3	10-18
A511	39. *Falco cherrug*		0-1		4-8
A103	40. *Falco peregrinus*				3-5
A119	41. *Porzana porzana*		R		
A120	42. *Porzana parva*		R		
A122	43. *Crex crex*		0-4		
A127	44. *Grus grus*				0-90
A129	45. *Otis tarda*				0-2
A131	46. *Himantopus himantopus*		0-3		2-30
A132	47. *Recurvirostra avosetta*		0-12		60-120
A140	48. *Pluvialis apricaria*				250-800
A149	49. *Calidris alpina*				600-1,000
A151	50. *Philomachus pugnax*				2,200-7,000
A154	51. *Gallinago media*				VR
A157	52. *Limosa lapponica*				0-2
A166	53. *Tringa glareola*				800-1,400
A170	54. *Phalaropus lobatus*				0-1
A176	55. *Ichthyaetus melanocephalus*				0-1
A177	56. *Hydrocoloeus* (*Larus*) *minutus*				2-30
A189	57. *Gelochelidon nilotica*				0-1
A190	58. *Hydroprogne* (*Sterna*) *caspia*				0-1
A193	59. *Sterna hirundo*		0-20		80-240
A195	60. *Sterna albifrons*				0-1

Table 1 (continuing): Birds species from Cefa Nature Park, 1991-2012.

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
A196	61. *Chlidonias hybridus*		5-240		350-650
A197	62. *Chlidonias niger*		0-10		45-300
A222	63. *Asio flammeus*		0-1		0-20
A229	64. *Alcedo atthis*		0-2	2-4	
A231	65. *Coracias garrulus*		0-1		0-8
A234	66. *Picus canus*	0-1			
A236	67. *Dryocopus martius*	1-2			
A429	68. *Dendrocopos syriacus*	1-4			
A238	69. *Dendrocopos medius*	2-4			
A245	70. *Galerida cristata*	C			
A246	71. *Lullula arborea*		1-2		
A255	72. *Anthus campestris*		0-2		
A272	73. *Luscinia svecica*		2-4		
A293	74. *Acrocephalus melanopogon*		1-3		
A307	75. *Sylvia nisoria*		1-4		
A321	76. *Ficedula albicollis*		1-2		
A338	77. *Lanius collurio*		C		
A339	78. *Lanius minor*		6-12		
Species which are not in Annex I from Birds Directive 79/409/CEE					
A004	1. *Tachybaptus ruficollis*		12-30		600-1,000
A005	2. *Podiceps cristatus*		120-200		600-800
A006	3. *Podiceps grisegena*		1-2		15-20
A008	4. *Podiceps nigricollis*		3-18		120-200
A017	5. *Phalacrocorax carbo*				1,200-2,500
A025	6. *Bubulcus ibis*				ER
A028	7. *Ardea cinerea*		293-370		800-1,200
A036	8. *Cygnus olor*		0-1		4-24
A039	9. *Anser fabalis*				ER
A041	10. *Anser albifrons*				5,000-15,000
A043	11. *Anser anser*		10-25		250-1,200
A048	12. *Tadorna tadorna*				10-20
A050	13. *Anas penelope*				600-1,000
A051	14. *Anas strepera*		10-12		120-360
A052	15. *Anas crecca*				6,000-10,000
A053	16. *Anas platyrhynchos*		20-30	20-50	4,000-7,000
A054	17. *Anas acuta*				140-260
A055	18. *Anas querquedula*		4-7		800-2,000
A056	19. *Anas clypeata*				1,000-2,000
A058	20. *Netta rufina*		0-2		0-8
A059	21. *Aythya ferina*		75-120	8-16	3,000-8,000

Table 1 (continuing): Birds species from Cefa Nature Park, 1991-2012.

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
A061	22. *Aythya fuligula*		0-1		400-800
A067	23. *Bucephala clangula*				120-250
A069	24. *Mergus serrator*				0-8
A070	25. *Mergus merganser*				10-28
A086	26. *Accipiter nisus*		0-1	4-10	
A085	27. *Accipiter gentilis*		2-3		
A087	28. *Buteo buteo*		3-5	12-30	
A088	29. *Buteo lagopus*			3-6	
A096	30. *Falco tinnunculus*		4-10	8-18	
A099	31. *Falco subbuteo*		1-2		
A113	32. *Coturnix coturnix*		10-25		
A115	33. *Phasianus colchicus*		C		
A118	34. *Rallus aquaticus*		10-30		
A123	35. *Gallinula chloropus*		160-240		250-320
A125	36. *Fulica atra*		120-200		8,000-14,000
A130	37. *Haematopus ostralegus*				0-2
A136	38. *Charadrius dubius*		5-12		60-140
A137	39. *Charadrius hiaticula*				4-18
A141	40. *Pluvialis squatarola*				60-120
A142	41. *Vanellus vanellus*		25-60		6,000-9,000
A144	42. *Calidris alba*				6-20
A149	43. *Calidris alpina*				S
Without code	44. *Calidris melanotos*				VR
A145	45. *Calidris minuta*				360-500
A146	46. *Calidris temminckii*				20-60
A147	47. *Calidris ferruginea*				160-220
A150	48. *Limicola falcinellus*				2-6
A152	49. *Lymnocryptes minimus*				30-60
A153	50. *Gallinago gallinago*		0-6		300-450
A155	51. *Scolopax rusticola*		0-1		8-16
A156	52. *Limosa limosa*				6,000-9,000
A158	53. *Numenius phaeopus*				800-1,200
A160	54. *Numenius arquata*		0-7		1,400-1,800
A161	55. *Tringa erythropus*				1,500-2,500
A162	56. *Tringa totanus*		1-7		120-280
A163	57. *Tringa stagnatilis*				40-60
A164	58. *Tringa nebularia*				240-460
A165	59. *Tringa ochropus*				140-300
A168	60. *Actitis hypoleucos*			0-1	150-230
A169	61. *Arenaria interpres*				0-1
A171	62. *Phalaropus fulicarius*				0-8

Table 1 (continuing): Birds species from Cefa Nature Park, 1991-2012.

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
A179	63. *Chroicocephalus ridibundus*		0-30		15,000-35,000
A182	64. *Larus canus*				360-700
A183	65. *Larus fuscus*				4-12
A184	66. *Larus argentatus*				VR
A604	67. *Larus michahellis*				VR
A184	68. *Larus cachinnans*				1,000-2,000
A198	69. *Chlidonias leucopterus*				45-60
A207	70. *Columba oenas*		1-3		VR
A206	71. *Columba livia*		C		
A208	72. *Columba palumbus*		4-10		R
A210	73. *Streptopelia turtur*		3-9		VR
A209	74. *Streptopelia decaocto*				
A212	75. *Cuculus canorus*		RC		RC
A214	76. *Otus scops*		1-3		
A221	77. *Asio otus*		2-3		
A218	78. *Athene noctua*		2-3		
A213	79. *Tyto alba*		3-4		
A226	80. *Apus apus*				400-800
A230	81. *Merops apiaster*				200-600
A235	82. *Picus viridis*		C		
A237	83. *Dendrocopos major*		C		
A240	84. *Dendrocopos minor*		C		
A232	85. *Upupa epops*		1-2		25-50
A233	86. *Jynx torquilla*		1-3		15-25
A247	87. *Alauda arvensis*		C		RC
A249	88. *Riparia riparia*				3,000-8,000
A251	89. *Hirundo rustica*		C		
A253	90. *Delichon urbicum (urbica)*		C		8,000-14,000
A256	91. *Anthus trivialis*		1-4		
A257	92. *Anthus pratensis*				20-50
A258	93. *Anthus cervinus*				2-10
A259	94. *Anthus spinoletta*			1-5	400-800
A260	95. *Motacilla flava flava*		70-180		1,000-2,000
A261	96. *Motacilla cinerea*				S
A262	97. *Motacilla alba*		20-55		1,500-3,000
A263	98. *Bombycilla garrulus*				ER
A265	99. *Troglodytes troglodytes*		C		
A266	100. *Prunella modularis*		C		
A269	101. *Erithacus rubecula*		A		RC
A270	102. *Luscinia luscinia*		ER		ER

Table 1 (continuing): Birds species from Cefa Nature Park, 1991-2012.

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
A271	103. *Luscinia megarhynchos*		RC		RC
A273	104. *Phoenicurus ochruros*		C		RC
A274	105. *Phoenicurus phoenicurus*				VR
A275	106. *Saxicola rubetra*		VR		VR
A276	107. *Saxicola torquata*		R		R
A278	108. *Oenanthe oenanthe*		R		S
A283	109. *Turdus merula*	A			
A284	110. *Turdus pilaris*				R
A285	111. *Turdus philomelos*		R		RC
A286	112. *Turdus iliacus*				ER
A287	113. *Turdus viscivorus*		VR		R
A290	114. *Locustella naevia*		0-2		ER
A291	115. *Locustella fluviatilis*		VR		VR
A292	116. *Locustella luscinioides*		RC		RC
A295	117. *Acrocephalus shoenobaenus*		A		A
A296	118. *Acrocephalus palustris*		RC		RC
A297	119. *Acrocephalus scirpaceus*		A		A
A298	120. *Acrocephalus arundinaceus*		A		A
A438	121. *Hippolais pallida*				ER
A299	122. *Hippolais icterina*		VR		RC
A308	123. *Sylvia curruca*		RC		RC
A309	124. *Sylvia communis*		RC		RC
A310	125. *Sylvia borin*		R		R
A311	126. *Sylvia atricapilla*		RC		C
A314	127. *Phylloscopus sibilatrix*		VR		R
A315	128. *Phylloscopus collybita*		RC		C
A316	129. *Phylloscopus trochilus*		S		C
A317	130. *Regulus regulus*				S
A318	131. *Regulus ignicapillus*				S
A319	132. *Muscicapa striata*		R		RC
A324	133. *Aegithalos caudatus*		C		
A330	134. *Parus major*		C		
A329	135. *Cyanistes (Parus) caeruleus*		C		
A325	136. *Poecile (Parus) palustris*		C		
A323	137. *Panurus biarmicus*		C		
A336	138. *Remiz pendulinus*		20-40		RC
A332	139. *Sitta europaea*		C		
A337	140. *Oriolus oriolus*		6-12		VR
A340	141. *Lanius excubitor*			15-45	
A342	142. *Garrulus glandarius*		A		
A343	143. *Pica pica*		A		

Table 1 (continuing): Birds species from Cefa Nature Park, 1991-2012.

Natura 2000 Code	Species	Population size			
		Resident species	Migratory species		
			Breeding (pairs)	Wintering (individuals)	Staging (individuals)
A347	144. *Corvus monedula*		A		
A348	145. *Corvus frugilegus*		A		
A349	146. *Corvus cornix*		A		
A350	147. *Corvus corax*		5-8		
A351	148. *Sturnus vulgaris*		C		A
A353	149. *Sturnus roseus*				ER
A354	150. *Passer montanus*		A		
A356	151. *Passer domesticus*		A		
A359	152. *Fringilla coelebs*	C			
A360	153. *Fringilla montifringilla*			RC	
A361	154. *Serinus serinus*		R		R
A363	155. *Carduelis chloris*	RC			
A364	156. *Carduelis carduelis*	RC			
A365	157. *Carduelis spinus*			ER	
A366	158. *Carduelis cannabina*	S			
A367	159. *Carduelis flavirostris*			ER	
A368	160. *Carduelis flammea*				ER
A369	161. *Loxia curvirostris*				ER
A372	162. *Pyrrhula pyrrhula*				VR
A373	163. *Coccothraustes coccothraustes*	R			
A374	164. *Calcarius lapponicus*			ER	
A375	165. *Plectrophenax nivalis*				ER
A376	166. *Emberiza citrinella*		C		
A381	167. *Emberiza schoeniclus*		C		
A383	168. *Miliaria calandra*		C		

Migration birds in the spring/fall passages from Cefa Nature Park

Cefa fishponds, as well as those from the surrounding areas, provide (thanks to their placement on the Pannonic-Bulgarian migration path) ideal habitats for feeding, weight gaining and rest for thousands of birds during spring and fall migrations.

A characteristic of the spring passage is that it starts very early due to mild winters and short time frosts. Cefa Nature Park conditions provide for birds in the spring passage with resting habitats. First on the water surfaces, on the bottoms of the ponds emptied during this time of the year and on pastures, in the two forest bodies and neighbouring arable lands.

Fall passage starts early at Cefa, August-December, depending on the temperature. Favorable conditions, especially for shorebirds, occur during this time of the year by industrial fishing that requires water removal from ponds, leaving only shallow water layers. Thus, on such ponds, thousands of birds can be recorded, belonging to species such as Eurasian Curlew *Numenius arquata* and Whimbrel *N. phaeopus*, Northern Lapwing *Vanellus vanellus*, Black-tailed Godwit *Limosa limosa*, Ruff *Philomachus pugnax*, European Golden Plover *Pluvialis apricaria*, Gray Plover *P. squatarola*, Spotted Redshank *Tringa erythropus*, Common Redshank *T. totanus*, Marsh Sandpiper *T. stagnatilis*, Greenshank *T. nebularia*, Green Sandpiper *T. ochropus*, Wood Sandpiper *T. glareola*, Common Sandpiper *Actitis hypoleucos*, Little Ringed Plover *Charadrius dubius*, Ringed Plover *C. hiaticula*, Sanderling *Calidris alba*, Little Stint *C. minuta*, Temminck's Stint *C. temminckii*, Curlew Sandpiper *C. ferruginea*, Dunlin *C. alpina*, Black-winged Stilt *Himantopus himantopus*, Avocet *Recurvirostra avosetta*, Jack Snipe *Lymnocryptes minimus*, Common Snipe *Gallinago gallinago*.

Also attracted by the trophic supply of the ponds with decreasing water levels, during their passage, there are species like the gulls and terns: Black-headed Gull *Chroicocephalus* (*Larus*) *ridibundus* (15,000-35,000 individuals), Caspian Gull *Larus cachinnans* (1,000-2,000 individuals) Common Gull *L. canus* (360-700 individuals), Lesser Black-backed Gull *L. fuscus*, Little Gull *Hydrocoloeus* (*Larus*) *minutus*, Common Tern *Sterna hirundo* (80-240 individuals), Whiskered Tern *Chlidonias hybridus* (350-650 individuals), White-winged Tern *Chlidonias leucopterus* (45-60 individuals).

Eurasian Spoonbills *Platalea leucorodia* (sometimes even Glossy Ibis *Plegadis falcinellus*), which are nesting in the Kis-Sarret area from Körös-Maros National Park, perform in large groups during migration on ponds drained of water.

A lot less, but regularly recorded during their passage on the emptied ponds, there are individuals of species: Bar-tailed Godwit *Limosa lapponica*, Little Tern *Sterna albifrons*, Caspian Tern *Hydroprogne* (*Sterna*) *caspia*, Gull-billed Tern *Gelochelidon nilotica*, Ruddy Turnstone *Arenaria interpres*, Red-necked Phalarope *Phalaropus lobatus*, Red Phalarope *Phalaropus fulicarius*, Broad-billed Sandpiper *Limicola falcinellus*, Eurasian Oystercatcher *Haematopus ostralegus*, Mediterranean Gull *Ichthyaetus* (*Larus*) *melanocephalus*.

Surfaces with reed provide night habitats during fall for about 3,000-8,000 of the Sand Martin *Riparia riparia* and 8,000-14,000 Northern House Martin *Delichon urbicum* (*urbica*).

In the ponds area, even if not directly influenced by them, can be recorded during their fall passage, 200-600 of European Bee-eater *Merops apiaster*, 400-800 Water Pipit *Anthus spinoletta*, 1,000-2,000 Yellow Wagtail *Motacilla flava*, and 1,500-3,000 White Wagtail *M. alba*.

Fields covered with hay, pastures and agricultural crops are the resting and/or feeding place outside the nesting period for Greater White-fronted Goose *Anser albifrons* (over 10,000 individuals) and the endangered species: Lesser White-fronted Goose *Anser erythropus* (3 individuals), Red-breasted Goose *Branta ruficollis* (up to nine individuals), Common Crane *Grus grus* (90 individuals), and Short-eared Owl *Asio flammeus* (20 individuals).

Of those recorded as extremely rare during winter or in passage are: Cattle Egret *Bubulcus ibis*, Bohemian Waxwing *Bombycilla garrulus*, Common Crossbill *Loxia curvirostra*, Snow Bunting *Plectrophenax nivalis*, Lapland Bunting *Calcarius lapponicus* and Dalmatian Pelican *Pelecanus crispus*. Ölvedi Szilárd (personal communication) identified once (October 2011), during a bird watching marathon species Pectoral Sandpiper *Calidris melanotos*.

Species' richness attracts predatory bird species due to a great number of birds found during their migration passage and in winter. Thus, recorded during passage going through this area were: five to eight individuals of Black Kite *Milvus migrans*, one Red Kite *Milvus milvus*, 15-55 White-tailed Eagle *Haliaetus albicilla*, two Short-toed Eagle *Circaetus gallicus*, 150-220 Western Marsh Harrier *Circus aeruginosus*, 90-100 Hen Harrier *C. cyaneus*, two Pallid Harrier *C. macrouros*, 12-18 Montagu's Harrier *C. pygargus*, two Lesser Spotted Eagle *Aquila pomarina*, one Greater Spotted Eagle *A. clanga*, one to three Eastern Imperial Eagle *A. heliaca*, one Booted Eagle Aquila *Hieraaetus pennatus*, 10-12 Osprey *Pandion haliaetus*, 12 Red-footed Falcon *Falco vespertinus*, 10-18 Merlin *F. columbarius*, four to eight Saker Falcon *F. cherrug*, three to five Peregrine Falcon *F. peregrinus*, 10-18 Common Kestrel *F. tinnunculus*, four to nine Eurasian Sparrowhawk *Accipiter nisus*, 12-30 Common Buzzard *Buteo buteo*, three to six Rough-legged Buzzard *B. lagopus*, one to three Long-legged Buzzard *B. rufinus*.

Breeding birds species in Cefa Nature Park

Breeding bird species in Rădvani Forest

Rădvani Forest is an adequate habitat for nesting to a great number of herons. Also, it displays proper conditions for nesting of several diurnal and nocturnal predatory species, as well as multitudes of Passeriformes.

In Rădvani Forest, there is a mixed colony of herons, already known from the ’40s (Munteanu, 2000). There are breeding together: Grey Heron *Ardea cinerea* (293-370 pairs), Night Heron *Nycticorax nycticorax* (120-150 pairs) and Little Egret *Egretta garzetta* (5-14 pairs). The colony is installed in about 100 English Oak *Quercus robur* and European Ash *Fraxinus excelsior* trees, with heights ranging from 20-25 m. The number of nests vary from one to eight on a tree with an average of four to five nests per tree.

In the Rădvani forest, there is a pair of Black Stork *Ciconia nigra*, nesting here, even though not always successfully. The habitat is adequate for this species, necessitating the presence of an unexplored forest, traversed by water streams.

Among the predatory birds nesting in the Cefa Nature Park are: Honey Buzzard *Pernis apivorus* (one pair), Black Kite *Milvus migrans* (one pair), Eurasian Sparrowhawk *Accipiter nisus* (one pair), Common Buzzard *Buteo buteo* (three to five pairs), Common Kestrel *Falco tinnunculus* (four to nine), Hobby *Falco subbuteo* (one to two pairs).

For the Lesser Spotted Eagle *Aquila pomarina* (one pair) and Peregrine Falcon *Falco cherrug* (one pair), there were no certain nesting records, but there is an evidence that supports this fact; during the last few years the adult pair was observed throughout the nesting period in the forest area.

Additionally, in Rădvani forest nests also a pair of White-tailed Eagle *Haliaetus albicilla*.

Of the nocturnal predatory birds nesting here, there are two to three pairs of Long-eared Owl *Asio otus* and one to three pairs of Eurasian Scops Owl *Otus scops*.

In the Rădvani Forest area, common nesting species are: woodpeckers (*Dryocopus martius*, *Dendrocopos syriacus*, *D. medius*, and *Picus canus*), wrynecks (*Jynx torquilla*), pigeons and doves (Stock Dove *Columba oenas*, Wood Pigeon *C. palumbus*, and European Turtle Dove *Streptopelia turtur*), Common Cuckoo *Cuculus canorus*, Hooded Crow *Corvus cornix* and many other species of singing birds (Thrush Nightingale *Luscinia luscinia*, Common Nightingales *L. megarhynchos*, European Robin *Erithacus rubecula*, Blackbird *Turdus merula*, Song Thrush *T. philomelos*, Mistle Thrush *T. viscivorus*, Lesser Whitethroat *Sylvia curruca*, Common Whitethroat *S. communis*, Barred Warbler *S. nisoria*, Garden Warbler *S. borin*, Blackcap *S. atricapilla*, Wood Warbler *Phylloscopus sibilatrix,* Common Chiffchaff *P. collybita*, Willow Warbler *P. trochilus*, Collared Flycatcher *Ficedula albicollis*, Spotted Flycatcher *Muscicapa striata*, Great Tit *Parus major*, Blue Tit *Cyanistes* (*Parus*) *caeruleus*, Marsh Tit *Poecile (Parus) palustris*, Goldfinch *Carduelis carduelis*, Common Starling *Sturnus vulgaris*, Hawfinch *Coccothraustes coccothraustes*, Chaffinch *Fringilla coelebs*, Yellowhammer *Emberiza citrinella*, Golden Oriole *Oriolus oriolus*, Greenfinch *Carduelis chloris*, European Serin *Serinus serinus*, Woodlark *Lullula arborea*, Black Redstart *Phoenicurus ochruros*, Common Redstart *P. phoenicurus*, and Eurasian Nuthatch *Sitta europaea*).

Near the Rădvani Forest border area, on the Ateaș locality pasture, nests the European Roller *Coracias garrulus* (one to three pairs) and also one to two pairs of Eurasian Hoopoe *Upupa epops*.

Breeding bird species from fishponds area in Cefa Nature Park

The vegetation formed on the fishponds constitutes an important habitat for aquatic avifauna. Here the breeding species are: Great Egret *Egretta alba* (10-15 pairs), Greylag Goose *Anser anser*, Moorhen *Gallinula chloropus*, Eurasian Coot *Fulica atra*, Little Grebe *Tachybaptus ruficollis* (15-40 pairs) and Black-necked Grebe *Podiceps nigricollis* (10-18 pairs).

On the islets formed by the floating vegetation nests, 240 pairs of Whiskered Tern *Chlidonias hybridus*, 10 pairs of Black Tern *Chlidonias niger* and 15-35 pairs of Ferrugineous Duck *Aythya nyroca*.

Wide reed areas are the optimal habitat for the nesting of 10-12 pairs of Western Marsh Harrier *Circus aeruginosus*. Moreover, in these areas covered with reed nest the six to nine pairs of Bittern *Botaurus stellaris*, 40-50 pairs of Little Bittern *Ixobrychus minutus*, three to seven pairs of Squacco Heron *Ardeolla ralloides*, eight to nine pairs of Purple Heron *Ardea purpurea*, and also the Spotted Crake *Porzana porzana*.

Ducks nest among the pools and in their immediate vicinity: Mallard *Anas platyrhynchos* (20-30 pairs), Pochard *Aythya ferina* (75-120 pairs), Garganey *Anas querquedula* (four to seven pairs), Tufted Duck *Aythya fuligula* (one to two pairs), Gadwall *Anas strepera* (10-12 pairs), Red-crested Pochard *Neta rufina* (one to two pairs).

Some of the birds nesting in reeds and trees on the banks of the canals are as follows: warblers (Great Reed Warbler *Acrocephalus arundinaceus*, Sedge Warbler *A. shoenobaenus*, Moustached Warbler *A. melanopogon*, Marsh Warbler *A. palustris*, European Reed Warbler *A. scirpaceus*), Grasshopper Warbler *Locustella naevia*, River Warbler *L. fluviatilis*, Savi's Warbler *L. luscinioides*, Icterine Warbler *Hippolais icterina*) Reed Bunting *Emberiza schoeniclus*, Penduline Tit *Remiz pendulinus* (20-40 pairs) and Bluethroat *Luscinia svecica* (two to four pairs).

On the banks of the canals which spread all over the Cefa Nature Park are nesting, four to eight pairs of Common Kingfisher *Alcedo atthis*.

Breeding bird species from meadows, pastures, arable lands and swamps

These areas are well represented in Cefa Nature Park, the following birds species are nesting here: Northern Lapwing *Vanellus vanellus* (25-60 pairs), Common Snipe *Gallinago gallinago* (three to six pairs), White Wagtail *Motacilla alba* (20-55 pairs), Yellow Wagtail *Motacilla flava* (70-180 pairs), Black-tailed Godwit *Limosa limosa* (two to six), Common Redshank *Tringa totanus* (one to seven pairs).

Over the last years the studied ponds dry up in summer time, thus they are less disturbed and with small height vegetation, or without vegetation. The following bird species nest in this area: Eurasian Curlew *Numernius arquata* (up to seven pairs), Black-winged Stilt *Himantopus himantopus* (up to three pairs), Pied Avocet *Recurvirostra avosetta* (up to 12 pairs), Common Tern *Sterna hirundo* (up to 20 pairs), Little Ringed Plover *Charadrius dubius* (10-16 pairs), and Black-headed Gull *Chroicocephalus* (*Larus*) *ridibundus* (up to 30 pairs).

In the less disturbed grass fields, there were identified nests of Short-eared Owl *Asio flammeus*.

Agricultural crops from Cefa Nature Park are the nesting place for a series of species of protected birds. Here (towards the Romanian-Hungarian national border) a nest of Montagu's Harrier *Circus pygargus* was identified, and the presence of another nesting pair of this rare predator is still uncertain.

Connected to the agricultural crops during their nesting period are also the Common Skylark *Alauda arvensis*, Tawny Pipit *Anthus campestris* (four to eight pairs), Corn Bunting *Miliaria calandra*, and in the bushes bordering the agricultural lands nest the Red-backed Shrike *Lanius collurio* and Lesser Grey Shrike *L. minor* (10-12 pairs). In these habitats during nesting period, four pairs of Corncrake *Crex crex* were identified.

Furthermore, in these habitats the erratic individuals belonging to the Great Bustard *Otis tarda* were recorded, nesting on the hay fields close to Geszt and Mezőgyán (in the nearby Hungary).

Analysis of threats to the bird fauna in Cefa Nature Park

There are anthropogenic pressures carried out on the species and habitats today, with different levels of intensity, such as:

Hunting

Directly affecting all species feeding and nesting on these wetlands. Even though it is done only for the species permitted to be hunted by the national legislation, this activity affects all of the strictly protected species found on these habitats or in the mixed migration and/or feeding groups (Lesser White-Fronted Goose *Anser erythropus*, Red-Breasted Goose *Branta ruficollis*, Ferruginous Duck *Aythya nyroca*, Pygmy Cormorant *Phalacrocorax pygmaeus*, and Common Sandpiper *Actitis hypoleucos* etc.).

Fishery management activities

Inappropriate cutting and/or burning of reeds affects the species nesting in these habitats (warblers, penduline tits, bluethroat, reed buntings, bitterns, etc.). If this burning is done during the migration periods, it can affect the species using the reed as a resting place very seriously during their fall passage (*Riparia riparia, Delichon urbica,* and *Apus apus*).

Cutting the natant vegetation formed by Water Chestnut *Trapa natans*, during nesting (in species such as *Aythya nyroca, Chlidonias hybridus, C. niger,* and *C. leucopterus*), has a direct impact on the nesting success of these species that use islets as support for the nests;

Modifying water levels during nesting directly affects the species nesting on the water surface or in its immediate vicinity (*Himantopus himantopus*, *Recurvirostra avosetta*, *Sterna hirundo*, and *Chroicocephalus ridibundus*), leaving the nests on dry land or flooding the eggs.

Forestry management activities

Removal of trees in the forest (even dry ones) during the reproduction period directly affects the nesting success of certain species.

Other activities (that may be performed or done in a greater extent) which might affect bird species and their habitats are: intensive sport fishing done in more basins than at present; pasturing intensification or definitive abandonment of it; changing of land use; agricultural activity intensification and especially the use of insecticides might affect the species that are used as food by bird populations; building more vacation houses; the extension of the present land within the built-up area; establishment of industrial development areas in the vicinity; increased access of auto vehicle to the meadows; wind farm development; occurrence of investments in Concentrating Solar Power Technologies; pollution of the aquatic ecosystems because of agriculture, management and intensive fishing; draining and inning of wetlands.

CONCLUSIONS

In the habitats from Cefa Nature Park, over half (66%) of the bird species identified are present with certainty on the territory of Romania (246 species from 373 which are present in Checklist of the Birds of Romania (**).

The area is important both for species reproducing here and also for sedentary and those migratory, providing diverse nesting habitats, distributed on vast areas.

The protected area provides opportunities for refuge, rest and feeding for a variety of migratory species during spring and fall passage and also during winter. Therefore, hundreds of thousands of aquatic and semi-aquatic bird species are present in these seasons in Cefa.

The human pressure is still low in the Cefa Nature Park, which leads the maintenance to be in good to excellent condition of preservation of bird species and their habitats. Even so, the authors' recommendations for the authorities of protected area management are with regard first to the reduction of the anthropogenic pressure intensity represented by hunting and fishpond management (related to maintaining the water level during nesting period, removal of natant vegetation after completion of nesting in the targeted species and mechanic cutting of reeds).

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REFERENCES

1. Bird Directive (79/409/EEC), 1979 – Council Directive on the conservation of wild birds.
2. Bruun B., Delin H. and Svensson L. 1999 – Păsările din România și Europa, Edit. Hamlyn Londra, 1-320. (in Romanian)
3. Curtean-Bănăduc A., Bănăduc D. and Sîrbu I. (eds), 2012 – The Cefa Nature Park, *Transylvanian Review of Systematical and Ecological Research*, 13, 210.
4. Decision 251/1981 of Bihor County Council. (in Romanian)
5. Law no. 5/2000 regarding the national territory planning, section III, protected areas. (in Romanian)
6. Munteanu D., 2000 – Ornitofauna heleşteelor de la Cefa şi a Pădurii Rădvan, *Crisicum*, 3, 197-201. (in Romanian)
7. Munteanu D. (ed.), 2004 – Ariile de importanţă avifaunistică din România – documentaţii. Publicația Societății Ornitologice Române, Editura Alma Mater, Cluj-Napoca, 252. (in Romanian)
8. Papp T. and Sándor A. (eds), 2007 – Ariile de Importanţă Avifaunistică din România, Publicația Societății Ornitologice Române și Asociației pentru Protecția Păsărilor și a Naturii “Grupul Milvus”, Tîrgu-Mureş, 252. (in Romanian)
9. Papp T. and Fântână C. (eds), 2008 – Ariile de Importanţă Avifaunistică din România, Publicația Societății Ornitologice Române și Asociației pentru Protecția Păsărilor și a Naturii “Grupul Milvus”, Tîrgu-Mureş, 1-319. (in Romanian)
10. Sutherland W. J., Newton I. and Green R. E., 2004 – Bird Ecology and Conservation - A Handbook of Techniques Oxford University Press, Oxford, 1-386.
11. Svensson L., Mullarney K., Zetterstrom D. and Grant P. J., 2010 – Collins Bird Guide, The most complete field guide to the birds of Britain and Europe, HarperCollins, London, UK, 1-392.
12. * – Avisabe - The world bird database - last visualization: 25.06.2012. (http://avibase.bsc-eoc.org/avibase.jsp?pg=home&lang=EN)
13. * – Checklist of the Birds of Romania - last visualization: 25.06.2012. (http://www.milvus.ro/images/PDF/Checklist%20of%20the%20Birds%20of%20Romania.pdf)

DE GRUYTER OPEN

DIVERSITY OF AQUATIC ECOSYSTEMS IN URBAN AREAS - PUBLIC EXPECTATIONS

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ABSTRACT

In urban ecosystems, typically created by humans, it is very difficult to balance the needs of all its inhabitants. Significance of nature in the cities has been perceived since the ancient times. In the city there are many problems associated with the lack or sometimes excess of water, as well as poor quality. In times of water resources decline and their progressive degradation, each aquatic ecosystem should be investigated because of its values. Among the aquatic ecosystems occurring in the cities, there are: river valleys, natural lakes, water reservoirs, as well as small bodies of water. The aim of this study is to raise public awareness about the role of aquatic ecosystems in cities with different sizes and with a varying number of inhabitants. All respondents in each type of city felt the need of water presence in their surroundings and treated it as a necessary part of the proper functioning, as well as a place for rest and recreation. However, lack of management and a poor ecological status of them were noticed.

RÉSUMÉ: La diversité des écosystèmes aquatiques dans les zones urbaines - les attentes du public.

Dans les écosystèmes urbains, généralement créés par l'homme, il est difficile d'évaluer les besoins de tous les habitants. L'importance de la nature dans les villes a été perçu depuis les temps anciens. En ville, il existe des problèmes liés à l'absence et parfois l'excès d'eau, ainsi que sa mauvaise qualité. En période de déclin des ressources en eau et de leur dégradation progressive, chaque écosystème aquatique devrait être étudié en raison de sa valeur. Parmi les écosystèmes aquatiques présents dans les villes, il y a des vallées fluviales, des lacs naturels, des réservoirs d'eau, ainsi que de petits plans d'eau. L'objectif de l'étude était de déterminer la sensibilité du public aux écosystèmes aquatiques dans des villes de taille et de nombre d'habitants différents. Toutes les personnes interrogées provenant de chaque type de ville ont fait part de leur besoin de présence d'eau dans leur environnement, perçu comme un élément nécessaire à son bon fonctionnement. Les sites aquatiques constitues également des lieux de repos et de loisirs. Cependant, la mauvaise gestion de l'eau et le mauvais état écologique des eaux ont été soulignés.

REZUMAT: Diversitatea ecosistemelor acvatice în zone urbane - aşteptările publicului.

În ecosistemele acvatice urbane, în general create de om, este foarte dificil să se echilibreze necesităţile tuturor locuitorilor. Importanţa prezenţei naturii în oraşe a fost recepţionată din timpuri străvechi. În oraş există multe probleme legate de absenţa, câteodată de excesul dar şi de calitatea proastă a apelor. În perioadele de declin ale resurselor de apă şi degradarea lor progresivă este necesară studierea valorii fiecărui ecosistem acvatic. Între ecosistemele acvatice din oraş există atât văi fluviale, lacuri naturale, rezervoare de apă, cât şi corpuri mici de apă. Obiectivul acestui studiu a fost determinarea sensibilizării publicului cu privire la rolul ecosistemelor acvatice din oraşe diferenţiate în funcţie de mărime şi număr de locuitori. Toţi cei interogaţi din fiecare tip de oraş au simţit necesitatea prezenţei apei în împrejurimile lor, văzând-o ca un element necesar pentru buna funcţionare, dar în aceeaşi măsură şi ca loc de odihnă şi de agrement. În acelaşi timp a fost remarcat modul deficitar de gestionare a apelor şi starea lor ecologică de calitate redusă.

INTRODUCTION

In urban ecosystems, typically created by humans, it is very difficult to balance the needs of all its inhabitants. Significance of nature in the cities was perceived from the ancient times (Barthel et al., 2010; Damurski, 2012). In the city there are many problems associated with the lack or sometimes the excess of water, as well as poor quality of water. The progressive course of civilization significantly transformed that unique element. Water in the environment is a priceless treasure, and it is usually a limited resource in certain cities. The development of the city, by impairing a hydrological regime, limits its ability to provide essential basic services: supplying and regulation (Fig. 1).

The problem of water shortage is usually associated with areas of warm temperatures. However, Poland is among the countries with a very serious poverty of water resources. On one hand, there are climatic conditions and on the other is an adverse action to reduce the small retention. Such situations aggravate water deficit in the country, as well as affect the occurrence of negative phenomena. The measure of rising problems with water management in Poland is progressing steppe of large areas of the country and threatening areas by rising water deficit. Among these places are Lublin and its surrounding areas.

In times of water resource's decline and their progressive degradation, each aquatic ecosystem should be investigated because of its values. An important meaning in enriching water resources are the specific types of water bodies; the small ones, as well as bigger sized ones. In addition to the poor quality of surface waters, there are problems associated with the management of many reservoir's surroundings, especially in suburban areas (Chełmicki, 2012). Among aquatic ecosystems occurring in the cities there are river valleys, natural lakes, water reservoirs, as well as small water bodies. Water reservoirs are one of the environmental elements of importance with their valuable function, like water retention for municipalities (Mioduszewski, 2006; Sender and Kułak, 2010). Furthermore, they are perceived as high-value enclaves of the natural environment, as well as objects with recreation function for the rest (Mioduszewski, 1999; Celiński et al., 2001).

Strategy of hydrosphere conservation should be aimed at reducing a deficit through the construction of new intakes, reducing losses in water supply systems and eliminating the exploitation of water resources by industry. In order to improve, the national balance sheet is needed both to increase retention by increasing forest cover and protection, revitalization and creation of new hydrogenic areas. Extremely important in this process is the public awareness.

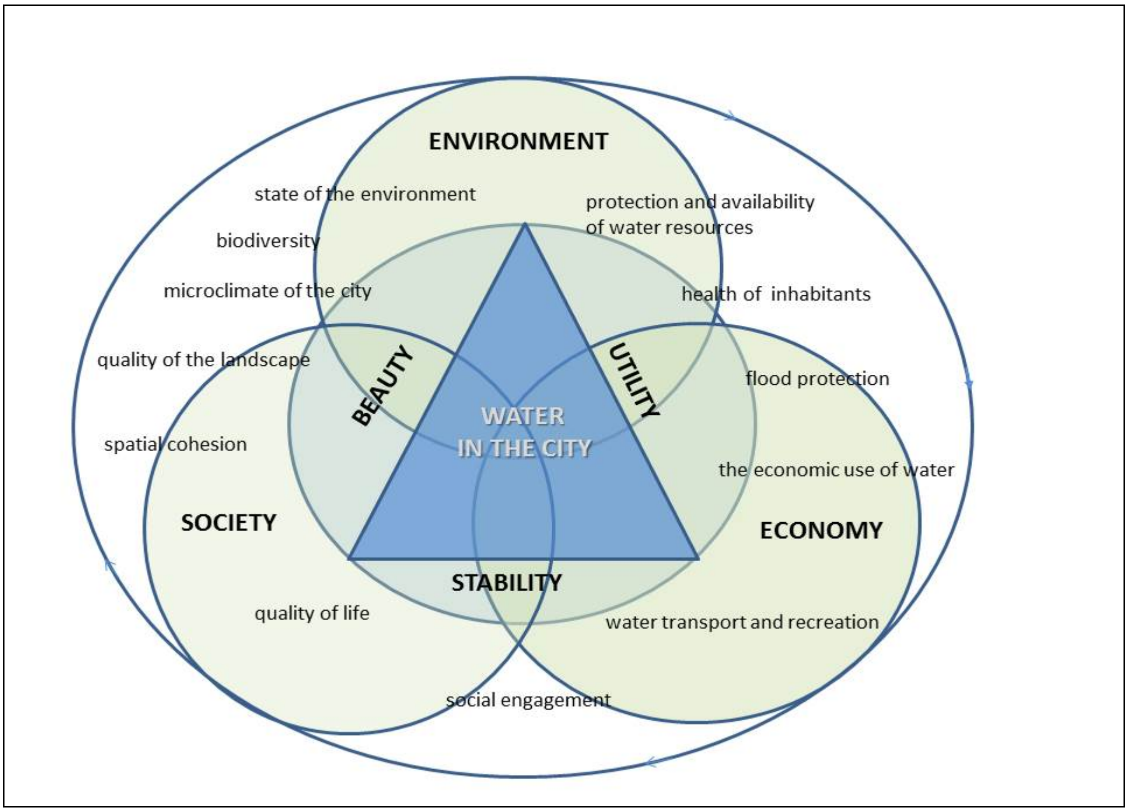


Figure 1: The importance of water in city by Januchta-Szostak, 2011 (revised).

A result of the social dialogue is the knowledge of how important for us these things are on a local scale. This form supports, directs, and also reminds, the importance of the issue. In Poland, wide public participation is rarely used. This is due to the lack of knowledge of the legal state and also the lack of tradition and skills in this area (Pawłowska, 2012).

The aim of the study was to determine the public awareness about the role of aquatic ecosystems in cities with different sizes and number of inhabitants.

METHODS

The expectations of inhabitants of chosen communities in relation to aquatic ecosystems in the city were analyzed on the basis of the survey.

The survey was conducted among 152 people in 2013. Questions were shown and answers were written down in a questionnaire. The survey was carried out among people spending time over the water; age groups were not analyzed. Analyzes were conducted in three cities in Lublin Voivodeship, differentiated in terms of population and size: Lublin (348 thousand inhabitants, 147.5 km^2 surface), Janów Lubelski (11,904 thousand inhabitants, 14.80 km^2 surface) and Kock (3,484 thousand inhabitants, 16.78 km^2 surface) (Fig. 2). The survey included 14 questions related to the impact of aquatic ecosystems and their influence on quality of life in the city. The presence and diversity of aquatic ecosystems were one of the main criteria for the selection of cities. In order to obtain statistical verification of received data, a nonparametric statistics λ^2 (Chi square) was used.

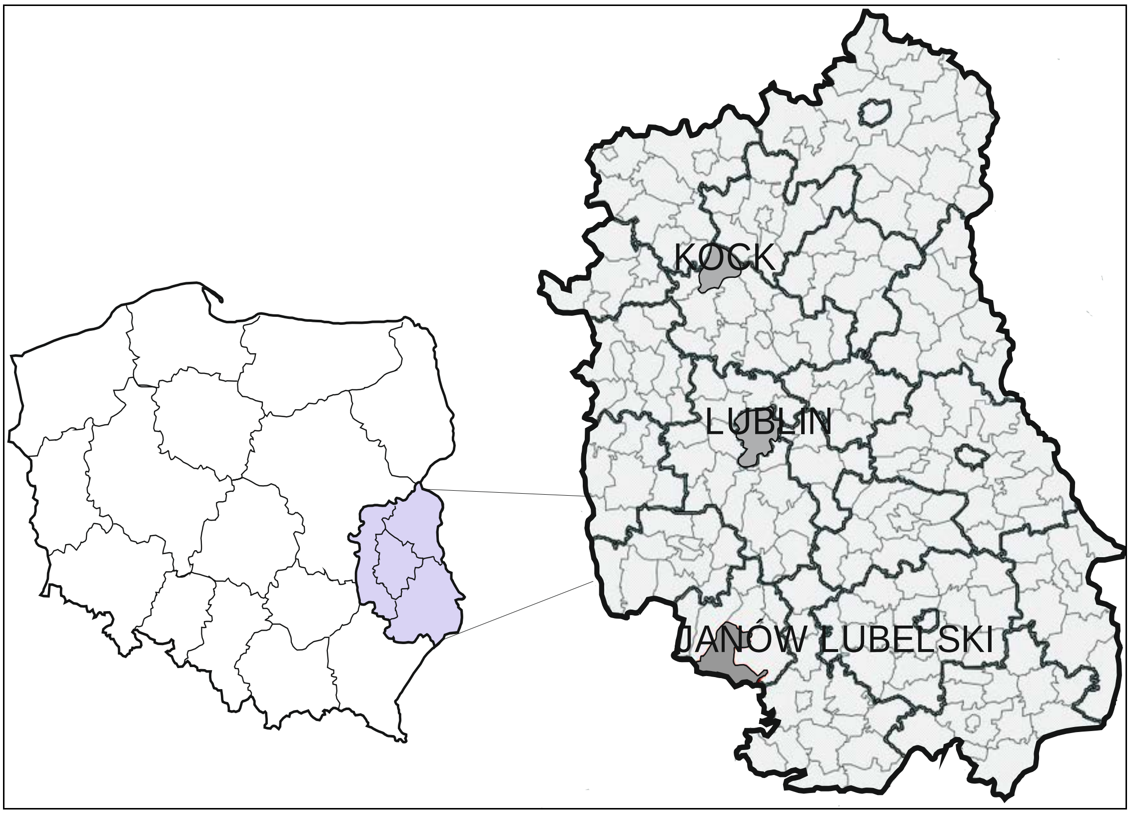


Figure 2: The study area, the location of the designated cities on the background of Lublin Voivodeship.

RESULTS AND DISCUSSIONS

In all studied cities, regardless of size, inhabitants felt the need of the water presence in their surroundings and treated it as a necessary part of the proper functioning. But what is more interesting is that this need increased significantly with the size of the city (Fig. 3). These differences were statistically significant ($\chi^2(1) = 0.003.76$; $p < 0.05$). We surmised that in small cities people are more used to surrounding nature than in bigger cities. This may be due to their greater openness to nature.

All respondents confirmed the need for the occurrence of recreational reservoirs in the city; whereas among the existing ones it was said about insufficient and often inappropriate use of their coasts. The answer was justified yet mismatched the current land use to the needs (Fig. 4).

Among all respondents, only in opinion of inhabitants of the big city there is a right way of management in river valley. The smaller city, the less people think that land use management is proper. The highest number of respondents spoke about the lack of any development in a small town.

Fluvial water ecosystems provided citizens with an important role too (Fig. 4), although the question was about threats from water, rivers were especially indicated (Tab. 1). The need for river regulations in the city was supported by the great majority of respondents (from 94% in the large cities to 51% in the small cities). The answer was justified that in this way it improved the appearance of the city.

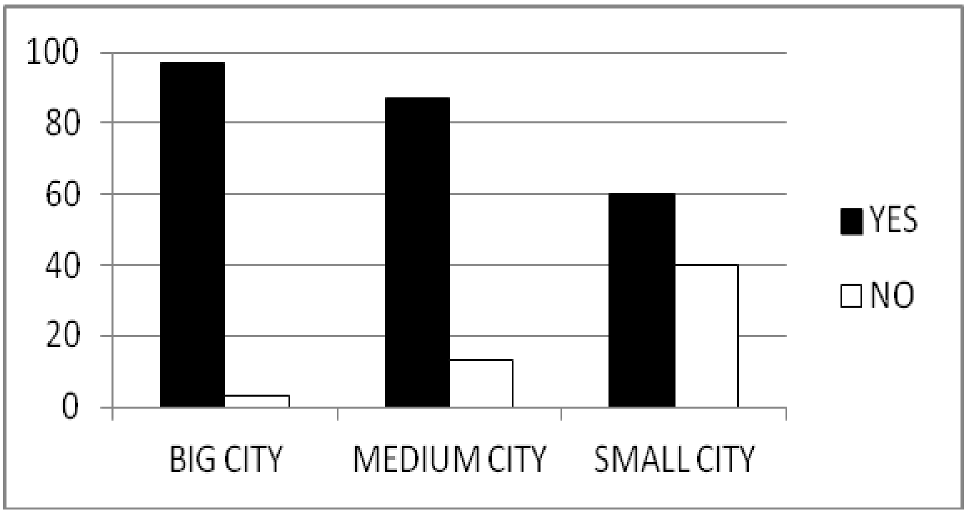


Figure 3: Answer to the question: "Is the water (lake, river, pond, etc.) an important element in the functioning of the city?" (n = 152).

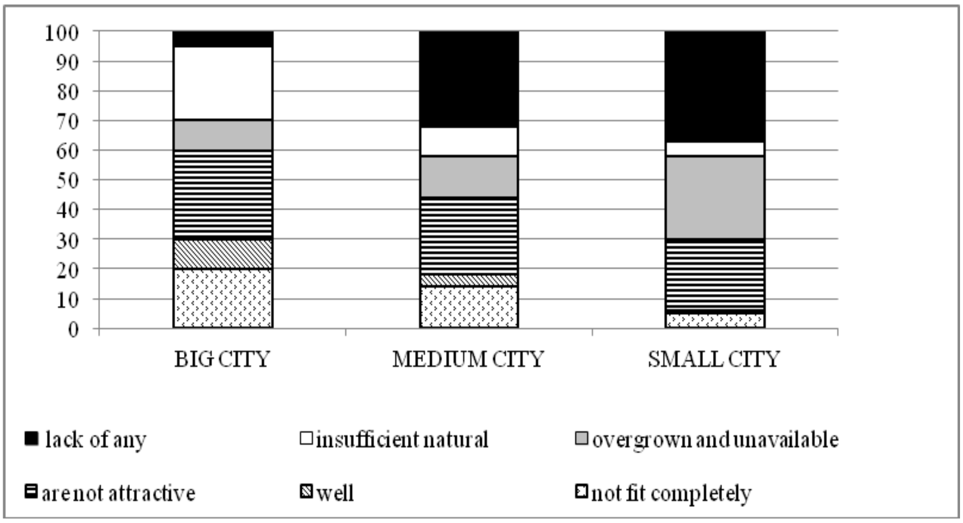


Figure 4: Answer to the question: "Is the development of river (lake) banks adequate?" (n = 152).

The great majority of respondents considered aquatic ecosystems in the city as a place for rest and recreation, just like inhabitants of other cities in Poland and in the world (Mroczek and Kostecka, 2008; Kułak and Chmielewski, 2010).

City size is also important in understanding them as environmentally valuable places. Natural role of waters in the cities was more important for the residents of small towns. These differences were statistically significant ($\chi^2(1) = 0.01$; $p < 0.05$) (Fig. 5).

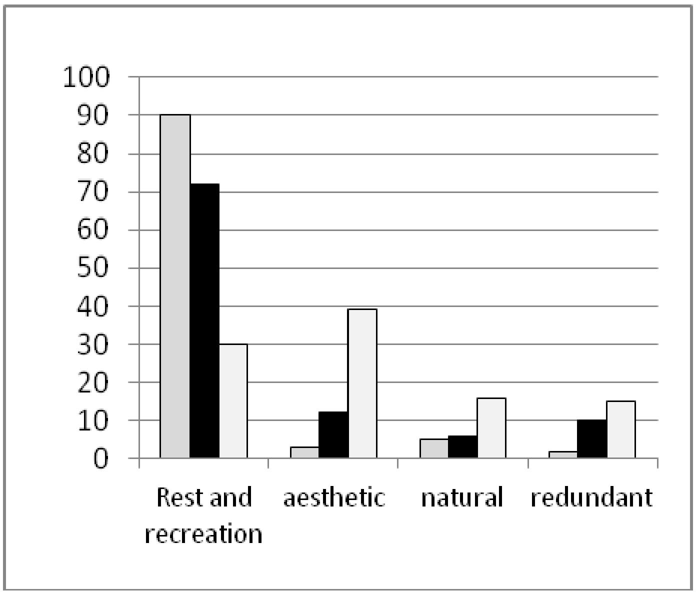


Figure 5 a: Answer to the question: “Specify the importance a) river, b) water reservoir in your city?” (n = 152).

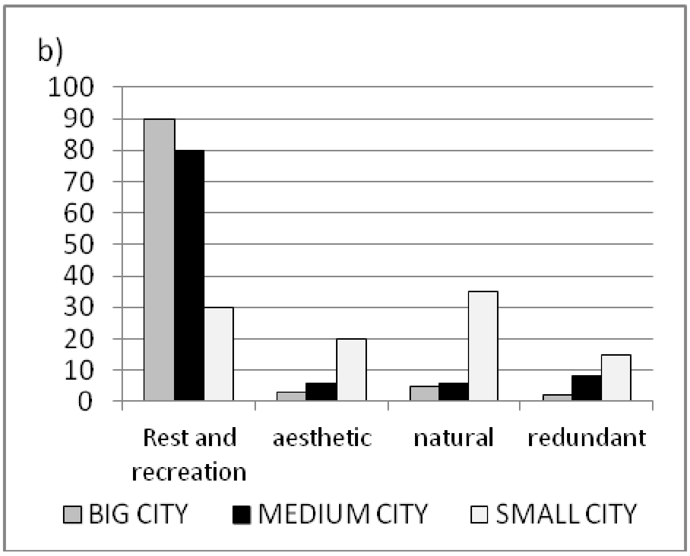


Figure 5b: Answer to the question: “Specify the importance a) river, b) water reservoir in your city?” (n = 152).

Asking about the role of river valleys, especially as ecological corridors, frequent answers in large cities were “not sure” (from 45 to 55%), while a consistent “yes” in a small town -70% (Fig. 6). It suggested a lack of proper ecological knowledge in bigger cities, or not focusing on this issue at all.

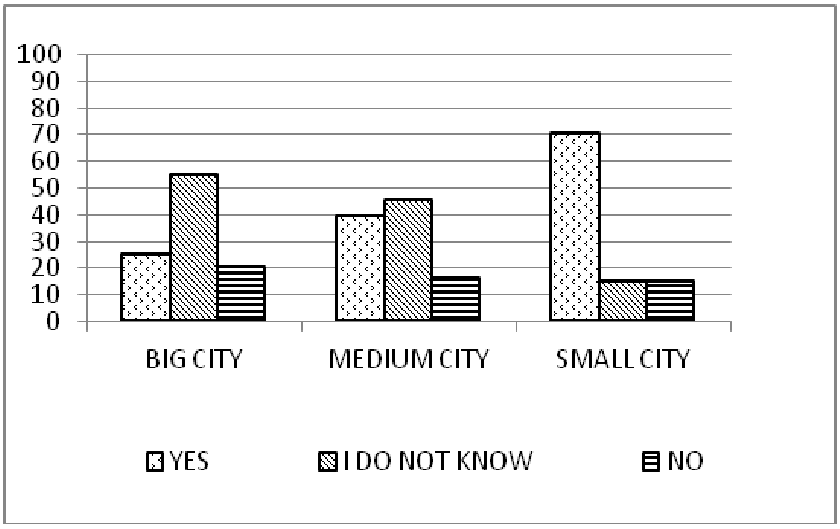


Figure 6: Answer to the question: "Does the water serve as an ecological corridor in the city?" (n = 152).

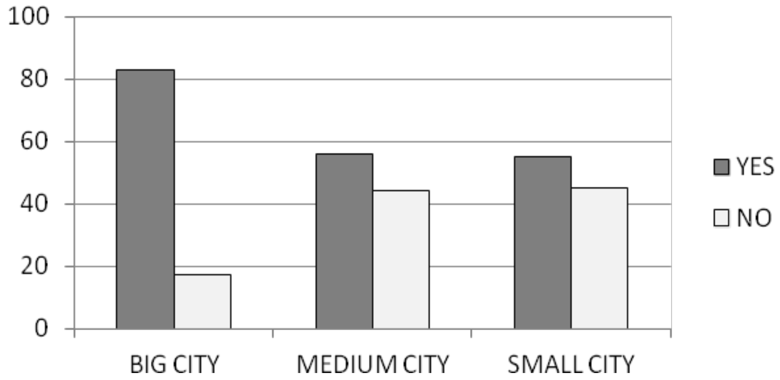


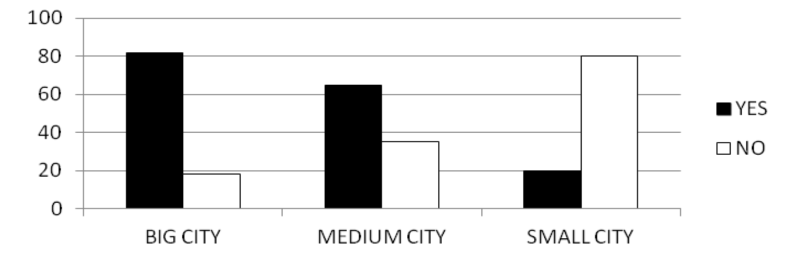
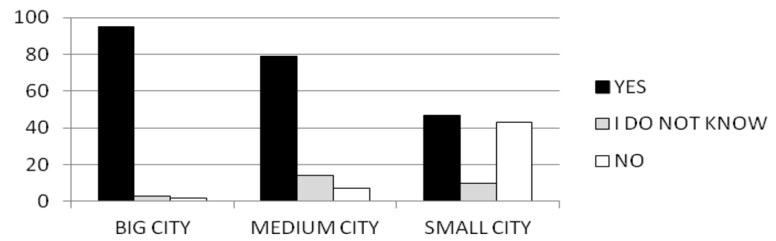
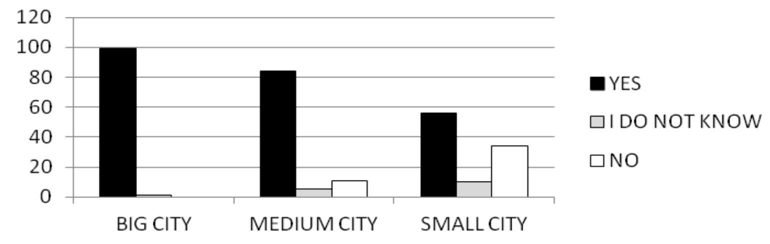
Figure 7: Answer to the question: "Are fountains/ponds in the city required?" (n = 152).

Everyone recognized the problem of poor water quality among urban water ecosystems, but not everyone was familiar with the methods and possibilities of its improvement. This problem concerned especially small towns. People did not see the need for drains in those towns (Tab. 1).

Natural ecosystems in large and medium cities attracted less attention than those created by human. Generally they were characterized by smaller, natural values and poorer ecological condition (Kuczyńska-Kippen et al., 2004). Residents of large cities had greater need for the occurrence of ecosystems created by man (Fig. 7).

Urban planning in our times should undeniably be sustainable with water management in the region. On one hand it should ensure good quality of urban water, and on the other, it should revitalize the area according to their natural destiny. Each kind of urban water, both natural and artificial, enrich biodiversity (Sender and Kułak, 2010). Human needs are inextricably linked to its natural surroundings. Water in the city improves the quality of urban space by making it more stable, and also provides a range of services (Januchta-Szostak, 2013).

Table 1: Significance of aquatic ecosystems in the city - the characteristics of answers (percentage share).

<table>
<tr><td rowspan="2"></td><td>Size of city</td><td rowspan="2">Big city</td><td rowspan="2">Medium city</td><td rowspan="2">Small city</td></tr>
<tr><td>Answer</td></tr>
<tr><td>Does the water in the city cause any fear?</td><td colspan="4">
</td></tr>
<tr><td rowspan="2">Is river regulation necessary in the city?</td><td>Yes</td><td>97</td><td>67</td><td>51</td></tr>
<tr><td>No</td><td>3</td><td>33</td><td>49</td></tr>
<tr><td rowspan="3">Is land development of river banks (lakes) correct?</td><td>Yes</td><td>55</td><td>60</td><td>70</td></tr>
<tr><td>I do not know</td><td>25</td><td>14</td><td>15</td></tr>
<tr><td>No</td><td>20</td><td>26</td><td>15</td></tr>
<tr><td rowspan="3">Is rainwater management appropriate?</td><td>Yes</td><td>20</td><td>30</td><td>31</td></tr>
<tr><td>I do not know</td><td>23</td><td>24</td><td>40</td></tr>
<tr><td>No</td><td>57</td><td>46</td><td>29</td></tr>
<tr><td rowspan="3">Is the water quality good?</td><td>Yes</td><td>9</td><td>18</td><td>25</td></tr>
<tr><td>I do not know</td><td>11</td><td>20</td><td>16</td></tr>
<tr><td>No</td><td>80</td><td>62</td><td>59</td></tr>
<tr><td>Is sewerage needed in the city?</td><td colspan="4">
</td></tr>
<tr><td>Is the water supply needed in the city?</td><td colspan="4">
</td></tr>
<tr><td rowspan="3">Does the sewage treatment adversely affect urban landscape?</td><td>Yes</td><td>16</td><td>27</td><td>25</td></tr>
<tr><td>I do not know</td><td>5</td><td>3</td><td>9</td></tr>
<tr><td>No</td><td>79</td><td>70</td><td>66</td></tr>
</table>

CONCLUSIONS

Complete public awareness about the quantity and quality of water is extremely valuable in carrying out any action to balance any losses and state improvement. Unfortunately, conducted research did not confirm willingness of the society to make significant compromises. However, studies have highlighted that there is a problem of water in cities. Everyone recognized the problem of poor water quality among urban water ecosystems, but not everyone was familiar with the methods and possibilities of its improvement.

One of the solutions could be an increase of ecological education, not only among children, but also among adults. In Western Europe it has been observed as a special “care” of man over almost every water body, especially in urban areas, where tanks “are conducted” in harmony with nature (Kułak and Chmielewski, 2011).

Another, can be promoting small retention as an activity increasing water resources in urban and suburban areas.

The most significant role and tools have urban planning and conservation units that should play integral part of sustainable management of water covering the whole catchment area. That’s the way of land use and the type of activity in the catchment area’s influence on the quality of water (Radwan and Sender, 2008) and the occurrence of flood risks.

Regardless of the city size and the number of the cities residents, respondents recognized the necessity of the occurrence of an aquatic ecosystems’ variety in their immediate vicinity.

In large cities, recreation was the main function which water should serve, whereas in smaller ones, water was important because of its natural meaning.

Residents of large cities had a greater need for the occurrence of ecosystems created by man.

City size and the number of residents was irrelevant in the case of indication of the ecological status of these ecosystems, which was defined as unsatisfactory. However, the need to improve the ecological status of waters was assessed unequally. Such possibilities were not pointed out in small towns.

The way of river valley’s management and reservoir embankments was inadequate, especially in big cities.

REFERENCES

1. Barthel S., Sorlin S. and Ljungkvist J., 2010 – Innovative memory and resilient cities echoes from ancient Constantinopole, in Sinclair et al. (eds), The urban mind, cultural and environmental dynamics, Uppsala University Press, 391-405.
2. Celiński F., Czylok A. and Kubajak A., 2001 – The nature guide to Dąbrowa Górnicza, Wyd. Kubajak, Krzeszowice, 1-72. (in Polish)
3. Chełmicki W., 2012 – Water, resources, degradation, conservation, Wyd. Nauk, PWN, 1-305. (in Polish)
4. Damurski Ł., 2012 – Polish planners' attitudes towards citizen participation, *Problemy Ekorozwoju - Problems of sustainable development*, 7, 2, 87-96.
5. Januchta-Szostak A., 2011 ─ Water in urban public space, Model forms of management of rainwater and surface Walters, Wyd. Politechnika Poznańska, 91-110. (in Polish)
6. Januchta-Szostak A., 2013 ─ Water ecosystems service in urban areas, in Bergier J. and Kronenberg J., (eds), Sustainable development - applications, Wyd Fund, *Sendzimira Kraków*, 3, 89-110. (in Polish)
7. Kuczyńska-Kippen N., Nowosad P. and Grzegorz G., 2004 ─ The assessment of water quality of lakes in the Wielkopolski National Park and recreational reservoirs in Poznan city in spring, in Roczniki Akademii Rolniczej w Poznaniu, CCCLXIII, 193-200. (in Polish)
8. Kułak A. and Chmielewski T. J., 2010 ─ The expectation social relating qualities farm implementing waterside recreational areas: examples from Poland, Germany and Turkey, *Problemy Ekologii Krajobrazu*, 27, 253-258. (in Polish)
9. Mioduszewski W., 1999 ─ Protection and formation of water supplies in agricultural landscape, in Wyd. IMUZ, Falenty. (in Polish)
10. Mioduszewski W., 2006 ─ Influence of small water reservoirs on groundwater level, Teka Komisji Ochrony i Kształtowania Środowiska Przyrodniczego PAN Lublin, III, 136-140. (in Polish)
11. Pawłowska K., 2012 – Public participation in decision making process aboute nature in the city, in Bergier J. and Kronenberg J., (eds), Sustainable development - applications, Wydawnictwo Fundacja Sendzimira, Kraków, 3, 49-68. (in Polish)
12. Radwan S. and Sender J., 2008 ─ Freshwater ecosystems - types, concepts of functioning and principles of protection, in Gliński J. and Michalczyk Z., (eds.), Chosen problems of water retention, UMCS Lublin, PAN O/LUBLIN, 83-93. (in Polish)
13. Sender J. and Kułak A., 2010 ─ Significance and development of small water body in the immediate vicinity of Zemborzycki water reservoir in Lublin, Teka Komisji Ochrony i Kształtowania Środowiska Przyrodniczego PAN Lublin, 7, 365-373.

THE NIGHTMARE: GENETICALLY MODIFIED ORGANISMS AS ALIEN SPECIES

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KEYWORDS: genetically modified organisms (GMOs), biotechnology.

ABSTRACT

Biotechnological applications in medicine, industry and agriculture allow the economic production of important products, thus influencing national economy and revenue. Genetic modifications on microorganisms, plants and animals are major techniques to produce a desirable trait or product in biotechnological applications. However, GMOs also give rise to severe debate on aspects such as safety and environmental impact of transgenic products. In general these controversies arise as a result of misinformation. Ethical, legal and socially acceptable aspects of GMOs are strongly influenced by social, economic and political conditions, owing to the strong economic impact of high incomes for biotechnology companies.

RÉSUMÉ: Le cauchemar: les organismes génétiquement modifiés perçus comme des espèces envahissantes.

Les applications de la biotechnologie en médicine, industrie et agriculture permettent l’obtention de produits importants par des modalités économiquement intéressantes, influençant ainsi les économies et les budgets nationaux. Les modifications génétiques apportées aux microorganismes, aux plantes et aux animaux sont des techniques majeures utilisées afin d’obtenir un certain trait ou produit dans le cadre des applications biotechnologiques. Néanmoins les OGM sont aussi la cause des débats ardus sur la sécurité des produits transgéniques et leur impact sur l’environnement. Généralement ces controverses apparaissent à la suite d’une communication défectueuse. Les aspects éthiques, juridiques et sociaux par rapport à l’acceptation des OGM sont fortement influencés par le contexte social, économique et politique, à cause de l’impact économique important des revenus engendrés par les compagnies de biotechnologie.

REZUMAT: Coşmarul: organismele modificate genetic văzute ca specii invazive.

Aplicațiile biotehnologiei în medicină, industrie și agricultură permit obținerea de produse importante prin modalități interesante din punct de vedere economic, influențând pe această cale economiile și bugetele statelor. Modificările genetice aduse microorganismelor, plantelor și animalelor sunt tehnici majore utilizate pentru a obține o trăsătură dorită sau un produs dorit în cadrul aplicațiilor biotehnologice. Cu toate acestea, OMG-urile sunt și cauza unor dezbateri aprinse cu privire la siguranța produselor transgenice sau cu privire la impactul lor asupra mediului. În general, aceste controverse apar datorită informării defectuoase. Aspectele etice, legale și sociale ale acceptării OMG-urilor sunt puternic influențate de contextul social, economic și politic, datorită impactului economic mare al veniturilor ridicate obținute de către companiile biotehnologice.

INTRODUCTION

Genetically modified organisms (GMOs) are products of modern biotechnology that encapsulate any living organism containing a novel combination of genetic material other than the natural one. In fact, the logic of the process comes from a horizontal gene transfer that naturally occurs between different species and results in an alteration of the targeted genome. For example, *Agrobacterium* sp. is able to transfer small parts of its plasmid genome to plants; or lentiviruses can transfer their genes to animal cells. Many research groups aim to determine the function of the genes by mutation, recombination, and the addition or deletion of genetic material. Nowadays, the recombinant DNA technology is widely used to produce desirable phenotype such as resistance to pests or herbicides, as well as increased production capability or quality. Genetic modifications are also important to obtain desirable traits in animals such as featherless chickens, hypoallergenic pets and pharmaceutical camels. Also the data that is obtained from gene knockout, knockdown, targeting or sequencing research allows us to understand the molecular mechanism of the human diseases. Nowadays the genetic modifications are widely used for the production of commercially valuable proteins, humanized antibodies or vaccines in pharmaceutical industry. Actually, the major aim of the pharmaceutical companies is implementation of the personalized medical applications including gene therapy by the power of the valuable data that is gained from genetic research.

In white biotechnology, producers benefit from GM microorganisms and gain important opportunities to produce value added products, and also improve enhanced productivity and yield. White biotechnology techniques that remodel all of the processing procedure help to reduce the amount of input as well as output such as waste and CO_2 emissions during the process by ways through which sustainable ecofriendly products with ruinous price can be achieved. The genetic manipulations can also be used to produce ecofriendly microorganisms that are able to clean up contaminated natural and semi natural aquatic, semiaquatic and terrestrial areas. On the other hand, risk assessment of GMO in aquatic and semiaquatic areas are more troublesome than terrestrial areas due to control in the network of interactions among species which is more difficult due to absence of safety borders. The powers of the genetic modifications are inconceivable, yet the fear over the genetic modifications that come from the unpredictable results force us to be cautious.

The economic and politics aspect of GMO on Africa

The debates related to GMO's are complex due to the power of GMO's and its related products on world economy. Nowadays the major problem comes from different views that originated by scientific and political arguments. South Africa, Burkina Faso and Egypt are three main African countries that have cultivated genetically modified crops in commercial basis (Adenle, 2011). The major problem of the African population is starvation due to drought, flooding, and poor harvests; as a result of this situation, importation of the quarter of African food causes economic crisis and collapsing of these areas because the majority of the public are engaged in agriculture (Cooke and Downie, 2010). Bioengineered plants and its products have strong economic impact due to high incomes for farmers as well as low prices and increased quality food for consumers (Anderson, 2010). Due to economic welfare gains from crop biotechnology, African and Asian countries support cultivation of biotech crops. On the other hand, until the third world countries develop scientific groundwork and reach high technological levels, their dependency to multinational companies and international research agencies cause a collapse of the third world countrys' economies.

Kenya has claimed that GM crops are important to solve the world's starvation problem, thus GM varieties have such properties as early-maturing, drought, pest and disease resistance (Cartagena Protocol on Biosafety, 2010). Thus Kenya appealed to the African Union in January of 2013 to evaluate GM crops in aspects of economic, strategic and international profit (Hoefler, 2013). Kenya's Minister for Science and Technology declared that genetically modified organisms (GMOs) is crucial for economic and technological development, thus Kenya regulates its legal groundwork suitable to benefit from GM products. On the other hand, most of the African countries have obeyed the rules of Cartagena Protocol on Biosafety. For example, the Tanzanian government effort to develop its own National Biosafety Framework (NBF) to reduce the risks of modern biotechnology (Mugurusi and Mwinjaka, 2006), yet the knowledge and awareness of the public is not good enough. Tanzanian farmers do not raise awareness of potential risk of the GM crops. Unlike Tanzanian government farmers who attach importance to increase overall crop production rather than potential health or ecological related risk (Lewis et al., 2010).

Cassava (*Manihot esculenta* C.) is an important carbohydrate and micronutrient source in rural areas of Africa, Asia, and Latin America, yet in case of nutritional deficiencies or inadequate process of the plant results neurotoxicity due to its high content of cyanogenic glycoside (Rivadeneyra-Domínguez et al., 2013). The genetically modified cassava is important for food and feed safety as well as enhanced starch production (Ihemere et al., 2006; Jansen van Rijssen et al., 2013), thus GM cassava is an important food crop that is used by more than 500 million people. An another important source of caloric intake in the tropical African people diet is maize (Miracle, 1966). Genetically modified maize that is resistant to insects and drought is cultivated in Kenya, South Africa, Tanzania, Uganda, and Zimbabwe; and up to 80% of cultivated white maize is genetically modified in South Africa.

Debates related to biosafety of the GM products

Genetically modified product has already been on the market without labeling. The presence of Starlink corn and Roundup Ready soybean was found on the Egyptian food market (Elsanhoty et al., 2002). Elsanhoty et al. (2002) have often detected genetically modified rice, maize, and soy by qualitative and quantitative DNA-based methods in Saudi food products (Elsanhoty et al., 2013). Rabiei et al. (2013) demonstrated the presence of GM maize in Iranian specific food products by qualitative PCR. In another study, fresh and processed foods were screened to check genetic modifications by SYBR green-based, real time polymerase chain reaction (RT-PCR) method in Kuwait and positive results were obtained from the samples (Al-Salameen et al., 2012). Genetically modified organisms were also found without labeling on food and animal feed in China (Zhou et al., 2005).

Sieradzki and colleagues have shown how GM DNA is digested as well as their conventional counterparts; but no samples were obtained from animal tissue the GM DNA transfer from feed to animal tissues and bacterial gut flora (Sieradzki et al., 2013). Another study that was performed on animals showed that diets containing GM maize, potato, rice or soybean are nutritionally equivalent to their non-GM counterparts and are also safe for human and animals (Snell et al., 2012). Snell et al. (2012) have evaluated long-term as well as multigenerational animal feeding studies via systematic review of many data that included: biochemical analyses, histological examination of specific organs, haematology and the detection of transgenic DNA from different studies; yet any significant differences between GM plants and non-GM counterparts could not be found (Snell et al., 2012). Besides these studies, Séralini et al. (2012) performed a study that aimed to show life-long consumption of an agricultural genetically modified organism (Séralini et al., 2012), yet this publication caused speculation and many comments were sent to authors; consequently, journals withdrew the paper. The main reason of this speculation was Séralini and colleagues preferred a rat strain that were prone to cancer and also mycotoxin content in the feed could trigger cancer initiation as well as GM feed (Pilu, 2013). None of these specific studies showed till the present long term cumulative negative effects of genetically modified organisms efficiently, thus there are numerous concerns related to GMO's due to uknown/unpredictable effects on human health and environment.

One of the important questions related to GM plant derived food and feed is allergenic reactions based on the fact that transgene can be identical to an allergen in a different food source (Panda et al., 2013). The second inquietude is the potential risk of conversion of non-toxic amino acid sequences to toxic compounds after modification of proteins (Hammond et al., 2013). Another apprehension is denaturation of the protein during the processing conditions to functionally active proteins that are harmful to human health (Hammond et al., 2013). Thus both labeling and traceability is crucial to obtain risk assessment of GM products. The European Union has strict regulations and policyes to protect human life, health and welfare aside assessment of environmental risks due to the questions regarding GMOs' safety (Davison, 2010). European Commission has authorized food and feed ingredients containing, consisting of, or produced from different GM products such as cotton, maize, potato, soy-bean or sugar beet; yet authorization for usage varies among GM products due to genetic characteristics (European Commission Report, 2012). In the European Union, common procedures for risk assessment and authorization are efficient to protect human, animal, and plant health as well as prevent the spread of the GMOs' slaughter of biodiversity.

The current status of Turkey: in 1993, "Biodiversity Convention" is a global agreement addressing the regulation related to biodiversity and was signed by a total number of 156 countries including Turkey, then the complementary regulation "Cartagena Protocol on Biosafety" has been approved in 2004. The legal regulation related to GMOs' production, consumption and inspection was first legally regulated and for the first time genetically modified product definition was enacted in Turkey in 2004. In 2009 another specific regulation that aims to regulate and control importations, exportation and also processing of GMOs' as food and feed additives has entered into force in Turkey. The procedures and principles that regulate the establishment and implementation of biosafety systems includes control, regulation and monitoring of these systems to prevent risks arising from GMOs which were determined within the scope of "Bio safety Law" in 2010.

The nightmare of genetic modifications

The long term effects of the GMOs on human beings or the environment is not clear, thus public reaction is worrisome due to information pollution. The main question is whether GMOs are an environmental threat or ecological risk to the universe. The debate comes from the fact that genetically modified organisms are seen as alien species that are able to spread out and supplant native species. The hypothetical risk is if a transgene will be invasive and flow throughout species and cause new ecologically harmfull phenotypes or alter the current metabolic pathways and thus produce more toxic compounds.

The fear of the transgene dispersal can be a result of transportation by pollen migration or mixing the GM and non-GM seeds (Ricroch et al., 2009). Pollen mediated gene flow can occur between transgenic plant and wild races and related species (Tang et al., 2005; Hüsken and Dietz-Pfeilstetter, 2007). The transgene transportation by pollen migration can cause an increase in the recessive alleles frequencies and both recessive alleles and transgenic alleles can be distributed quite quickly, especially in selfing plants. The cross pollination is also another important challenge due to the capability of introducing the altered gene in the normal plant via pollination with GM plants. Galeano and colleagues performed a study in Uruguay and the results of the study showed that the transgenic pollen were spread out of the control area and 0.13% of the transgene were determined in the offspring of the non-GM crops (Galeano et al., 2010). Transportation of the transgenic plants are also a potential risk to biodiversity. Waminal and colleagues have shown that genetic alteration on wild type race in different private farms and public areas near a transportation route of genetically engineered maize (Waminal et al., 2013). The other drawback is that weeds can gain resistance genes from GMO's via cross-pollination of the weeds by resistant plants. The gene flow between the crop and certain weeds can cause weeds that have resistance to different herbicides to obtain an advantage. Terminator gene technology that allows inhibiting cross pollination by producing sterile seeds from the genetically modified plant could be a solution to prevent herbicide-resistant biotypes of weeds. On the other hand, terminator gene technology causes extra economic burdens to farmers due to the requirement of re-purchasing the non-sterile seed each year. This point also explains why genetically modified crops could not be the solution of economic crisis in third world countries.

Aside from terrestrial ecosystems, genetic modifications can be seen as a threatening problem for the natural and seminatural aquatic and semiaquatic ecosystems diversity. In fact, in aquatic and semiaquatic systems, utilization of the genetic modifications in plants are more troublesome because the prevention of the gene flow can not be gained via safety borders. Nowadays, genetically modified algae and its biomass are important for biofuel production, yet during the cultivation process, gene flow or mono cultivation are the major problems for aquatic ecosystems. On the other hand, monitoring the area is crucial to gain biosafety of the other aquatic organisms such as fish or crustaceans. In aquatic ecosystems, controlled passing of the organisms or the intervention via direct regulation of the control is impossible by biosafety borders.

In the views of aquatic and semiaquatic organisms, escape of transgenics organisms are a threatening problem for aquatic communities. Introduction of transgenic fish that are capable to grow up more easily than its counterpart cause substantial shifts in aquatic ecosystems and culminate as a transgenic dominant species. Furthermore, that situation causes a lose of genetic diversity and as a result causes elimination of the recessive traits and also increase the transgenic allele frequencies. Due to that reason, considerable efforts must be shown for controlling and monitoring the GM organisms for effective ecosystem management.

Biotechnology in ecological aspects

Biotechnological application on the industrial process allows the design of desirable phenotypes in order to produce important industrial products by creating value-added products with advanced technology. Metabolic engineering is a process that allows changing metabolic pathways to produce industrial and pharmaceutically important molecules such as valuable proteins, polypeptides, as well as primary and secondary metabolites. For example, rational design of the metabolic pathway of *S. cerevisae* allows resistance to oxidative stress and this helps to reduce the requirements of the microbial process and also increases the yield process and allows easily optimizing fermentation processes which increases the yield give advantage to reduce the amounts of toxic waste.

Biotechnical principles allow toxicity reduction of the conventional process via replacement of biotechnological methods or biodegradation of industrial pollutants. For example, creating the product via manipulation of the enzymatic process instead of chemical usage allows the reduction of toxic chemical requirements, thus finding ecological friendly solutions during the production process. In fact, enzymes have been used for a long time in industrial application, but the genetic manipulations on microorganisms yield super enzymes that have high substrate, specificity and catalytic properties such as maximum efficiency at a desired temperature with lower feedback inhibition properties. For example, genetically modified lipases and esterases are mainly used in biofuel production, textile processing, waste treatment, and also preferred as detergent additives in industry.

By ecological aspects, the organic wastes or microbial bulk can be used to produce biofuels (hydrogen or ethanol) and those new renewable energy alternatives are different from natural fuels or nuclear fuel with its ecological friendly properties. If the biofuel contaminations occur due to spills, these biomolecules can be easily degragate in the environment. Although biofuels have the same emission with fossil fuels, biofuels are still the best alternative due to low sulfur content, therefore biofuels are a good alternative to protect the earth against acid rain. In another perspective, the countries that have enough land area can profit from biofuel protection in commercial basis and gain its economic independence from fossil fuel producing countries.

Genetically modified organisms can be used for bioremediation of contaminated water and landscape via conversion of organic compounds into smaller pieces (biotransformation) or complete convertion of the cell mass by mineralization of organic molecules until CO_2, water and inorganic elements which turn into inorganic compounds (mineralization). Genetic modification of the microorganisms also allows coagulating sedimentation of the colloidal solids in wastewater and resolves organic matter for stabilization. Bioremediation occurs via genetically modified organisms or products of GMOs by reducing the nitrogen and phosphorus content in domestic and agricultural wastewater. For example, pesticide contaminated water can be cleaned by organophosphate degrading enzymes that immobilized on nonwoven polyester textiles (Gao et al., 2014). In another example, purification of oil pollution at sea can be achieved by genetic modification of the *Proteobacteria*, *Pseudomonas* and *Cycloclasticus*, and this is important to break down spilled hydrocarbon quickly during accidents such as Exxon Valdez. After the Exxon Waldez accident, scientists performed a study to produce transgenic *Pseudomonas* that are capable to degradate petroleum as a nutrient source to survive and clean-up aquatic areas quickly and safely in extreme cold conditions. Removing hazardous chemicals from industrial wastewater is an ecologically important application of biotechnology. For example, industry, textile effluent contaminated environments can easily be cleaned up from malachite green dye by *Ochrobactrum* sp. (Vijayalakshmidevi and Muthukumar, 2013). Polluting effects of diesel fuel, the process and mechanism of its biodegradation, the role of different microbes having degradation potential and their application strategies, were under the scientists attention (Bhawsar and Cameotra, 2011).

On the other hand, bioterrorism can be a major fear for aquatic, semiaquatic and terrestrial ecosystems because genetically modified organisms can easily adapt to specific environments and can be the dominant species in an extremely short period of time.

If we think about the transfer of insects that gain resistance to different categories of insecticide and damage ecological systems and their specific balance or cultivation of herbicide and pesticide resistant weed species by enemies. Simply, bioterrorist application contaminates water by infectious genetically modified microorganism that are resistant to antibiotics.

Kenya has claimed that GM crops are important to solve the world's starvation problem, thus GM varieties have such properties as early-maturing, drought, pest and disease resistance which will be promote to utilization (Cartagena Protocol on Biosafety, 2010). Thus Kenya appealed to the African Union in January of 2013 to evaluate GM crops in aspects of economic, strategic and also so called international profit (Hoefler, 2013). Kenya's Minister for Science and Technology declared that genetically modified organisms (GMOs) are crucial for economic and technological development, thus Kenya's regulation of its legal groundwork is suitable to benefit from GM products.

On the other hand, most of the African countries have wiselly obeyed the specific rules of Cartagena Protocol on Biosafety. For example, the Tanzanian government's effort to develop its own National Biosafety Framework (NBF) to reduce the risks of modern biotechnology (Mugurusi and Mwinjaka, 2006), yet the knowledge and awareness of the public is not good enough. Tanzanian farmers are not aware of the potential risk of the GM crops. Unlike the Tanzanian government, farmers attach importance to increase overall crop production rather than potential health or ecological related risk (Lewis et al., 2010).

CONCLUSIONS

There is an ongoing international debate related to genetic engineering of organisms in order to produce desirable phenotype.

The general public opinion and power of civil society activist groups draws attention to genetically modified organisms and try to force the governments to legally see how to make arrangements that also seal countries' fate on economic and politics areas.

In green biotechnology, the principal advantage of genetic modifications is a significant improvement of food taste and texture, nutritional value and crop yield as well as the reduction in crop susceptibility to different pathogens and also environmental stresses.

The general disadvantage seems to be connected with health and environmental risk. The possibilities of allergic and toxic reactions, loss of biodiversity, genetic pollution, ecotoxicity are main concerns over GMOs.

The most important economic disadvantage of the green biotechnology is to transform biotechnological seed companies into a global monopoly and cause poorer farmers.

In red biotechnology the genetic modifications allow scientists to grasp a better understanding of molecular mechanisms of diseases. New generation of biopharmaceuticals will improve drug safety. Pharmacogenomics allows personalized medicine rather than "one drug fits all" and that improves an individual's response to drugs by optimizing drug dosage, maximizing therapeutic effect and minimizing side effects. The main controversy over red biotechnology is discrimination of the indivuals due to genetic information of the databases. The main disadvantage comes from the fact that leakage of medical or genetic information causes non-ethical approaches and behaviors by private insurers or employers.

Innovations in industrial biotechnology allow to create new products or to improve the existing production processes. This knowledge based technology provides sustainable development for countries producing value-added co and by-products of bioprocesses. Metabolic engineering, fermentation technology and production of bio-fuels are the main research focus on white technology. The main advantage of white biotechnology is protection of environment and ensures healthy eco-systems. If handled properly, all parts of biotechnology benefits humankind, yet the careless and non-ethical usage of the technology may cause disasters like the nuclear bomb.

REFERENCES

1. Adenle A. A., 2011 – Response to issues on GM agriculture in Africa: Are transgenic crops safe? *BMC Research Notes*, 4, 388.
2. Al-Salameen F., Kumar V., Al-Aqeel H., Al-Hashash H. and Hejji A. B., 2012 – Detection of genetically modified DNA in fresh and processed foods sold in Kuwait, *GM Crops Food*, 3, 4, 283-288.
3. Anderson K., 2010 – Economic impacts of policies affecting crop biotechnology and trade, *New Biotechnology*, 27, 558-564.
4. Bhawsar S. and Cameotra S. S., 2011 – Biodegradation of diesel fuel, *Transylvanian Review of Systematical and Ecological Research*, The Wetlands Diversity, Curtean-Bănăduc et al., (eds), 12, 169-180.
5. Cooke J. G. and Downie R., 2010 – African Perspectives on Genetically Modified Crops Genetically Modified Crops Assessing the Debate in Zambia, Kenya and South Africa, A Report of the CSIS Global Food Security Project, Center for Strategic and International Studies, Washington, USA.
6. Davison J., 2010 – GM plants: Science, politics and EC regulations, *Plant Science*, 178, 2, 94-98.
7. Elsanhoty R. M., Al-Turki A. I. and Ramadan M. F., 2013 – Prevalence of genetically modified rice, maize, and soy in Saudi food products, *Applied Biochemistry and Biotechnology*, 171, 4, 883-899.
8. Elsanhoty R., Broll H., Grohmann L., Linke B., Spiegelberg A., Bögl K. W. and Zagon J. 2002 – Genetically modified maize and soybean on the Egyptian food market, *Nahrung*, 46, 5, 360-363.
9. European Commission, 2012 – Register of genetically modified food and feed European Commission, Health and Consumers, EU register of authorised GMOs Available at: http://ec.europa.eu/food/dyna/gm_register/index_en.cfm (10.12.2013).
10. Galeano P., Debat C. M., Ruibal F., Fraguas L. F. and Galván G. A., 2010 – Cross-fertilization between genetically modified and non-genetically modified maize crops in Uruguay, *Environmental Biosafety Research*, 9, 3, 147-154.
11. Gao Y., Truong Y. B., Cacioli P., Butler P. and Kyratzis I. L., 2014 – Bioremediation of pesticide contaminated water using an organophosphate degrading enzyme immobilized on nonwoven polyester textiles, *Enzyme and Microbial Technology*, 10, 54, 38-44.
12. Hammond B., Kough J., Herouet-Guicheney C. and Jez J. M., 2013 – Toxicological evaluation of proteins introduced into food crops, *Critical Reviews in Toxicology*, 43, 2, 25-42.
13. Hüsken A. and Dietz-Pfeilstetter A., 2007 – Pollen-mediated intraspecific gene flow from herbicide resistant oilseed rape (Brassica napus L.), *Transgenic Research*, 16, 5, 557-69.
14. Ihemere U., Arias-Garzon D., Lawrence S. and Sayre R. 2006 – Genetic modification of cassava for enhanced starch production, *Plant Biotechnology Journal*, 4, 453-465.
15. Jansen van Rijssen F. W., Morris E. J. and Eloff J. N., 2013 – Food Safety: Importance of Composition for Assessing Genetically Modified Cassava (Manihot esculenta Crantz), *Journal of Agricultural and Food Chemistry*, 61, 8333-8339.
16. Lewis C. P., Newell J. N., Herron C. M. and Nawabu H., 2010 – Tanzanian farmers' knowledge and attitudes to GM biotechnology and the potential use of GM crops to provide improved levels of food security, A Qualitative Study, *BMC Public Health*, 12, 407.
17. Mugurusi K. and Mwinjaka S., 2006 – National Biosafety Framework for Tanzania: Regulatory regime on genetically modified organisms, in Rege J. E. O., Nyamu A. M. and Sendalo D. (eds), The role of biotechnology in animal agriculture to address poverty in Africa: Opportunities and challenges, *Proceedings of the 4th All Africa Conference on Animal Agriculture and the 31st annual meeting of Tanzania Society for Animal Production*, Arusha, Tanzania, 20-24 September 2005, Dar es Salaam, Tanzania: TSAP and Nairobi, Kenya: ILRI.

18. Panda R., Ariyarathna H., Amnuaycheewa P., Tetteh A., Pramod S. N., Taylor S. L. Ballmer-Weber B. K. and Goodman R. E., 2013 – Challenges in testing genetically modified crops for potential increases in endogenous allergen expression for safety, *Allergy*, 68, 2, 142-151.
19. Pilu R., 2013 – Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize, *Food and Chemical Toxicology*, 53, 454.
20. Rabiei M., Mehdizadeh M., Rastegar H., Vahidi H. and Alebouyeh M., 2013 – Detection of genetically modified maize in processed foods sold commercially in Iran by qualitative PCR, *Iranian Journal of Pharmaceutical Research*, 12, 1, 25-30.
21. Ricroch A., Bergé J. B. and Messéan A., 2009 – Literature review of the dispersal of transgenes from genetically modified maize, *Comptes Rendus Biologies*, 332, 10, 861-75.
22. Rivadeneyra-Domínguez E., Vázquez-Luna A., Rodríguez-Landa J. F. and Díaz-Sobac R., 2013 – Neurotoxic effect of linamarin in rats associated with cassava (Manihot esculenta Crantz) consumption, *Food and Chemical Toxicology*, 59, 230-235.
23. Séralini G. E., Clair E., Mesnage R., Gress S., Defarge N., Malatesta M., Hennequin D. and de Vendômois J. S., 2012 – Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize, *Food and Chemical Toxicology,* 50, 11, 4221-4231.
24. Sieradzki Z., Mazur M., Kwiatek K., Swiatkiewicz S., Swiatkiewicz M., Koreleski J., Hanczakowska E., Arczewska-Włosek A. and Goldsztejn M., 2013 – Assessing the possibility of genetically modified DNA transfer from GM feed to broiler, laying hen, pig and calf tissues, *Polish Journal of Veterinary Sciences*, 16, 3, 435-441.
25. Snell C., Bernheim A., Bergé J. B., Kuntz M., Pascal G., Paris A. and Ricroch A. E. 2012 – Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: a literature review, *Food and Chemical Toxicology*, 50, 3-4, 1134-1148.
26. Tang G., Song W. and Zhou W., 2005 – Gene flow and its ecological risks of transgenic oilseed rape (Brassica napus), *Ying Yong Sheng Tai Xue Bao*, 16, 12, 2465-8.
27. Unknown, 2010 – Cartagena Protocol on Biosafety: Fifth meeting of the Conference of the Parties UN conference adopts international liability rules for ecological damage resulting from genetically modified organisms, available at: http://dev.gmo-safety.eu/news/1233.conference-adopts-international-liability-rules-ecological-damage-resulting-genetically-modified-organisms.html (10.12.2013).
28. Vijayalakshmidevi S. R. and Muthukumar K., 2013 – Biodegradation of malachite green by Ochrobactrum sp., *World Journal of Microbiology and Biotechnology*. (in printing)
29. Waminal N. E., Ryu K. H., Choi S. H. and Kim H. H., 2013 – Randomly Detected Genetically Modified (GM) Maize (Zea mays L.) near a Transport Route Revealed a Fragile 45S rDNA Phenotype PLoS One. 9, e74060.
30. Zhou J. C., Yang M. J., Yang X. F. and Huang J. M., 2005 – Detection of genetically modified organisms in food and animal feed by polymerase chain reaction, *Wei Sheng Yan Jiu*, 34, 6, 732-734.

DE GRUYTER OPEN

EFFECTS OF RIVER REGULATION ON PLANT DISPERSAL AND VEGETATION

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KEYWORDS: river corridors, seed bank, river regulation, plant dispersal invasions.

ABSTRACT

This study compares the vegetation and seed deposits of free-flowing parts of a river with those regulated by straightening, as well as identifying the correlation between the breadth of the river-bed, existent vegetation and distribution of plant species along the river corridor. The 31 sampling plots in the Ukrainian Carpathians, at an equal distance of four km from each other, were positioned across different vegetation zones. Vegetation and seed bank data were collected. The study showed that effective distribution of plants has a place in native (non-regulated) river-corridors with a river-bed breadth of 15-30 m. The reduction and straightening of the river-bed decrease the number of species that can be dispersed along river. The percentage of seeds of alien species greatly increases, from 0.1% in the free-flowing to 10% in the regulated parts of rivers. River regulation causes transformation of native vegetation communities in these plots into associations of invasive herbaceous perennial species; such as associations of *Helianthus tuberosus* and *Solidago gigantea*. The analyses do not show a clear link between the breadth of the river-bed and number of invasive species in the vegetation community. The research suggests that river regulation has a clear negative effect on vegetation by decreasing the resistance of plant communities to alien species.

RESUMEN: Efecto de la regulación fluvial en la vegetación y dispersión de plantas.

En este estudio se hace una comparación entre vegetación y depósitos de semillas en cuerpos de deriva, y la regulación fluvial hecha mediante obliteración de flujo; así mismo se identifica una correlación entre la anchura del cauce, la vegetación existente y la distribución de las especies de plantas observadas a lo largo del corredor fluvial. En el área de los Cárpatos ucranianos, en distintas zonas con vegetación, se establecieron 31 sitios de muestreo dispuestos de forma equidistante cada cuatro km unos de otros. Se realizó una colecta de la vegetación y se tomaron datos del banco de semillas. El estudio mostró que la distribución efectiva de las plantas tiene lugar en corredores fluviales autóctonos (no regulados) con un cauce de entre 15 y 30 metros. La obliteración del cauce reduce el número de especies que pueden dispersarse a lo largo del río. El porcentaje de semillas de especies foráneas se incrementa dramáticamente de 0,1% en los objetos flotantes, hasta 10% en los segmentos regulados de los ríos. En estos lugares, la regulación fluvial transforma las comunidades vegetales nativas a asociaciones de especies de hierbas invasivas como *Helianthus tuberosus* y *Solidago gigantea*. Los análisis no muestran una relación clara entre el cauce del río y el número de especies invasivas en las comunidades de plantas. Esta investigación sugiere que la regulación fluvial tiene evidentes impactos negativos en la vegetación, provocando una disminución en la resistencia de las comunidades vegetales nativas a las especies de plantas invasivas.

REZUMAT: Efecte ale regularizării râurilor asupra speciilor de plante şi a vegetaţiei.

Prezentul studiu compară vegetaţia şi depozitele de seminţe din sectoarele liber curgătoare ale râurilor cu cele regularizate prin rectificarea cursului, precum şi identifică corelaţia dintre lăţimea albiei, vegetaţia existentă şi distribuţia de specii de plante de-a lungul coridorului râului. Cele 31 de staţii studiate, situate la o distanţă de patru kilometri una de celalaltă, au fost alese în zone cu diferite tipuri de vegetaţie. Au fost colectate atât date de vegetaţie, cât şi a băncilor de seminţe. Studiul arată că distribuţia actuală a speciilor de plante este legată de coridoarele naturale, neregularizate cu o lăţime a albiei de 15-30 m. În partea redusă şi rectificată a albiei scade numărul speciilor distribuite de-a lungul râului. Procentajul de seminţe ale speciilor neofite creşte extrem de mult de la 0,1% în sectoarele liber curgătoare la 10% în părţile regularizate ale râurilor. Regularizarea de râuri cauzează transformarea comunităţilor naturale de vegetaţie în aceste sectoare spre comunităţi de specii de plante perene, invazive cum sunt cele de *Helianthus tuberosus* şi *Solidago gigantea*. Analiza nu arată o relaţie clară între lăţimea albiei şi numărul de specii invazive în asociaţia de plante. Cercetarea desfăşurată arată că regularizarea râurilor are efecte negative clare asupra vegetaţiei ripariene prin scăderea rezistenţei comunităţilor de plante la specii neofite.

INTRODUCTION

As functional linkages between sites, floodplain ecosystems of the Transcarpathia are an important component of ecological corridors. They are essential to maintaining and restoring a degree of coherence in fragmented ecosystems. These corridors are naturally existing connections, where the focus is on conservation of biodiversity (Bennett and Mulongoy, 2006). River corridors encompass sharp gradients of environmental factors and ecological processes. Thanks to these characteristics they has important functional role (Curtean-Bănăduc et al., 2014) and are considered hotspots of species diversity (Gepp et al., 1985; Schneider and Schariz, 1986; Naiman et al., 1993; De'camps and Tabacchi, 1994; Naiman and De'camps, 1997).

The rivers corridors are unique in regard to biodiversity: Transcarpathia harbours refuges of ancient primeval riverine forests of Europe. The territory covered by fragmented primeval Pannonian riverine forests consists of 1,400 hectares, 70% of which are unique oak-ashen forests. This is the same size as the one covered by primeval riverine forests in Austria, Hungary and Slovenia, combined. Unfortunately, 13,000 ha of floodplain forests within the Transcarpathian Plain have been destroyed over the last century. A similar situation has been identified in neighboring Slovakia as well. The decrease of riverine forest areas in the northeastern part of the Hungarian Plain during the last century is calculated to be 41% (transboundary lowland Slovakia) and 44% (Transcarpathia), respectively (Prots, 2010).

Currently, river corridors in the Transcarpathia are threatened by strong human impact as well as building of small hydroelectric power stations, dams and river bed straightening. These activities change the native hydrologic regime and may cause the destroying of river corridor functions. The studies showed the negative effects of fragmentation by dams on river corridors (Petts, 1984; Dynesius and Nilsson, 1994). Vegetation changes following hydrological alterations have been documented for vascular plants (Nilsson et al., 1991, 1993; Nilsson and Jansson, 1995; Toner and Keddy, 1997) and for bryophytes (Englund et al., 1997) as well, but there are few observations on how river regulation by dams and river bed straightening affects the plant dispersal. We assume that baseless river regulation may increase an invasion of alien plants, as well as negatively affect species' diversity and plants' dispersal. More knowledge about this is needed for sustainable development of floodplain ecosystems.

At first, the river regulation by dams and river bed straightening, caused the contraction of river bed and floodplains. Therefore this paper will focus on the correlation between the breadth of river-bed and the extant to which vegetation and plants species distribute along river corridors.

MATERIALS AND METHODS

Study area

This study was carried out in the riparian ecosystems of Ukrainian Transcarpathia (Zakarpatska Oblast Province; neighbouring Hungary, Slovakia, Romania and Poland). This territory has a total area of 12,800 km^2 and is located in the Carpathian Mountains region of Western Ukraine. The region's climate is moderate and continental with about 700-1,500 mm of rainfall per year. The average temperature in summer is +21°C and -4 C in winter (Bodnar, 1987).

The main river of the Transcarpathian region is Tisa (Tisza), which is a part of the Danube basin. The river basin of Tisa includes more than 9,000 rivers and streams, the most important being Borzhava, Latorytsia and Uzh (Pop, 2003; Anychin and Spyrydorov, 1947). The Uzh and Latorytsia were chosen for our study as the two biggest rivers with similar environmental conditions. The Uzh is 133 km long (112 km of which are on the Ukrainian territory), the basin area is 2,750 km^2; Latorytsia is 188 km long (156.6 km on Ukrainian territory), with a basin area of 7,680 km^2. Both rivers have their headwaters in the high Carpathian Mountains at altitudes of one thousand (Uzh) eight hundreds metres (Latorytsia) crossing a region of low volcanic mountains and lowland plain. The average water consumption in the mountain region is 8.8 m^3/s. At the source, rivers are very rapid, but in the lowland plain, the river bed widens and the rate of water decreases; the average flow velocity being 0.4-0.6 m/s.

The strong and spontaneous floods, up to eight to nine per year (normally caused in March-August by intense rains), promote considerable differences in water levels with steep rises and following falling levels, are a special feature in the regime of both rivers. During the growing season, the water level is highest in March-July and usually lowest in August-September (Herenchuk, 1981).

Sampling and data collection

In total, 31 sampling plots (16 along Uzh and 15 along Latorytsia), at an equal distance of four km from each other, were positioned across three different zones. These included high mountains, volcanic mountains and lowland plain (Fig. 1). The 28 sampling plots were located at free-floating parts of rivers (16 along Uzh and 12 along Latorytsia); three sampling plots were located along Latorytsia at the regulated part. The sampling plots were located on the river shore exposed to flooding.

A permanent vegetation quadrate of 200 m^2 was established at each sampling plot. Vegetation composition was determined during August 2010, using the Braun-Blanquet methodology (Braun-Blanquet, 1964).

The composition of the seed bank was determined (Ter Heerdt et al., 1996) by sampling and carefully digging up the sediment (Ter Heerdt et al., 1996) using a standard 6.9 cm diameter and 6.3 cm height metal cylinder (volume is 235,46 cm^3). The seed bank was sampled in five replicates at each of the thirty one plots. The five samples from the same plot were mixed and one averaged sample of soil was prepared.

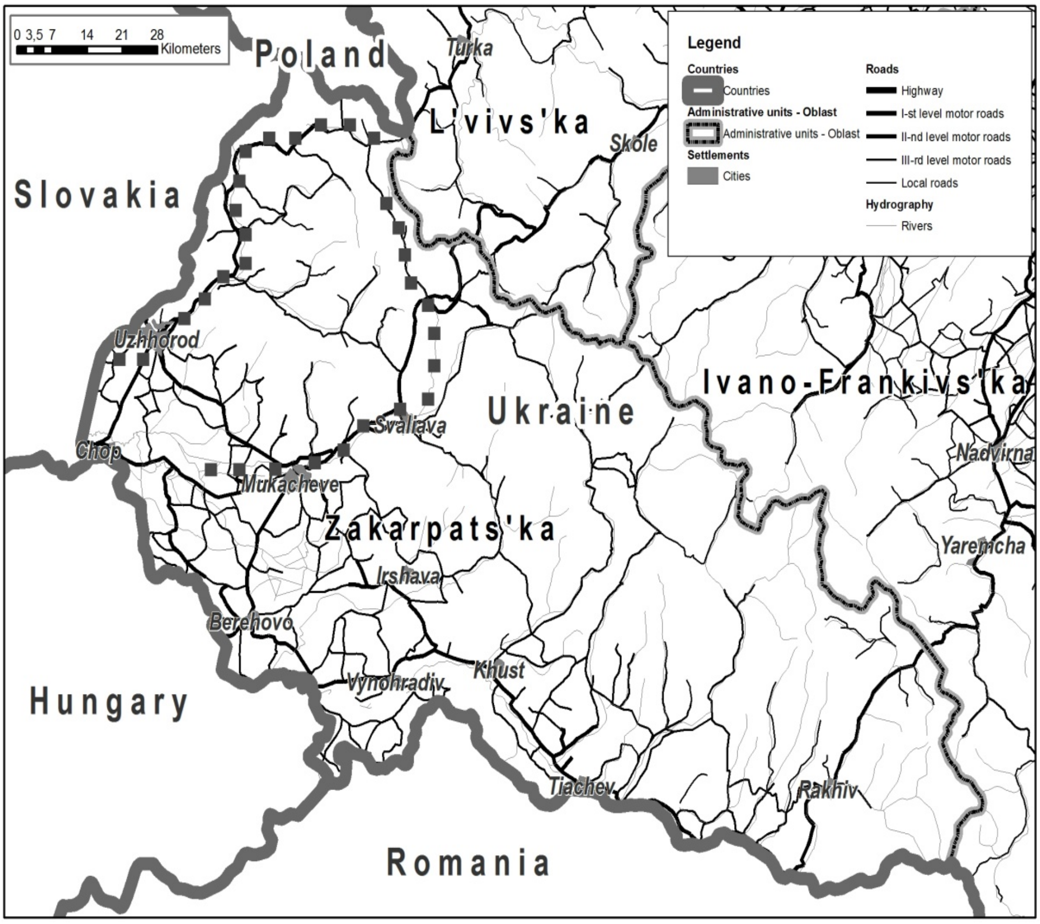

Figure 1: The location of samples plots (black cubes) in the Transcarpathia of Ukraine.

In laboratory pebbles and large organic remains were singled out. At the next step all samples were sieved twice; first through a five millimeters mesh, then large seeds were selected from dropout manually, sifting under binocular viewing. Soil that had passed through the first sieve was sieved through the one millimeter mesh, which was only slightly larger than the mean particle size of the sand, for separating small seeds.

All separated seeds from the same plot were collected, calculated and then identified using a printed atlas for seeds identification (Maysuryan and Atabekova, 1978) and electronic identification of seeds (http://seeds.eldoc.ub.rug.nl/root/).

RESULTS AND DISCUSSION

The extant vegetation cover at each plot has been studied along Uzh and Latorytsia rivers. This study shows the contrasts in the species richness floodplain ecosystems of regulated and free-floating rivers. The river-bed straightening shows a rise in the number of invasive species by decreasing resistance of vegetation communities to alien plants invasion. It causes forming of synanthropic vegetation types at the regulated parts of rivers.

The analyses showed that on 28 plots the innate floodplain vegetation cover is intact, though at some plots it was restored after the building of dams and bridges. At the upper course of both rivers the plants communities are presented by class *Rhamno-Prunetea spinosae* Rivas Goday and Borja Carbonell 1961 ex R. Tx. 1962. Further downstream, where vegetation cover is being restored after disturbances, it forms wet meadows, which belong to associations of classes *Molinio-Arrhenatheretea* R. Tx. 1937. At the Pannonian lowland, where the river-bed was widened from 20 to 40 meters, the native vegetation is presented by floodplain forest associations of classes *Salicetea purpureae* Moor 1958 and *Querco-Fagetea* Br.-Bl. et Vlieger 1937 (Tabs. 1 and 2).

It has been defined, that river bed straightening has caused the most crucial impact on extant floodplain vegetation by contraction of river-bed and floodplains. The innate floodplain vegetation on the three plots located along the fragment of Latorytsia River, that has been regulated, is replaced by invasive species. River-bed at this territory has been reduced from 40-45 to 10 meters and existent floodplain forests and bushes have been cut out. The vegetation at these plots is represented by perennial invasive herb communities that belong to associations of *Helianthus tuberosus* Hilb. 1972 and *Solidago gigantea* Hilb. 1972 of the class *Artemisietea vulgaris* Lohmeyer et al. ex von Rochow 1951 (Tab. 2).

The percentage of alien species abundance from all the vegetation cover at the study plots located along unregulated, as well as regulated parts of the rivers, doesn't show a strict correlation with the breadth of river-bed and varies from 15.6% to 27.3%. But the abundance of species doesn't show the participation of a part of these species in the studied communities.

Table 1: The description of sample plots along Uzh River.

Vegetation type	Breadth of riverbed	Location of the plots (enumeration of the plots starts from river headwaters)
Class *Rhamno-Prunetea spinosae* Rivas Goday and Borja Carbonell 1961 ex R. Tx. 1962 *Pruno-Ligustretum* R. Tx. 1952	10-20	Plots no. 1-2 at Uzh River, close to the village of Luh
Class *Molinio-Arrhenatheretea* R. Tx. 1937 *Ranunculo repentis-Alopecuretum geniculati* R Tx. 1937	15	Plot no. 3 at Uzh River, close to the village of Stavne
Class *Salicetea purpureae* Moor 1958 *Salicetum purpureae* Wendelberger-Zelinka 1952 *Salicetum albae* Issler 1926 *Salicetum fragilis* Passarge 1957	15-40	Plot no. 4-16 at Uzh River, close to village of Stavne, Zhornava, Kostryna, Sil, Velykyi Bereznyi, Zarichovo, Perechyn, Nevytske, town of Uzhgorod

Table 2: The description of sample plots along Latorytsia River.

Vegetation type	Breadth of riverbed	Location of the plots (numeration of the plots starts from river headwaters)
Class Rhamno-Prunetea spinosae Rivas Goday and Borja Carbonell 1961 ex R. Tx. 1962 Pruno-Ligustretum R. Tx. 1952	15	Plot no. 1 at Latorytsia River, close to village of Bilasovytsia, downstream
Class Salicetea purpureae Moor 1958 Salicetum fragilis Passarge 1957 Salicetum purpureae Wendelberger-Zelinka 1952 Salicetum eleagno-purpureae	15-30	Plots no. 2-11 at Latorytsia River, close to villages of Tyshiv, Nyzni Vorota, Pidpolozzia, Gankovytsia
Class Querco-Fagetea Br.-Bl. et Vlieger 1937 Fraxino-Populetum Jurko 1958	40	Plots no. 12 at Latorytsia River, close to village of Suskovo
Class Artemisietea vulgaris Lohmeyer et al., ex von Rochow 1951 Solidago gigantea Hilb. 1972 Helianthus tuberosus Hilb. 1972	20	Plots no. 13-15 at Latorytsia River, close to village of Velyki Lychky

Also, the analysis doesn’t show a clear link between the breadth of river-bed and the number of invasive species in the vegetation communities. Perhaps the correlation between species richness and the river-bed straightening may not be explained by the direct impact of straightening. It could be explained by the indirect effect of vegetation cover fragmentation. This illustration is corroborated by the results of another study (Andersson et al., 2000). The group of researchers compared two adjacent rivers, one free-flowing and the other regulated, from northern Sweden. They estimated the floristic continuity along the two rivers by comparing the drift flora with the riparian flora further upstream. It was shown, that the floristic continuity was higher in the free-flowing river compared to the regulated river.

The comparison of non regulated and regulated neighbouring plots (with the same riverbed, 20 m) has been arranged along Latorytsia River. The graph shows that the percentage of share of alien spontaneous species for non regulated plots varies from 8% to 18%. In the same time, percentage of alien species increased to 82% at the plots located along the part of river that was regulated by straightening. The graph shows the negative impact of regulation by straightening on natural floodplain vegetation ($P = 0.012$) (Fig. 2).

The study of the seed bank illustrated the correlation between the breadth of the riverbed and the number of seeds deposited in the silt. The average number of seeds per plot for the upper course of the rivers is 51 seeds per plot for Uzh and 40 for Latorytsia. The biggest seed richness was shown in the plots which are located with the breadth of river-bed between 15 and 30 meters. The numbers of seeds in the silt are lower in the lowland area ($P = 0.04$) (Fig. 3).

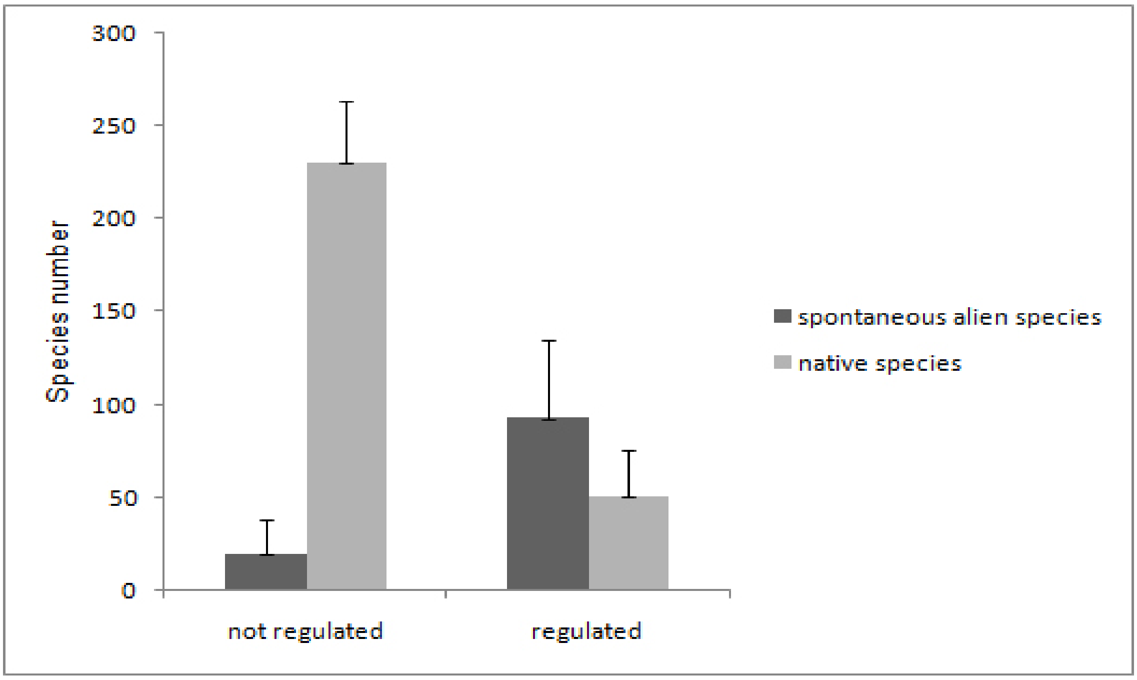

Figure 2: The number of native and invasive species that occur in floodplain vegetation along regulated and non regulated parts of Latorytsia River and standard deviation of meanings.

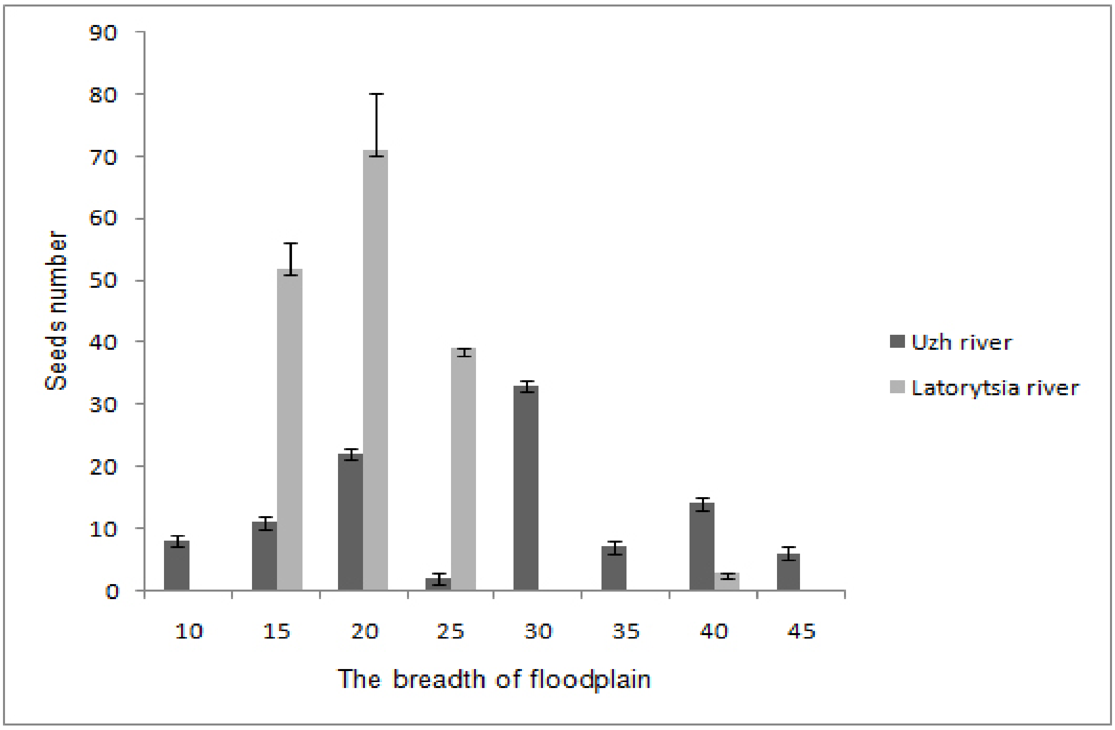

Figure 3: The breadth of river-bed and species diversity of seeds accumulated in the silt for Uzh and Latorytsia rivers and standard deviation of meanings.

Furthermore, the result of this specific study showed the clear significant impact of riverbed regulation also on seeds dispersal. The floristic comparison of seeds deposits from regulated and non regulated river parts suggests that the percentage of alien species increases after regulation. The considerable participation of alien species in seed bank may support the further fast invasion of alien species into natural vegetation communities.

CONCLUSIONS

The comparison of seed bank for the neighbouring plots showed that percentage of alien species seeds increases sharply from 0.1% at the free-floating natural parts of river to 10% at the regulated parts.

The plots located at submontane zone are characterized by bigger species richness and bigger number of seeds in the silt. This situation may be explained by the fact that in these parts of the rivers, the river flow is good enough for transporting numerous species and seeds can be accumulated on shores of gently sloping rivers. The river straitening increases the rivers drift, which could have a negative impact on diversity and survival of seeds.

The species similarity of extant vegetation and closed seed bank is very low. Moreover, the comparison of seed deposits with potential of source communities further upstream in the rivers suggests that an upstream-downstream similarity decreases after regulation. This result is in conformity with literature data (Andersson et al., 2000; Skoglund, 1990). The probable mechanism for this is the restriction of transported diasporas by river regulation. Nilsson and Jansson (1995) concluded the fact that regulated rivers cannot create their own pattern of species richness by means of long-distance dispersal of plants, i.e. there is no regional dispersal of the flora, but a dependence upon local contributions only.

This specific study showed the fact that effective distribution of plants has a place in native (not regulated) river-corridors with the breadth of river-bed within 15-30 meters. The reducing and straightening of the river-bed can decrease the number of species that could be dispersed along river. It makes the restoring of wet meadows at the places where floodplain forests and bushes were cut out impossible. Instead, river regulation cases transform the native vegetation communities at these plots in associations of invasive perennial herbs species, such as associations with dominance of *Helianthus tuberosus* and *Solidago gigantea* or *S. canadensis*. However, to provide a better understanding of the effects of river regulations on riparian vegetation and seed dispersal (Willson, 1992; Wilson et al., 1990), future studies are needed.

REFERENCES

1. Andersson E., Nilsson C. and Johansson M. E., 2000 – Effects of river fragmentation on plant dispersal and riparian flora, *Regulated Rivers: Research and Management* 16, 1, 83-89.
2. Bennett G. and Mulongoy K. J., 2006 – Review of experience with ecological networks, corridors and buffer zones, *Secretariat of the Convention on Biological Diversity*, *Montreal*, *Technical Series*, 23, 100.
3. Bodnar V. L., 1987 – Natural resources of Transcarpathia/Num. auth., (ed.), Bodnar V. L., Uzhgorod Carpathians, 284.
4. Braun-Blanquet J., 1964 – Pflanzensoziologie, Grundzüge der Vegetationskunde, (3. Auflage), Springer Verlag, Wien, 865. (in German)
5. Curtean-Bănăduc A., Schneider-Binder E. and Bănăduc D., 2014 – The importance of the riverine ligneous vegetation for the Danube Basin lotic ecosystems, in Cianfaglione K. (ed.), L'importanza degli Alberi e del Bosco, Cultura, scienza e coscienza del territorio, Temi Ed., Trento, Italia, ISBN: 978-88-973772-63-9, I-II, 187-210
6. De'camps H. and Tabacchi E., 1994 – Species richness in vegetation along river margins, in Giller P. S., Hildrew A. G. and Rafaelli D. G. (eds), Aquatic Ecology: Scale, Pattern and Process, Blackwell Scientific Publications, London, 1-10.
7. Dynesius M. and Nilsson C., 1994 – Fragmentation and flow regulation of river systems in the northern third of the world, *Science*, 266, 753-762.
8. Englund G., Jonsson B. G. and Malmqvist B., 1997 – Effects of flow regulation on bryophytes in North Swedish rivers, *Biological Conservation*, 79, 79-86.
9. Herenchuk K. I. (ed.), 1981 – Nature of Zakarpatska Oblast, Lviv: Publisher High School, 156. (in Ukrainian)
10. Maysuryan N. A. and Atabekova A. I., 1978 – The determinant of the seeds and fruits of weeds, Edition 2th, 288.
11. Naiman R. J. and De'camps H., 1997 – The ecology of interfaces: riparian zones, *Annual Review of Ecology and Systematics*, 28, 621-658.
12. Naiman R. J., De'camps H. and Pollock M., 1993 – The role of riparian corridors in maintaining regional biodiversity, *Ecological Application*, 3, 209-212.
13. Nilsson C. and Jansson R., 1995 – Floristic differences between riparian corridors of regulated and free-flowing boreal rivers, *Regulation Rivers*, 11, 55-66.
14. Nilsson C., Gardfjell M. and Grelsson G., 1991 – Importance of hydrochory in structuring plant communities along rivers, *Canadian Journal of Botany*, 69, 2631-2633.
15. Nilsson C., Nilsson E., Johansson M. E., Dynesius M., Grelsson G., Xiong S., Jansson R. and Danvind M., 1993 – Processes structuring riparian vegetation, *Current Topics in Botanical Research*, 1, 419-431.
16. Petts G., 1984 – Impounded Rivers: Perspectives for Ecological Management, Wiley, Chichester, 326.
17. Pop S. S., 2003 – Natural resources of the Transcarpathia, Uzhgorod: L. L. C. "Spektral", 296. (in Ukrainian)
18. Prots B. 2010 – Europas unbekannte Urwälder in Transkarpatien, Ost-West, Europäische Perspektiven, 11, 3, 212-218. (in German)
19. Schneider R. L. and Sharitz R. R., 1986 – Seed bank dynamics in a southeastern riverine swamp, *American Journal of Botany*, 73, 7, 1022-1030.
20. Skoglund S. J., 1990 – Seed dispersing agents in two regularly flooded river sites, *Canadian Journal of Botany* 68, 754-60.
21. Ter Heerdt G. N. J., Verweij G. L., Bekker R. M. and Bakker J. P. 1996 – An improved method for seed-bank analysis: seedling emergence after removing the soil by sieving, *Functional Ecology* 10, 144-151.
22. Toner M. and Keddy P., 1997 – River hydrology and riparian wetlands: a predictive model for ecological assembly, *Ecological Application*, 71, 236-246.

23. Willson M. F., 1992 – The ecology of seed dispersal, in Fenner (ed.) Seeds, The ecology of regeneration in plant communities, CAB International, Wallingford, 61-85.
24. Willson M. F., Rice B. L. and Westoby M., 1990 – Seed dispersal spectra: a comparison of temperate communities, *Journal of Vegetation Science*, 1, 547-560.

IMPLEMENTATION OF A SUSTAINABLE LOGISTIC SYSTEM MODEL FOR THE COMMUNAL WASTE COLLECTION IN THE MUNICIPALITY OF BITOLA (MACEDONIA)

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KEYWORDS: sustainable logistic model, Municipality of Bitola, Macedonia, communal waste.

ABSTRACT

The purpose of this paper aims for collection, transport and depositing of the communal waste in the Municipality of Bitola. The justification of another systematic approach toward the communal waste in the Municipality of Bitola is also represented.

There are many benefits of the implementation of this kind of sustainable logistic model system for collection of the communal waste in the Municipality of Bitola. It was summarized that the benefits that would be obtained lead to improvement of the living conditions, and with that the implementation of this model would be justified completely.

RESUMEN: Implementación de un modelo logístico de sustentabilidad en un sistema de recolección de desperdicios comunitarios en el municipio de Bitola (Macedonia).

En este trabajo se expone el problema, el sujeto y los objetivos de la recolección, transporte y reubicación de desperdicios comunitarios en el municipio de Bitola. Asimismo, se plantea un enfoque sistémático para abordar el problema de los desperdicios comunitarios en ese municipio.

Se esperan obtener considerables beneficios con la implementación de un modelo logístico de sustentabilidad aplicado a la recolección de desperdicios comunitarios en el municipio de Bitola. Los beneficios que se obtendrían de este sistema darían lugar a un mejoramiento en la calidad de vida de la comunidad, lo cual justifica sobradamente el uso del modelo.

REZUMAT: Implementarea unui model logistic sustenabil pentru sistemul de colectare a deșeurilor comunale în Municipiul Bitola (Macedonia).

În acest articol este prezentată problema, subiectul și obiectivele în ceea ce privește colectarea, transportul și depozitarea deșeurilor comunale în Municipiul Bitola. De asemenea, este prezentată motivația alegerii unui alt sistem de abordare a problemei deșeurilor comunale din Bitola.

Sunt prezentate beneficiile implementării acestui tip de model logistic sustenabil pentru colectarea deșeurilor comunale din Bitola. Pe scurt, beneficiile obținute duc la îmbunătățirea condițiilor de viață și astfel punerea în aplicare a acestui model este justificată.

INTRODUCTION

Basic preconditions of each state must provide good living conditions for the citizens. The aspects that contribute to regular decision making are various. One of these aspects that contributes to that is the logistic aspect. The communal logistics also contributes to all functional aspects that compound certain systems.

In this paper, the implementation in the next years of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola is presented. According to that model, this paper itself would represent one reality about the Municipality of Bitola and for the appearance of the communal waste. At the same time, that would allow us to conclude the unambiguously resulted benefits for the citizens and the enterprise of the selection, collection, transport and depositing of the communal waste in the Municipality.

The main drive about the implementation of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola is its uniqueness. As a confirmation of its uniqueness, we shall clearly present real data about the Municipality of Bitola and the way of communal waste collection.

Theoretically, in the Republic of Macedonia it has not yet been studied; additionally, the logistic aspect of collection, selection, transport and depositing of the communal waste has practically not been applied. It is assumed that every man generates different kinds of waste daily and it is obvious that this phenomenon deserves adequate treatment.

According to the last census in 2002, there are 86,408 citizens living in Bitola (Talevski, 2010) and with the new territorial division of 2004, the rural municipalities of Bistrica, Kukurechani and Capari are also added to this figure which increases the number of citizens with an additional 15 percent. This information is represented in table 1.

Table 1: Data regarding the population numbers, households and apartments in the Municipality of Bitola with additional 65 villages according to the territorial division of 2004.

Bitola Municipality	Total population	Households	Apartments (all types)
Bitola population	86,408	26,387	33,232
City of Bitola	74,550	23,010	28,155
65 villages	11,858	3,377	5,077

MATERIALS AND METHODS

Based on the results about the Republic of Macedonia, it is defined that the daily production of communal waste/citizen in Republic of Macedonia (Dukoski, 2005), is:

- 0.7 kg/day for urban environments (where 60% of the total population lives);
- 0.5 kg/day for rural environments (where 60% of the total population lives).

In other words, annual production of communal waste in Republic of Macedonia amounts 470,000 tones, out of which 322,000 tones are disposed at municipal waste piles, and 148,000 tones in the rural areas.

Acording to the data, collected from the services of the enterprise - Komunalec of Bitola (2005), the quantities of collected and transported communal waste for the Municipality of Bitola ranges from 36,000 to 40,000 tones of annual waste that is disposed on a waste pile situated at 17 kilometers away from the town (Dukoski, 2001; Dukoski and Talevski, 2011). The communal waste is collected in a non-systematic way that financially burdens the enterprise itself and also lowers the service satisfaction level of citizens. The data clearly defines the problem of the research.

The study revealed the real issues which are confronting the citizens. The activities for the collection, transport, and disposing of the communal waste at a pile, identifies in detail the complete process of great importance logistic actions with its characteristics and parameters that directly or indirectly influence the efficiency of the system organized in this way. The researched subject of the contemporary technological processes and treatments of organized collection, selection, and transport of the communal waste to the waste pile, and with its implementation, would obtain effective and sustainable logistic system models for collection of the communal waste in the Municipality of Bitola. This sustainable logistic model with all of its characteristics, shapes and phases of its creation is presented in figure 1.

The main aim of this paper's research is the inadequate implementation of sustainable logistic system models for the communal waste collection in the Municipality of Bitola.

The aims of the research are based on the following facts: with the help of the scientific methods we prove that the application of the measures and decisions of collection, transport and disposal of the communal waste, it could successfully identify, solve and implement the logistic model of sustainable systems for the communal waste collection in the Municipality of Bitola, qualitatively selected measures for the communal waste collection improvement in the Municipality of Bitola and the introduction of the contemporary technological ways and treatment of this phenomenon, and successfulness in the functionality of this activity in the town.

RESULTS AND DISCUSSION

Justification of the implementation of the sustainable logistic system model for the comunal waste collection in the Municipality of Bitola

This paper with its recognitions and views should be used as an example about the correct approach with the phenomenon of the communal waste and that is:

- its selection (minimizing the quantities of the communal waste at every place);
- collecting the previously selected (separated communal waste);
- transport of various types of communal waste (plastic, glass and paper communal waste to process, and the rest of the communal waste to the waste pile);
- contemporary depositing (with the possibility of applying certain technologies for other purposes).

Findings that are presented in this paper could also serve to reduce expenses of the Komunalec enterprise of Bitola and also the income increase by a different approach to work.

The sustainable logistic system model for the communal waste collection in the Municipality of Bitola itself has many elements of improvement, also for the users of the service and for the citizens of the Municipality of Bitola. The benefit of the citizens is imperative for such systematic approaches toward the communal waste that in all justifies the efforts of this paper.

Great work that is applied in one Municipality should always be justified. It is known that the introduction of any innovation is an expenditure that burdens the citizens, and it is obvious that it should be worth it, but first of all it needs to be applicable. The sustainable logistic system model for the communal waste collection in the Municipality of Bitola also should have to be justified and meet certain requirements of the citizens. Therefore, the justification of its introduction should be represented through the benefits that the Komunalec enterprise of Bitola would have, as well as the benefits that the citizens of the Municipality of Bitola would receive.

Benefits of the Komunalek enterprise of Bitola

The benefits for introducing the sustainable logistic system model for the communal waste collection in Bitola and for the enterprise Komunalec of Bitola would be:

- introduction of contemporary way of selected communal waste collection;
- reduction of tours to the waste pile (at least for 30%);
- improvement of the employees' work conditions at field and in the enterprise itself;
- creation of possibilities for activity enlargement and opportunites for new jobs.

We concluded that the introduction of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola for the Komunalec enterprise would lead to positive economic benefits.

Benefits for the citizens of Bitola

Benefits for the introduction of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola that would benefit the citizens of the Municipality of Bitola are as follows:

- improving the living conditions for the locals;
- the increasing number of checkpoints for picking up the communal waste of the households;
- reducing the cost for the communal waste pick up;
- economical benefits resulted from the selective collection of the plastic, glass, paper and other communal waste.

The introduction of the sustainable logistic system model for collecting the communal waste in the Municipality of Bitola for the citizens of the Municipality of Bitola would lead to a modern update for cultural and contemporary life.

Common benefits

From the quoted benefits of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola and also from the systematic approach towards the phenomenon of the communal waste, from ecological, economical and traffic aspect, the justification would be complete, positive and applicable.

Therefore, it could be stated that the sustainable logistic system model for the communal waste collection in the Municipality of Bitola is justified.

Implementation of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola

The implementation represents a flexible approach in the development of the superstructure product in ways that should meet the required needs and necessities of the enterprise (Dukoski, 2001). Concretely, implementation of the sustainable logistic system model for the communal waste collection in the Municipality of Bitola would be complete only with real and commonly accepted application in the every day citizens' activities of the Municipality of Bitola, and also the employees of the Komunalec enterprise of Bitola. In this paper, the implementation refers on the sustainable logistic system model for the communal waste collection in the Municipality of Bitola.

Also the way it should be implemented will be represented in figure 1. The algorithm for implementing the sustainable logistic system model for the communal waste collection in the Municipality of Bitola with WHAT is necessary (the needs), WHEN and WHERE is necessary (movement, scope, road, and place) all with purpose HOW to implement (with which methods, people and equipment).

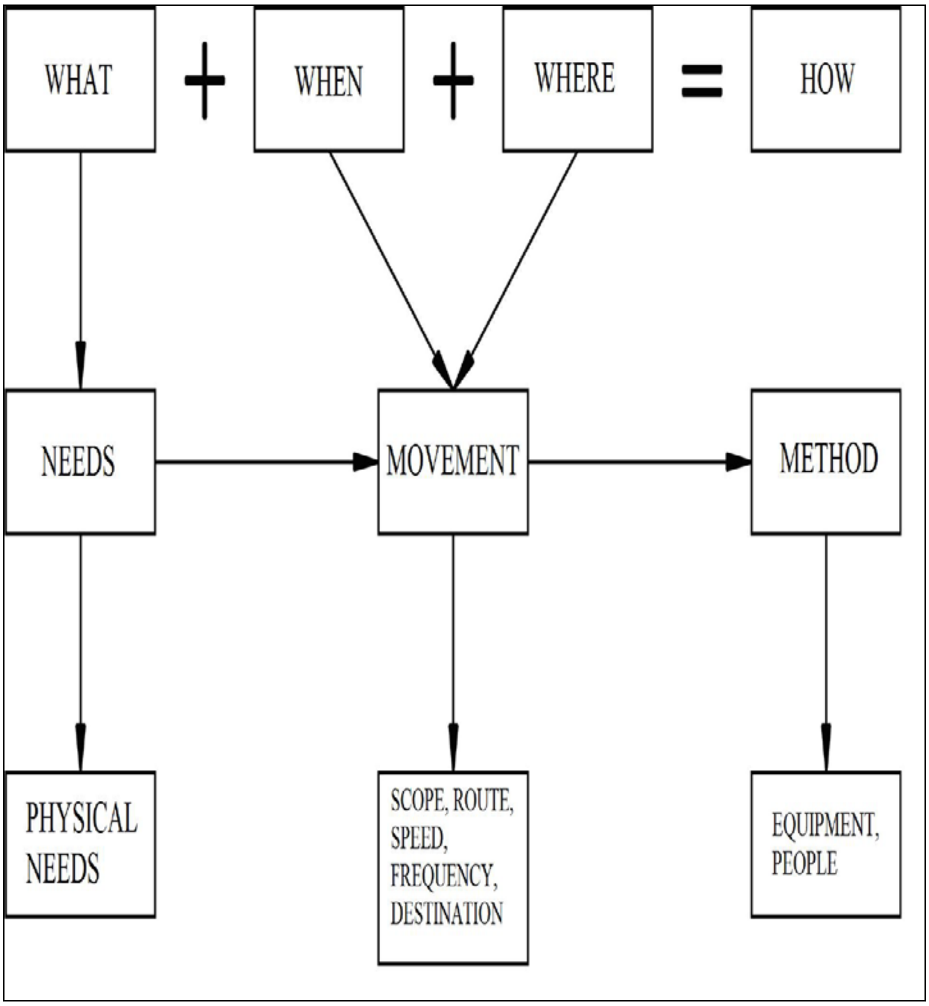

Figure 1: Implementation of the sustainable logistic system model algorithm for the communal waste collection in the Municipality of Bitola.

CONCLUSIONS

The benefit of this approach is that the subscribers are telling their requests, so the enterprises and the authorities realize that it is a good base for qualitative solutions.

The two way communication is the main base for future investments in this field of interest.

All the elements that make the phenomenon, selection, collection, transport and depositing of the communal waste could come to approval by the subscribers, employees and future investors only by two ways.

This work approach requires adequately implemented systems for the communal waste collection that would be one base for the aimed future steps with respect of WHAT + WHEN + WHERE = HOW principles.

REFERENCES

1. Dukoski I., 2001 – Maintenance of the motor vehicles - Logistics, Technical Faculty of Bitola, Bitola, Republic of Macedonia.
2. Dukoski I., 2005 – Logistic systems, written lectures of post graduate scientific studies, Technical Faculty of Bitola, Republic of Macedonia.
3. Dukoski I. and Talevski N., 2011 – Management with the communal waste in the Municipality of Bitola, Code of Technical Faculty, University St. Kliment Ohridski, Bitola, Republic of Macedonia.
4. Talevski N., 2010 – Sustainable logistic model of system for collection of the communal waste in the Municipality of Bitola, MSc Thesis, Technical Faculty of Bitola, Republic of Macedonia.
5. www.stat.gov.mk
6. www.mzspp.gov.mk
7. www.komunalecbt.com.mk/main.html

THE FOUR LEAF WATER CLOVER (*MARSILEA QUADRIFOLIA* L.) AN ENDANGERED SPECIES. ASPECTS OF CONSERVATION AND MANAGEMENT

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KEYWORDS: ecological requirements, endangered by extinction, extinct in the wild, competition capacity, conservation management.

ABSTRACT

The European species of the genus *Marsilea* are presented, with special regard to Four leaf water clover *Marsilea quadrifolia* L., the single species occurring in Central Europe. Based on field research on the Upper Rhine in Germany and the Lower Danube in Romania the ecological requirements of the species and the plant communities in which the species lives are analysed and compared with data from other European countries. Due to the decline of the species populations as a consequence of human activities, all European *Marsilea* species are rare, vulnerable, endangered by extinction or extinct in the wild and included in the Red data books of most European countries. Also all the European water clovers *Marsilea strigosa*, *Marsilea batardae* and *Marsilea quadrifolia* have been included in the Appendix I of the Bern Convention (1979) as strictly protected species and in the Annexe II of the European Flora Fauna Habitat Directive 92/43/1992. After analysis of ecological conditions, the state of conservation and the Red List categories of *Marsilea quadrifolia* following IUCN criteria in the countries of occurrence are presented and possible measures for conservation are discussed as well as realised reintroduction of the species in the wild.

ZUSAMMENFASSUNG: Der Kleefarn (*Marsilea quadrifolia* L.) eine bedrohte Art. Aspekte betreffend Schutz und Management.

Die europäischen Arten der Gattung *Marsilea* werden unter besonderer Berücksichtigung des Kleefarns *Marsilea quadrifolia* L., der einzigen in Mitteleuropa vorkommenden Art, untersucht. Auf Grund eigener Feldforschung am Oberrhein und an der Unteren Donau werden die ökologischen Ansprüche der Art und ihre Vergesellschaftung dargelegt und mit Angaben aus anderen europäischen Ländern verglichen. Bedingt durch die Verringerung der Populationen infolge menschlicher Tätigkeiten sind alle europäischen Arten der Gattung *Marsilea* selten, gefährdet, vom Aussterben bedroht oder bereits ausgestorben und in die Roten Bücher bzw. Listen fast aller europäischen Länder aufgenommen worden. Ebenso sind alle europäischen Kleefarnarten *Marsilea strigosa*, *Marsilea batardae* und *Marsilea quadrifolia* als streng geschützte Arten in Anhang I der Berner Konvention (1979) und Anhang II der Flora-Fauna-Habitatrichtlinie 92/43/1992 gelistet. Nach einer Analyse der ökologischen Ansprüche und des Erhaltungszustandes der Art sowie ihrer Einordnung in eine bestimmte Schutzkategorie in den einzelnen Ländern nach IUCN Kriterien, werden mögliche Schutz- und Erhaltungsmaßnahmen sowie bereits durchgeführte Maßnahmen zur Wiedereinbürgerung besprochen.

REZUMAT: Trifoiaşul de baltă (*Marsilea quadrifolia* L.), o specie periclitată. Aspecte de conservare şi management.

Lucrarea prezintă speciile europene ale genului *Marsilea*, cu privire specială asupra trifoiaşului de baltă *Marsilea quadrifolia* L., singura specie cu răspândire în Europa Centrală. În baza cercetărilor pe teren în regiunea Rinului superior în Germania şi a Dunării inferioare din România sunt analizate cerințele ecologice, precum şi comunitățile de plante în care creşte specia şi sunt comparate cu datele din alte ţări europene. Datorită reducerii populaţiilor în urma impactului antropic, toate speciile europene ale genului *Marsilea* sunt rare, vulnerabile periclitate prin extincţie sau deja dispărute, fiind cuprinse în Cărţile roşii, respectiv Listele roşii ale majorităţii ţărilor europene din care se cunoaşte specia. De asemenea, toate speciile europene de trifoiaş de baltă *Marsilea strigosa*, *Marsilea batardae* şi *Marsilea quadrifolia* sunt listate ca specii strict protejate în Anexa I a Convenţiei de la Berna (1979) şi în Anexa II a Directivei Floră-Faună-Habitate 92/43/1992. După analiza cerințelor ecologice şi a stării de conservare a speciei, precum şi a încadrării ei în anumite categorii de protecţie în diferitele ţări europene conform criteriilor UICN, sunt discutate posibile măsuri de protecţie şi de conservare, precum şi măsuri de reintroducere a speciei în zonele din care a dispărut.

INTRODUCTION

The genus *Marsilea* (Fam. Marsileaceae/Pteridophyta), including worldwide about 45 species of aquatic plants in tropical and warm regions (Cook, 1996), is represented in Europe by four species: *Marsilea quadrifolia* L., *Marsilea strigosa* Willd., *Marsilea batardae* Launert and *Marsilea aegyptica* Willd. All are hydro-helophytes or hygrophytes occuring mostly in standing, shallow permanent or temporary, sometime drying-out waters, in ponds, ditches and locally in ricefields. Due to the decline of the species as a consequence of human activities such as drainage and water pollution, all European *Marsilea* species are Rare, Vulnerable, Endangered by extinction or Extinct in the wild and included in the Red data books of most European countries. Of the four species mentioned, *Marsilea batardae* Launert is rare and endemic to the Iberian Peninsula (Medina et al., 2004; Banares et al., 2004). *Marsilea aegyptica* Willd. has been mentioned only from the Lower Volga area as a rare species with a disjunct distribution area (Tahtadjian et al., 1988). *Marsilea strigosa* Willd. is a Mediterranean species with pubescent leaves that occurs in Southern Europe, being mentioned from Italy (Conti et al., 1992), Southern France (Dehondt et al., 2005) and South-western Spain (Garcia et al., 2006; Banares et al., 2010). The species have been mentioned also from the Lower Volga area, but has been regarded as extinct in recent decades (Tahtadjian et al., 1988; Conti et al., 1992). The Four leaf water clover (named also Water Shamrock) *Marsilea quadrifolia* L., an Euroasiatic species, distributed over a larger area with prevailing small populations, is the single species of the genus *Marsilea* occurring in Central Europe.

Following the data from older publications and comparing them with recent data of the species, there has been observed a decrease in its distribution area, with it being extinct in many sites, considered in others as endangered by extinction or as a vulnerable species. This is why all the water clovers of the European Union - *Marsilea strigosa*, *M. batardae* and *M. quadrifolia* - have been included in the Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats/Bern Convention (1979) as a strictly protected species and in the Annexe II of the European Flora Fauna Habitat Directive 92/43/1992 including the animal and plant species of community interest whose conservation requires the designation of special areas.

The object of this paper is to follow the actual distribution of the water clover *Marsilea quadrifolia* L. in Europe on the basis of data from different countries and our own research data, to compare the ecological and phytocoenological data of the species from different regions of Europe as well as the conservation status and type of management measures. At the same time we discuss the applicable and needed measuers to conserve the species in the still existing sites and to find out - knowing the ecological requirements of the species - the appropriate sites for reintroduction or revitalization of stands, if sporocarps of the species persist in the area.

MATERIAL AND METHODS

On the basis of our own field research are presented data of *Marsilea quadrifolia* populations on the Upper Rhine (2009), the Lower Danube Giurgiu/Slobozia area (2004) and the Danube Delta (Rusca Polder 1993, Sfântu Gheorghe 2011) the ecology, phytocoenology and conservation status, human impacts and their consequences. The plant communities identified by *Marsilea quadrifolia* and the surrounding vegetation has been studied on the Rhine and on the Danube on the base of transects along ecological gradients with side-by-side phytocoenological sampling according to the method of Braun-Blanquet (1964). On the Rhine the sampling was realised within the framework of the Management Plan for the Natura 2000 Site "Floodplain of the Rhine between Iffezheim and Karlsruhe" (experimental plots 4 and 5).

The ecological and phytocoenological data are compared with those from literature concerning the species from other European countries. Possible management measures are discussed on the basis of the analysed field and literature data.

RESULTS AND DISCUSSION

Site conditions and distribution area.

The actual occurrence of *Marsilea quadrifolia* is related partly to natural water bodies such as oxbow lakes, flood channels and partly to man-made water bodies such as fishponds (Landolt, 1991; Dehondt et al., 2005; Schneider et al., 2005; Benedek et al., 2012) ricefields (Felföldy, 1990; Conti et al., 1992; Benedek et al., 2012), clay-pits (Landolt, 1991), gravel exploitation places, ditches with slowly running waters (Conti et al., 1992; Käsermann, 1999) and artificial lakes (Conti et al., 1992; Ramsar Information Sheet, 1998). The waters are mostly shallow and dry out temporary.

The species is mentioned as growing on muddy ground, clay-sandy or sandy soils (Käsermann, 1999; Oberdorfer, 2001; Tahtadjian et al., 1988), but it is also mentioned from marshy soils, rich in organic matter (Dehondt et al., 2005). In two cases the occurrence of the species is mentioned in relation to old pig pastures with open places free of vegetation (Käsermann, 1999; Pouchol, 2000; Oberdorfer, 2001; Philippi, 1969) as well as from hemp- and flax-steeping places (Philippi, 1969).

Concerning the nutrient content of the waters in which the species grows, occurrences are known in oligotrophic, oligo-mesotrophic and mesotrophic nutrient and humus-poor waters (Käsermann, 1999; Pouchol, 2000; Dehondt et al., 2005; Bundesamt für Naturschutz, 2012), but also nutrient-rich sites (Oberdorfer, 2001; Schneider, 1993; field sampling in the Danube Delta, Rusca area). But a strong eutrophication in sites with *Marsilea quadrifolia* is the cause of decline of the species populations (Pouchol, 2000). The waters in which the species occurs are frequently measured as deficient in calcium carbonate (Landolt, 1991; Oberdorfer, 2001) and *Marsilea quadrifolia* is considered to be a calcifuge (Dray, 1985).

According to our observations *Marsilea quadrifolia* occurs also in conditions of light to medium salinity, growing in the Danube Delta (Sf. Gheorghe) together with typical halophilous species. As a water macrophyte, the species occurs together with *Azolla filiculoides*, which indicates a light salinity. Under terrestrial conditions the species has been observed growing in the neighbourhood of *Juncus maritimus* and *Limonium meyeri*, typical halophilous species, as well as species indicating a light salinity such as *Pulicaria dysenterica, Trifolium fragiferum, Mentha pulegium, Cynodon dactylon* and *Tamarix ramosissima.* Similar conditions with those in the Danube Delta at Sf. Gheorghe, living on sandy saline substrate are mentioned for *Marsilea strigosa* from the Lower Volga area (Tahtadjian et al., 1988).

The water clover is known as a species with low concurrence capability which is related to tolerance towards different ecological factors (Felföldy, 1990; Horváth et al., 1995; Käsermann, 1999; Pouchol, 2000; Dehondt et al., 2005). As a heliophilous species without tolerance to shade, the water clover is quickly eliminated in the course of succession by higher growing and overshadowing species (Dehondt et al., 2005; Käsermann, 1999; Pouchol, 2000). It seems the species sometimes needs light disturbances related to human interventions which keep open the sites where *Marsilea quadrifolia* can establish without competition from other species (for example old pig pastures). These factors are near the trophic conditions strong limiting factors for the repartition of the species.

Geographical distribution

On the Iberian Peninsula the species occurred in wetlands on the Mediterranean coast, but at present is considered as extinct in the wild, being reintroduced in the Delta of the Ebro River (Aedo et al., 2012). In Portugal *Marsilea quadrifolia* being at present in a critical situation with strong regression it is mentioned in small area of Douro and Trás-os-Montes (ICN, 2006).

In France *Marsilea quadrifolia* is mentioned from the Centre of France in the plain of the Loire and Allier rivers, in the regions of Anjou, Touraine, Orléans, Sologne, Brenne, les Dombes, Lyon and in the Eastern France region of Franche-Comté: Bresse Comtoise, Piedmont of Vosges and the Sundgau near Belfort (Dehondt, 2005; Dehondt et al., 2005). In the last mentioned localities of the Franche-Comté region, the species occurs in a number of fishpond areas.

In Switzerland *Marsilea quadrifolia* is still mentioned from the "Pruntruter Zipfel" near Bonfol/region of Jura (Landolt, 1991; Käsermann, 1999) near to the locations of Franche-Comté in France. In all other localities known from older data in Switzerland, the species has disappeared.

In Italy this thermophilous Eurasian species is mentioned from sea level to 400 m altitude occurring in the Piemont area on the upper Po River and reaching to South in the area of Naples (Napoli), these localities being the most Southern of the distribution area in Europe (Conti et al., 1992).

In Germany *Marsilea quadrifolia* occured only on the Middle and Northern Upper Rhine, but apart from the existence in one location, in all the others mentioned as existing before 1945 (Haeupler and Schönfelder, 1988) the species is considered at present as extinct. In 1986 the Four leaf water clover has been registered South of Karlsruhe between the localities Mörsch and Neuburgweier (Rheinstetten) in the old floodplain of the river Rhine, in a location named Rösteläcker. As the species stands decreased more and more, being repressed through succession by species more competitive such as Reed (*Phragmites australis*) and Reed-mace (*Typha angustifolia*) the water clover disappeared. As the species were known in the area from old pig pastures as well as hemp- and flax-steeping places, in 2002 a pig pasture area has been established in the area of Rösteläcker/Rheinstetten, South of Karlsruhe (Radkowitsch, 2006). One year later in 2003 a new occurrence of *Marsilea quadrifolia* has been registered in a flashing area of a gravel extraction place near Lahr. From this location plant material were taken out and started-up a “conservation culture” in the Botanical Garden of the University Karlsruhe (Radkowitsch, 2006, 2007; Waitzmann and Schweizer, 2009). The last at present existing distribution point of the species in Germany on the Upper Rhine is the result of a recent reintroduction of the species in the wild.

In Poland, where the species exists at the Northern limit of its area, it is mentioned as extinct in the wild, but cultivated in the Botanical Garden of Warsaw University and reintroduced into a pond at the Bolestraszyce Arboretum near Przemysl (Kazmierczskowa and Zarzycki, 2001; Zarzycki and Szelag, 1992). From this place some of the individuals were transplanted to two reservoirs in the environment of Pulawy (Kazmierczskowa and Zarzycki, 2001). According to newer data, the species exists still in the Botanical Garden of Warsaw.

The map of occurrence of species *Marsilea quadrifolia* shows for the area of former Czechoslovakia only localities in the Eastern Slovakian lowland on the Latorica River (Husák and Otahelová, 1986), near to the area of the Ukrainian occurrences in Zakarpatia area (Shelijag-Sosonka, 1996). In the past *Marsilea quadrifolia* has been found in Slovakia also in the area of Bodrog, Laborec and Uh rivers (Botanix, 2012). The mention of *Marsilea quadrifolia* as occurring in the Czech Republic (IUCN, 2012) refers to the old literature data for Czechoslovakia, and are related to the distribution points in Eastern Slovakia.

In Austria the species is extinct in most of its former known localities, existing at present only in Styria/Steiermark in the Southeastern part of the country (Adler et al., 1994; Käsermann, 1999).

The distribution map of the species *Marsilea quadrifolia* in Hungary indicates localities between the Danube and the Tisza/Tisa rivers in the large Hungarian Plain, the so called “Alföld”, were the species occurs in the area of ricefields that from time to time dry out (Felföldy, 1990).

In Croatia the distribution map shows many locations along the Sava River (Borsic, 2012) and also some points on the Drava River, but most are from older literature data, only a few of the localities having recent confirmation by field research. The localities, where the Water clover occurs at present are strongly related to the pig pasturing as traditional activity in the Sava floodplain area, which in its turn is related to the Sava old oak hardwood floodplain forests area. In the floodplain used as pig pasture, there are locally large areas covered by *Marsilea quadrifolia* (oral communication by Mr. Damm C., 2011).

Marsilea quadrifolia is also listed in The Red Book of the Albanian flora (Vangjeli et al., 1995), as well in the Red Books for Bosnia and Herzegovina (Silic, 1996).

In Bulgaria, *Marsilea quadrifolia* species is mentioned in the Danube Plain from two sites, the Tracian lowland in Southern Bulgaria and the Strumska Valley (Dakov, 1984) occurring in permanent or temporary water bodies, swamps and rice cultures on muddy underground.

In Greece the species is mentioned as very rare, on the border of the artificial Lake Kerkini (Ramsar Information Sheet, 1998).

In Romania, the species records are published from different parts of the country (Topa, 1952). The localities are concentrated in the lowland area of the Western Plain, Oradea and Salonta area, the Southern part of the Crişuri region, and the lower Mureş and Timişoara area. Given as well are localities on the Danube (Ostrovul Corbului/Turnu Severin, Brăila) and lakes of the Romanian Plain around Bucharest as well as two points in Dobrogea, but at that time (1952) no data about the occurrence of the species existed for the Danube Delta. Mentioned are also in the older literature data for the Transylvanian Tableland, the so-called "Câmpia Transilvaniei", but these points were not confirmed at the middle of the 20th century (Topa, 1952). From many of the localities in which *Marsilea quadrifolia* was found six decades ago (Topa, 1952) the species has disappeared, while others are reconfirmed (Oprea, 2005) and some new locations has been discovered in the last years. On the Lower Danube the species exist at present in a partly abandoned fish pond area near Slobozia/Giurgiu (Schneider et al., 2005). In the Danube Delta the species is mentioned as rare (Ciocârlan, 1994) and described from the fishpond area of Rusca and on the mouth of Sulina branch into the Black Sea (Oţel, 2000). Recently (2011) the species were found at Sfântu Gheorghe near to the coast of the Black Sea in stands with high abundance-dominance and represented by *Marsilea quadrifolia* L. f. *natans* Kaulf. and f. *terrestris* Hayek (Tab. 2, Figs. 1 and 2).

The distribution map of *Marsilea quadrifolia* in Ukraine shows a concentration of some localities North of the Chilia/Kilija branch of the Danube Delta, on the lower and upper Dniester/Nistru, on the Southern Bug, in the Zakarpatia region of Western Ukraine and area of the Shatski Lakes part of Polessie Swamps (Shelijag-Sosonka, 1996).

Phytoceonological remarks.

Marsilea quadrifolia is mostly considered as a native accessorial species occurring in communities of the Class Isoeto-Nanojuncetea Br.-Bl. et Tx. 1943 (Kazmierczakowa and Zarzycki, 2001; Horváth et al., 1995; Dehondt et al., 2005) order Isoetetalia (Borsic, 2012) or order Cyperetalia fusci, alliance Nanocyperion flavescentis (Felföldy, 1990; Dehondt et al., 2005; Oberdorfer, 2001) or in the class of Litorelletea uniflorae Br.-Bl.et Tx. 1943, alliance Eleocharition acicularis (Dehondt et al., 2005; Oberdorfer, 2001). The occurrence together with *Elatine triandra*, characteristic for the order Cyperetalia fusci as well as with *Limosella aquatica*, *Cyperus fuscus*, *Juncus bulbosus* and *Lindernia procumbens* documents the affinity to communities of the alliance Nancyperion/Order Cyperetalia fusci/class Isoeto-Nanojuncetea. But the observed association with the species *Utricularia australis*, *Trapa natans*, *Myriophyllum spicatum,* and *Phragmites australis* (Dehondt et al., 2005) speaks for the affinity to communities of the class Potamogetonetea pectinati Klika 1941.

In Spain is mentioned the affiliation to the Class Oryzetea sativae (Banares et al., 2004).

The studied area in the plain of the river Rhine South of Karlsruhe and the samples from this area shows on the one side the identification of communities which are characteristic for Potamogetonetea (Tab. 1, column 1-6) interfering with Phragmitetea species and on the other side the integration in a pioneer community with species of the alliance Nanocyperion (Tab. 1, column 7-10) such are *Cyperus fuscus* and *Centaurium pulchellum*. The distinction is based on the different depth of the generally shallow water body. The first group is characteristic for the "deeper" part of the water body and the second for the edge of the water which is more rapidly falling dry as the other part. The entire water body can dry out, but the time period is different. The covering degree of *Marsilea quadrifolia* is locally very high, but also *Potamogeton nodosus* reaches a high covering degree in some phytocoenoses of the area (sample 4). As this species is more competitive it can be a threat to the water clover with less competition capacity.

Table 1: Phytocoenoses of *Marsilea quadrifolia* near Rheinstetten South of Karlsruhe, in Germany.

Number of sample	1	2	3	4	5	6	7	8	9	10
Cover degree in %	85	85	100	70	45	25	25	45	40	45
Marsilea quadrifolia floating leafs	4	4	5	1	3	2	2	3	+	+
Marsilea quadrifolia	2	+	-	-	-	-	-	-	-	-
Alisma plantago-aquatica	-	-	-	+	-	-	+	+	-	-
Lythrum salicaria	-	-	-	-	-	-	+	-	-	-
Salix purpurea	-	-	-	-	-	-	+	+	-	-
Cyperus fuscus	-	-	-	-	-	-	-	-	3	3
Equisetum palustre	-	-	-	-	-	-	-	-	+	+
Potamogeton nodosus	+	2	-	4	-	+	-	+	+	-
Centaurium pulchellum	-	-	-	-	-	-	-	-	-	1
Schoenoplectus lacustris	-	-	-	-	-	-	-	-	-	+
Alopecurus geniculatus	-	-	-	-	-	-	-	-	-	+
Agrostis stolonifera	-	-	-	-	-	-	-	+	+	+
Butomus umbellatus	-	-	-	-	1	-	-	-	-	-
Chara vulgaris	-	-	-	-	-	+	-	-	-	-
Place and data of sampling										
Rösteläcker, Rheinstetten/Karlsruhe 31.07.2009										

Other phytocoenological aspects can be observed for the studied site in the dune area of Sfântu Gheorghe in the Danube Delta (Tab. 2, Figs. 1 and 2). *Marsilea quadrifolia* is associated with floating aquatic macrophytes such as *Hydorcharis morsus ranae, Salvinia natans, Spirodela polyrhiza, Lemna minor, Lemna trisulca* characterstic for communities of the alliance Lemnion minoris Tx. 1955, classe Lemnetea minoris Tx. 1955 and rooted water macrophytes such are *Nymphoides peltata* characteristic for the alliance Nymphaeion albae Oberd. 1957, class Potamogetonetea pectinati Klika 41 (Tab. 2, column 1-6). The water clover presents furthermore in the site at Sfântu Gheorghe a larger surface of terrestrial stands (Tab. 2, column 7-10), which are in contact with reed communities edified by *Sparganium ramosum*, *Typha angustifolia* and the halophilous species *Juncus maritimus* and *Limonium meyeri* as well as grassland species characteristic for light salinity in the soil. In the area of Rusca polder/Danube Delta where the species occurs sporadically in shallow drying out waters (fishponds) no accompanying species has been observed.

On the Lower Danube near Slobozia upstream of the town of Giurgiu *Marsilea quadrifolia* has been observed (June 2004) in an abandoned fishponds area as growing in interference with stands of *Typha angustifolia*.

Figure 1: *Marsilea quadrifolia* L. with *Spirodela polyrhiza*, *Salvinia natans*, *Lemna minor*, *Lemna trisulca*, *Azolla filiculoides* (Danube Delta, Sfântu Gheorghe, 2011).

Figure 2: *Marsilea quadrifolia* stands, terrestrial form, in contact with stands of *Sparganium ramosum, Typha angustifolia* (on the left side) and *Juncus maritimus* (right side) on the dune area of Sfântu Gheorghe/Danube Delta near to the coast of the Black Sea (2011).

Table 2: *Marsilea quadrifolia* phytocoenoses in the Danube Delta, in the Romanian territory.

Number of sample	1	2	3	4	5	6	7	8	9	10
							terr	terr	terr	terr
Marsilea quadrifolia	4	4	4	2	2	3	4	4	4	-
Spirodela polyrhiza	-	1	-	1	+	+	-	-	-	-
Lemna minor	-	+	-	-	+	+	-	-	-	-
Salvinia natans	1	1	+	2	1	-	-	-	-	-
Nymphoides peltata	+	-	-	-	1	2	-	-	-	-
Azolla filiculoides	+	+	-	3	3	+	-	-	-	-
Hydrocharis morsus-ranae	-	-	-	-	+	+	-	-	-	-
Lemna trisulca	-	-	-	-	+	-	-	-	-	-
Ceratophyllum submersum	-	+	-	-	-	-	-	-	-	-
Typha angustifolia	-	+	1	+	+	3	1	+	1	-
Sparganium ramosum	-	-	2	-	-	-	1	1	-	-
Mentha pulegium	-	-	-	-	-	-	-	+	+	-
Juncus maritimus	-	-	-	-	-	-	1	+	+	3
Pulicaria dysenterica	-	-	-	-	-	-	-	+	-	+
Cynanchum acutum	-	-	-	-	-	-	-	-	1	+
Limonium meyeri	-	-	-	-	-	-	-	-	+	+
Tamarix ramosissima	-	-	-	-	-	-	-	-	-	+
Place and date of sampling										
Danube Delta, Sfântu Gheorghe, 06.09.2011										

Decline of the species occurrence

A continuous decline of the populations of *Marsilea quadrifolia* has been observed in Europe. This is due to human activities producing different changes in the quality of habitat or leading to destruction of the habitat. An important impact has the bank consolidation, undermining of the banks by muskrats (Käsermann, 1999; Pouchol, 2000), drainage and drying-out of waters and characteristic wetlands. The change of management of fishponds, intensification or abandoning of the use is mentioned as one of the important reasons for decreasing of populations of *Marsilea quadrifolia* (Dehondt et al., 2005). One of the important factors for the decline of the species is water eutrophication and water pollution (Käsermann, 1999; Pouchol, 2000; Shelijag-Sosonka, 1996). The change in agricultural practices with application of herbicides and the eutrophication is given as one of the reasons for the extinction of *Marsilea quadrifolia* in Spain (Banares et al., 2004). The change of habitat can change the competitive conditions for the species, such are for example shadowing, succession by higher and faster growing vegetation, resulting to the elimination of *Marsilea quadrifolia*, being disadvantaged with its deficient, low competition capacity in comparison to species with active dispersion.

Tourist activities can also have a negative influence for the sites in which the species are growing (Pouchol, 2000).

In the concrete case of the decline of the Four leaf water clover in Germany on the river Rhine, are mentioned as causes the rectification of the Rhine in the last centuries, the change of ground water capacity, the filling up of flood channels and other water bodies, the increase of nutrients, herbicides, pesticides, the type of management of waters and wetlands (Waitzmann and Schweizer, 2009). For all the European countries similar causes are mentioned as above discussed.

Conservation status and management

According to the IUCN 2012 worldwide Red List of threatened species, no major threats have been reported for *Marsilea quadrifolia*. The species "occurs throughout much of southern Europe east to China and Japan, including Cambodia and Lao PDR. Within Europe it occurs along many of the major river valleys, such are the Loire, Po and parts of the Danube, as well as in complexes of wetlands throughout central and southern Europe" (Gupta, 2012). Therefore the species is listed under the category "Least Concern" (categories and criteria version 3.1), which means widespread and abundant taxa as regards their extent of occurrence, area of occupancy, area extent and/or quality of habitat and number of locations or subpopulations (Gupta, 2012). The comment "widespread and abundant" cannot be taken into account for Europe, as the species is in visible decline, in general with low abundance and extinct in many places (Tab. 3). This is why it has been listed in the Annexes of the Bern Convention and the Flora Fauna Habitat Directive. The category of "least concern" can apply only from the point of view of Asian countries, where it seems the species has a larger distribution and occurs in larger populations.

As *Marsilea quadrifolia* is known for its low competition capability by changing site conditions (Felföldy, 1990; Dehondt et al., 2005), it is endangered in many sites by extinction or even extinct (Tab. 3).

In the sites with existing localities of *Marsilea quadrifolia* a continuous monitoring is needed to follow the evolution of the populations and to take appropriate management measures for conservation. The first is to improve the knowledge about management of populations, autecology of the species, colonisation capacity and reproduction biology. It is known, that the sporocarps, which emerge from terrestrial leaves at the time when the banks fall dry, are very resistant and with a long-term germination capacity (Käsermann, 1999; Pouchol, 2000).

In areas with fishponds the change of management from an intensive to more extensive one is needed and is proved in the region of Jura/France and in Switzerland (Käsermann, 1999; Dehondt et al., 2005). Mowing is needed in areas with interferences of *Marsilea quadrifolia* stands with reed and other tall herbaceous vegetation, to eliminate the shadowing effects, which can be dangerous for the *Marsilea* stands. Ligneous vegetation taking out is needed too, if it will have negative effects on water clover stands. It is also discussed in relation with the low competition capacity the creation of open soil area for the colonisation of *Marsilea quadrifolia* in appropriate sites (Radkowitsch, 2007; Pouchol, 2000; Dehondt et al., 2005).

There are usually two ways to assure the conservation of the species. One is to take sporocarps in botanical gardens and cultivate the species ex situ from sporocarps found in some of the sites, allowing possible reintroduction into the wild. The combination of ex situ with in situ cultivation (integrated conservation strategy) seems to be a successful approach. In Spain the species, being extinct in the wild (Banares et al., 2004), is cultivated in the Royal Botanical Garden of Madrid. The reintroduction is promising good results (Aedo et al., 2012). The hope is to obtain stable populations in natural habitats, which can lead to cancel the species from the list of those extinct in the nature.

Table 3: Red list categories of *Marsilea quadrifolia* in European countries.

Red List Categories	EX, EW	CR	EN	VU	Remarks
Country					
Spain	X				Cultivated in the Royal Botanical Garden of Madrid and reintroduced in the Delta of Ebro River (Aedo et al., 2012)
Portugal		Xr			Rare (Dray, 1985); Ramos et al., 1990; ICN, 2006
France				X	Dehondt, 2005; Dehondt et al., 2005
Switzerland	(X)				Reintroduced repeatedly in the fishponds at Bonfol (Jura) without durable success (Käsermann, 1999) and in Bellechasse
Italy				X	Conti et al., 1992
Germany	(X)		X		Strictly protected species (BfN, 2012; Ludwig and Schnittler, 1996; Breunig and Demuth, 2000); reintroduced in the wild with good results (Radkowitsch, 2007)
Poland	(X)		X		Cultivated in the Botanical Garden of Warsaw University and reintroduced in a pond near Przemysl (Kazmierczskowa and Zarzycki, 2001; Zarzycki and Szelag, 1992)
Austria			X		Only in Styria, in all other areas Burgenland, Upper Austria, Carinthia extinct (Adler et al., 1994; Käsermann, 1999)
Slovakia			Xr		Most vulnerable (Maglocky and Feráková, 1993)
Hungary			Xr		Protected taxon of Western European importance (Horváth et al., 1995)
Croatia			X		Borsic: in FCD-Flora Croatica Database 2012; Ministarstvo Graditelistva i zastite okolisa 1994; Nikolic, 1994
Bosnia-Herzegovina				X	Silic, 1996
Albania				X	Vangjeli et al., 1995
Romania				X	Oţel 2000 (data for the Danube Delta); Oprea, 2005; in the Red data book of the country the species is not included (Dihoru and Negrean, 2009); rare species Danube Delta (Ciocârlan, 1994)
Bulgaria			Xr		Dakov, 1984; sporangia conserved in the Spors and seeds bank of the Botanical Garden Sofia
Ukraine			Xr		Category I in the Ukrainian Red book of plants (Shelijag-Sosonka, 1996)

EX = Extinct, EW = Extinct in the wild, CR = Critically Endangered, EN = Endangered, VU = vulnerable. The category LR = low risk is not included in the table, as for *Marsilea quadrifolia* the category is at present without relevance (Walter and Gillett, 1998), r = rare species. The parenthesis of X in the category of extinct in the wild, means the reintroduction in the wild.

The species *Marsilea quadrifolia* has disappeared from the known locations in Germany. Sporocarps were collected from the last confirmed location in waters of a gravel extraction place near Lahr/Offenburg and initiated with this a “conservation culture” in the area of Botanical Garden of University of Karlsruhe (Radkowitsch, 2006). The programme of ex situ cultivation permitted obtaining specimens of *Marsilea quadrifolia* species, which has been reintroduced in the wild South of Karlsruhe in the former floodplain of the Rhine Rivwe near Rheinstetten in the site of “Rösteläcker”. The ex situ cultivation programme included also the foundation of a pig farm, the animals having the role to create open, vegetation free soil patches with a high diversity of macro- and microhabitats for the development of *Marsilea quadrifolia* being a species with low competition capability (Radkowitsch, 2007).

The implementation and monitoring of the reintroduction of *Marsilea quadrifolia* have been realised within the framework of a LIFE project “Living floodplains of the Rhine” ongoing from 2005 with efficiency control of the measures in the following two years (Radkowitsch, 2006; 2007).

In the frame of the elaboration of the Management Plan for the Natura 2000 Site “Floodplain of the Rhine between Iffezheim and Karlsruhe”, sampling of phytocoenoses edified by *Marsilea quadrifolia* (experimental plots four and five) were taken in July 2009 (Tab. 1). The samples document a satisfying evolution of the species population and also the development of the whole plant community with the characteristic species combination for the alliance Nanocyperion, for which the species is mentioned as being characteristic and also for phytocoenoses of plant communities included in the class Potamogetonetea.

But in the same time the monitoring clearly demonstrates near the successful reintroduction also the need for further monitoring and management, as recently there has been observed an increasing presence of *Potamogeton nodosus*. This species with higher competition capacity can become dangerous for the water clover (*Marsilea quadrifolia*) as a species of low competition capacity (Felföldy, 1990; Dehondt et al., 2005; Käsermann, 1999).

Ex situ conservation has been practised also in Switzerland territory, sporocarps from the Jura region in France have been cultivated and then reintroduced into the wild near Bellechasse. Ex situ conservation cultures were also created in the Botanical Garden of Warsaw University in Poland from where the species has been reintroduced into a pond near Przemysl (Kazmierczskowa and Zarzycki, 2001; Zarzycki and Szelag, 1992).

In Bulgaria where the species *Marsilea quadrifolia* is considered as endangered and rare, sporangia of it were introduced and conserved in the Spores and Seeds Bank of the Botanical Garden in Sofia, to be used in the future, if the decline of the species will progress.

All these efforts demonstrate that the species *Marsilea quadrifolia* requires special attention for conservation with appropriate measures, direct in sites where has been found the species in times before, but also in ex situ conservation cultures, which have an important role to assure survival in sites where the species is in decline, near to extinction or extinct.

CONCLUSIONS

It is clear that in European countries *Marsilea quadrifolia* is a species in decline due to human interventions in different ways, and needs in many cases a strict protection. This fact corresponds nearly for all European countries with the consequence that the species is listed in all Red lists and Red Data books of threatened flora in the conservation categories Extinct in the Wild, Extinct, Critically Endangered, Endangered and Vulnerable.

The low concurrence competition capacity and the low capacity of spread and colonising new sites are possibly the main factors for the decline of the species. On the other side the longevity of sporocarps which are resistant to drying-out, can lead to a reactivation of populations in sites where the species is considered as extinct, if the site conditions are again appropriate for evolution of the species. But in the most cases the reoccurrence in the same place, from which the species disappeared years ago is not possible, as many habitats have been unrecoverable destroyed by human interventions.

In the countries where the species is extinct in the wild, many efforts are being made to reintroduce the species into the wild. Successes in this direction have been achieved and offer promise for further reintroduction measures.

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REFERENCES

1. Adler W., Oswald K. and Fischer R., 1994 – Exkursionsflora von Österreich, Verlag Eugen Ulmer Stuttgart und Wien, 1180 (Marsilea quadrifolia). (in German)
2. Aedo C., Medina L. and Fernández M., 2012 – Plantas extinguidas de la flora espanola, Quercus, 321, 11, 42-48. (in Spanish)
3. Banares A., Blanca G., Güemes J., Moreno J. C. and Ortiz S. (eds), 2004 – Atlas y libro Rojo de la Flora Vascular Amenanzada de Espana, Dirección General de Conservación de la Naturaleza, Madrid, 1069. (in Spanish)
4. Banares A., Blanca G., Güemes J., Moreno J. C. and Ortiz S., 2010 – Atlas y Libro Rojo de la Flora Vascular Amenazada de Espana, Adenda 2010, Dirección General de Medio Natural y Politica Forestal (Ministerio de Media Ambiente y Medio Rural y Marino) - Sociedad Espanola de Biologia de la Conservacion de Plantas, Madrid, 170 (Marsilea strigosa). (in Spanish)
5. Benedek A.-M., Drăgulescu C., Frink J. P. and Petrovici M., 2012 – Flora and habitats of Cefa Nature Park (Crişana, Romania), *Transylvanian Review of Systematical and Ecological Research*, The Cefa Nature Park, Curtean-Bănăduc et al. (eds), 13, 35-68, Sibiu.
6. Borsic I., 2012 – Marsilea quadrifolia L., in Flora Croatica Database, Vascular Plants Taxonomy and Bibliography of Croatian Flora, Crvena knjiga, http://hirc.botanic.hr/fcd
7. Botanix, 2012 – The cultivation of the Four leaf Clover (Marsilea quadrifolia), Botanix - A journal about plants and gardening, www.botanix.kpr.eu/en/index.php?text=15-the-cultivation-of-the-four-leaf-clover-marsilea-quadrifolia
8. Breunig T. and Demuth S., 2000 – Rote Liste der Farn- und Samenpflanzen Baden-Württemberg, Landesanstalt für Umweltschutz Baden-Württemberg Herausgeber, Fachdienst Naturschutz, Naturschutzpraxis, Artenschutz 2, 160, 3, Neu bearbeitete Fassung (Stand 15.4.1999). (in German)
9. Bundesamt für Naturschutz BfN, 2012 – Flora Web. Bonn, floraweb.de
10. Conti F., Manzi A. and Pedrotti F., 1992 – Libro rosso delle piante d'Italia, WWF Italia in collaborazione con la Società Botanica Italiana, 637. (in Italian)
11. Cook C. D. K., 1996 – Aquatic plant book, SPB Academic Publishing, Amsterdam/New York, 228.
12. Dakov M. (ed.), 1984 – Tshervena kniga na NR Bulgaria, Red data book of the People's Republic of Bulgaria, 1, Rastenia/Plants, Publishing house of the Bulgarian Academy of Sciences, Sofia, 442 (Marsilea quadrifolia). (in Bulgarian)
13. Dehondt F., Ferrez Y. and Guyonneau I., 2005 – Connaissance de la flore rare ou menacée de Franche-Comté, Marsilea quadrifolia L., CBFC Conservatoire botanique de Franche-Comté, 19, Besancon. (in French)
14. Dihoru G. and Negrean G., 2009 – Red Book of Vascular Plants of Romania, Editura Academiei Române, Bucureşti, 630.
15. Dray A. M., 1985 – Plantas a proteger em Portugal Continental, Servico Nacional de Parques, Reservas e Conservacao da Natureza, Lisboa, 56. (in Portuguese)
16. Felföldy L., 1990 – Hinár határozó, (Marsilea), Budapest, *Vizügyi Hidrobiológia*, 18, 144. (in Hungarian)
17. Garcia M. P., Frenández Z. R., Cirujano S. and Sousa A., 2006 – Aquatic macrophytes in Donana protected area (SW Spain), *Limnetica*, 25, 1-2, 71-80.
18. Gupta A. K., 2012 – Marsilea quadrifolia L., in IUCN 2012, Red List of Threatened Species, Version 2012.2. www.iucnredlist.org/details/161864/0
19. Haeupler H. and Schönfelder P., 1988 – Atlas der Farn- und Blütenpflanzen der Bundesrepublik Deutschland, Eugen Ulmer Verlag Stuttgart, 768 (Marsilea quadrifolia). (in German)

20. Horváth F., Dobolyi Z. K., Morschhauser T., Lökös L., Karas L. and Szerdahelyi T., 1995 – Flóra adatbázis 1.2, Taxonlista és attribútum-állomány, Hungarian Academy of Sciences, Vácrátot, 267. (in Hungarian)
21. Husák S. and Otahelová H., 1986 – Contribution to the ecology of Marsilea quadrifolia L., *Folia Geobotanica et Phytotaxonomica*, Praha, 21, 85-89.
22. ICN, 2006 – Plano Sectorial da Rede Natura 2000, Flora, Marsilea quadrifolia, Lisboa, www.icn.pt/psrn2000/pdfs/flora
23. IUCN, 2012 – The IUCN Red List of threatened species 2012.2, www.iucnredlist.org
24. Kazmierczakowa R. and Zarzycki K. (eds), 2001 – Polish Red Data Book of Plants. Pteridophytes and flowering plants, Polish Academy of Science, W. Szafer Institute of Botany and Institute of Nature Conservation, Cracow, 664 (Marsilae quadrifolia).
25. Käsermann C., 1999 – Merkblätter Artenschutz - Blütenpflanzen und Farne (Stand Oktober 1999), 196-197, BUWL/SKEW/PRONATURA. (in German)
26. Landolt E., 1991 – Gefährdung der Farn- und Blütenpflanzen in der Schweiz mit gesamtschweizerischen und regionalen roten Listen, Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Bern, 185 (Marsilea quadrifolia). (in German)
27. Ludwig G. and Schnittler M. (eds) BfN (Hrsg.), 1996 – Rote Liste gefährdeter Pflanzen Deutschlands, Schriftenreihe für Vegetationskunde 28, Bundesamt für Naturschutz, Bonn-Bad Godesberg, 744. (in German)
28. Maglocky S. and Ferákova V., 1993 – Red list of ferns and floweing plants (Pteridophyta and Spermatophyta) of the flora of Slovakia (the second draft), *Biologia Bratislava*, 48, 4, 361-385.
29. Ministarstvo Graditelistva i zastite okolisa, 1994 – Crvena Knijiga biljnik vrsta Republike Hrvatsko, Zavod za Zastitu Prirode, Zagreb, 522. (in Croatian)
30. Nikolic T. (ed.), 1994 – Flora Croatica, Index Florae Croaticae, 1, *Natura Croatica*, 3, Supplement 2, 1-116.
31. Oberdorfer E., 2001 – Pflanzensoziologische Exkursionsflora für Deutschland und angrenzende Gebiete, Verlag Eugen Ulmer Stuttgart, 8, Aufl., 1051 (Marsilea quadrifolia). (in German)
32. Oprea A., 2005 – Lista critică a plantelor vasculare din România, Edit. Universității "Alexandru Ioan Cuza" Iași, 668. (in Romanian)
33. Oţel V. (ed.), 2000 – The Red List of plant and animal species from the Danube Delta Biosphere Reserve Romania, Institutul Naţional de Cercetare-Dezvoltare Delta Dunării/Danube Delta National Institute, edited by Fundatia Aves, 132.
34. Philippi G., 1969 – Zur Verbreitung und Soziologie einiger Arten von Zwergbinsen- und Strandlingsgesellschaften im badischen Oberrheingebiet, *Mitteilungen des Badischen Landesvereins für Naturkunde, Naturschutz N. F.*, 10, 139-172. (in German)
35. Pouchol S., 2000 – Steckbrief: Kleefarn - Marsilea, WWF Schweiz, http:// www.ville-ge.ch/cjb/rsf/fra/fiches/pdf/mars_quad_f.pdf; assets.wwf.ch/custom/arten/Kleefarn.pdf
36. Radkowitsch A., 2006 – Life - Effizienzkontrolle Schweinebeweidung von Marsilea-Wuchsorten, Projekt Life Rheinauen, Zwischenbericht, *Regierungspräsidium Karlsruhe Ref.*, 56, 23. (in German)
37. Radkowitsch A., 2007 – Life - Effizienzkontrolle Schweinebeweidung von Marsilea-Wuchsorten, Projekt Life Rheinauen, Zwischenbericht, *Regierungspräsidium Karlsruhe Ref.*, 56, 25. (in German)
38. Ramsar Information Sheet, 1998 – Greece Ramsar Site 58 (WI Site 3 GR006), A Directory of Wetlands of International Importance, www.wetlands.org/RSIS/_COP9Directory/Directory/3GR006.html

39. Schneider E., Nichersu I., Knoben R., Koppelman G., Chendres V., Tatole V. and Keukelaar F. (eds), 2005 – Protection of wetlands of the Danube, A pilot project for Cama-Dinu islets area, Final Report, project realised for the Ministerul Mediului şi a Gospodăririi Apelor România (Ministry of Environment and Water Management) by DDNI, WWF Germany, Apele Române, Royal Haskoning PHARE RO 0105 Cross Border Cooperation Programme Romania-Bulgaria.
40. Shelijag-Sosonka I. R., 1996 – Tshervona kniga Ukraini, Roslinnii Svit. Nationalna Akademija Nauk Ukraini/Red book of Ukraine, Flowering plants, Ukrainian Academy of Science, Kiev, 603 (Marsilea quadrifolia). (in Ukrainian)
41. Silic C., 1996 – Spisak Biljnik vrsta (Pteridophyta I Spermatophyta) ZA Crvenu Knjigu Bosne i Hercegovine/The list of the vegetable species (Pteridophyta and Spermatophyta) FOR, The "Red Book" of Bosnia and Hercegovina, Sarajevo, 367. (in Croatian)
42. Tahtadjian A. L., Geltman D. W. and Popova T. N. (eds), 1988 – Krasnaija kniga RSFSR, Rastenija, Akad. Nauk SSSR, Moskva, 590 (Marsilea), (in Russian)
43. Topa E., 1952 – Fam. Marsileaceae R. Br. in Flora Republicii Populare Române, I, Editura Academiei Republicii Populare Române, 150-152.
44. Vangjeli J., Ruci B. and Mullaj A., 1995 – Red Book, Threatened and rare plants species of Albania, Acad. of Science Institute of Biological Research, Tirana, 169.
45. Walter K. S. and Gillett H. (eds), 1998, 1997 – IUCN Red List of Threatened Plants, IUCN - The World Conservation Union, 862 (Marsileaceae).
46. Zarzycki K. and Szelag Z., 1992 – Red list of threatened vascular plants in Poland, in Zarzycki K., Wojewoda W. and Heinrich Z. (eds) - List of threatened plants in Poland, Second edition, Polish Academy of Sciences, W. Szafer Institute of Botany, Cracow, 87-98.

DE GRUYTER OPEN

DESCRIPTION OF AN ECOTECHNICAL METHOD, PROPOSED FOR THE HÂRTIBACIU RIVER ALONG THE SECTOR IN AGNITA, SIBIU COUNTY

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KEYWORDS: Romania, Olt River basin, ecosystem functions, water, stream, birds, vegetation, flow.

ABSTRACT

The Hârtibaciu River is channelled (covered by concrete) near the city of Agnita and represents the confluence of numerous sources of local pollution having a negative impact both qualitatively and quantitatively. Lack of riparian vegetation gives the Hârtibaciu River an unpleasant aspect and cannot provide an efficient filter.

This ecotechnical method helps to protect the special protected areas (SPAs) into Hârtibaciu River basin and to clean the river in the city of Agnita. By the means of this method the quality of the Cibin River can also be improved, as the Hârtibaciu River is a tributary of it.

RÉSUMÉ: Description de la méthode écotechnique proposée pour la Rivière de Hârtibaciu dans le secteur de la ville d'Agnita.

La rivière de Hârtibaciu est bétonnée sur toute la longueur de sa traversée de la ville d'Agnita et elle est le collecteur de nombreuses sources de pollutions locales ayant un impact négatif sur la rivière, autant qualitativement que du point de vue quantitatif. Le manque de végétation riparienne donne à cette rivière un aspect déplaisant et ses eaux sont filtrées inefficacement.

La méthode écotechnique proposée aide à protéger les zones de protection spéciales établies dans le bassin de la rivière de Hârtibaciu ainsi qu'à nettoyer la rivière dans son secteur citadin à Agnita. Un autre résultat de l'application de cette méthode est la possible amélioration de la qualité de la rivière Cibin, collecteur des eaux de Hârtibaciu.

REZUMAT: Descrierea metodei ecotehnice, propusă pentru râul Hârtibaciu, pe sectorul de apă, aflat în dreptul localității Agnita.

Râul Hârtibaciu este canalizat (betonat) în dreptul localității Agnita și colectează numeroase surse de poluare locale, cu impact negativ asupra calităţii apei şi comunităţilor acvatice. Lipsa vegetației ripariene determină ineficienţa proceselor de filtrare a poluanţilor şi conferă râului Hârtibaciu un aspect inestetic.

Metoda ecotehnică descrisă contribuie la managementul eficient al zonelor de protecție specială situate în bazinul hidrografic al râului Hârtibaciu şi la creştrea capacităţii de epurare a apelor râului pe teritoriul orașului Agnita. De asemenea, și calitatea râului Cibin, poate fi ameliorată prin această metodă, Hârtibaciul fiind un tributar al acestuia.

INTRODUCTION

The subject of this case study proposes an ecotechnical measure consisting of: capture (measuring), using channels inside the concrete banks, of urban pollution sources, development (measuring) of an ecological river bed equipped with a wetland and of some network of wetlands as a habitat for many protected bird species existing on the Hârtibaciu Plateau.

Along the lotic sector which passes through the city of Agnita, the Hârtibaciu River is almost completely dammed (Figs. 1 and 2) with solid concrete walls on the river banks.

Because the sources of pollution (industrial and domestic) from the city of Agnita (Fig. 3) and a complete lack of riparian vegetation, basic elements that support the selfcleaning of a lotic ecosystem were almost totally destroyed.

There are many sources of pollution that penetrate the waters directly into the river Hârtibaciu River without being treated.

METHOD

This water sector was chosen because it is almost completely determined by the Hârtibaciu water's course, within the city of Agnita, and also because of the destruction of various species of bird and fish habitats in the city and also downstream the city.

In order to finalize the ecological reconstruction of the Hârtibaciu River, the new river bed should be protected from any source of pollution, so the sources of pollution (city polluted water) must be captured through parallel channels built inside the concrete banks (Fig. 4).

Sizing parallel channels will be done according to the evacuated water flow (industrial and domestic) into the Hârtibaciu River.

In this case, it is not necessary to perform the un-concreting procedure on the river banks, as the Hârtibaciu River can be rebuilt ecotechnically within these banks.

Figure 1: Hârtibaciu River (http://ro.wikipedia.org).

Figure 2: Hartibâciu River (http://ro.wikipedia.org).

Figure 3: Pollution source, Hârtibaciu River.

RESULTS AND DISSCUSION

The river water quality at the exit of Hârtibaciu, Agnita is the fourth category.

The Hârtibaciu River flow area will be constructed as meander belts by wooden concrete to resist the floods.

In the immediate vicinity of the Hârtibaciu River, wetlands will be built and linked to the river through a system of channels (Fig. 5).

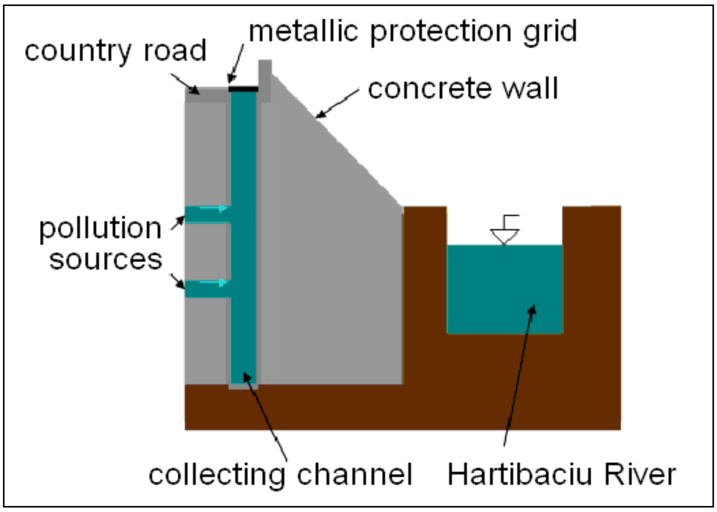

Figure 4: Collecting channel located on the right bank of Hârtibaciu River (scheme).

A meandering river bed with green sides, having the form of an inclined plane (Cibin River) are necessary to be created. Water flow area will be made of wood or concrete according to regional flood frequency and amplitude. Various fast-growing woody species (alder, willow, etc.) but also herbaceous species having fascicular roots (sedge, fescue, etc.) will be planted in line or in the form of rhombs, along these banks. The banks will filled up with soil up to the middle height of the dam protection (Fig. 5).

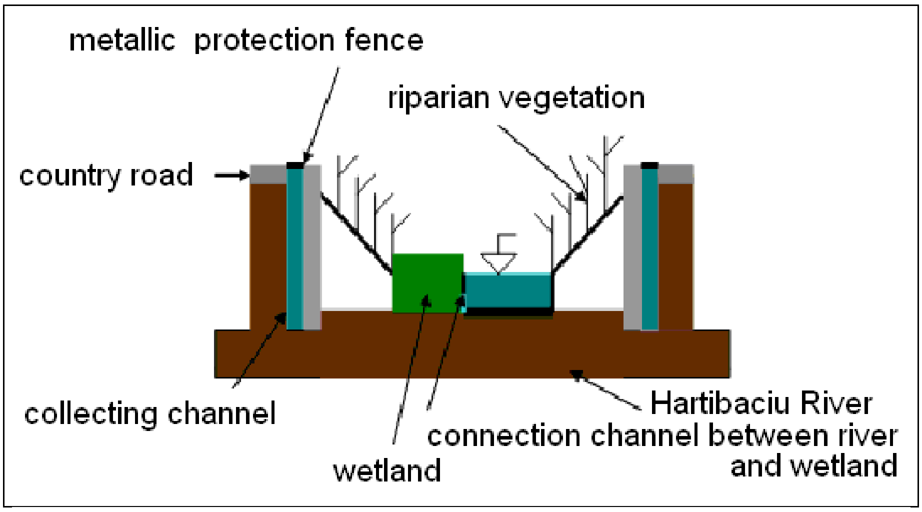

Figure 5: Ecotechnical arrangement of Hârtibaciu River in the city of Agnita - cross section (orientative scheme).

This ecotechnical method is suggested for the riverbed sector effective starting to 400 m length up to the complete river sector arrangement. The river sector which passes through Agnita will be completed at the exit of the city. The collecting channels must have the same slope as the Hârtibaciu River. The ecotechnical reconstruction of the Hârtibaciu River will also continue downstream the city of Agnita, having about 500 m length and creating riparian areas and wetlands.

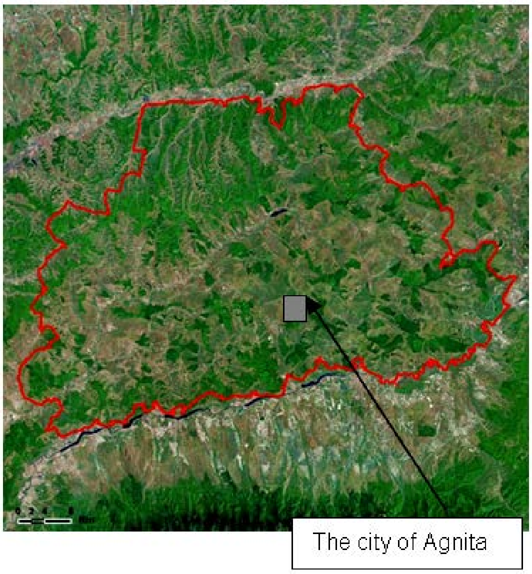

Figure 6: Hârtibaciu Plateau - Satellite image (source: Landsat Image © NASA).

According to GD 1284/2007, the Hârtibaciu Plateau (Fig. 6) has been declared a special area of aviafaunistic protection becoming a bird protection area, as a part of the European Natura 2000 network in Romania. This SPA covers parts of the territory of the counties of Brașov, Sibiu and Mureș, 39 municipalities and the five cities of Agnita, Dumbrăveni, Făgăraș, Sighișoara and Rupea, being in size, together with Sighișoara-Târnava Mare area the second protected area in the country, after the Danube Delta. Most of this area is in Sibiu County, in the Hârtibaciu Valley (Fig. 7).

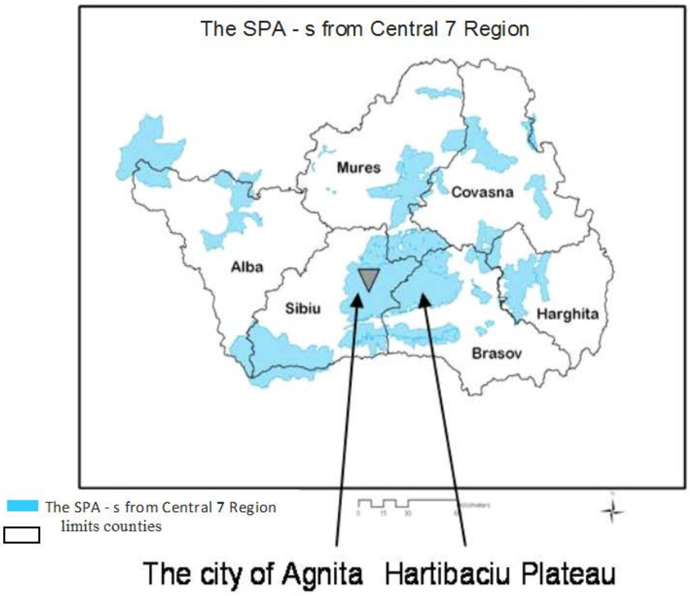

Figure 7: Hârtibaciu Plateau RO SPA 0099 (http://www.arpm7c.ro/img/spa%20web.jpg).

The aim of this special area for the protection of birds has been the preservation of 32 bird species: *Alcedo athis* (Kingfisher), *Anthus campestris* (Tawny Pipit), *Aquila pomarina* (The Lesser Spotted Eagle), *Aythya nyroca* (The Ferruginous Duck), *Botaurus stellaris* (The Eurasian Bittern), *Bubo bubo* (The Eurasian Eagle-owl), *Caprimulgus europaeus* (The European Nightjar), *Chlidonias hybridus* (The Whiskered Tern), *Chlidonias niger* (The Black Tern), *Ciconia ciconia* (The White Stork), *Ciconia nigra* (The Black Stork), *Circaetus gallicus* (The Short-toed Eagle), *Circus aeruginosus* (The Marsh Harrier), *Circus cyaneus* (The Hen Harrier), *Crex crex* (The Corncrake), *Dendrocopos leucotos* (The White-backed Woodpecker), *Dendrocopos medius* (The Middle Spotted Woodpecker), *Dendrocopos syriacus* (The Syrian Woodpecker), *Dryocopus martius* (The Black Woodpecker), *Egretta alba* (The Great Egret), *Falco vespertinus* (The Red-footed Falcon), *Himantopus himantopus* (The Black-winged Stilt), *Lanius collurio* (The Red-backed Shrike), *Lanius minor* (The Lesser Grey Shrike), *Lullula arborea* (The Woodlark), *Nycticorax nycticorax* (Black-crowned Night-heron), *Pernis apivorus* (The Honey Buzzard), *Philomachus pugnax* (The Ruff), *Picus canus* (The Grey-headed Woodpecker), *Sterna hirundo* (The Common Tern), *Strix uralensis* (The Ural Owl) and *Tringa glareola* (The Wood Sandpiper). The area hosts a significant number of typical species. Here, the most important population of The Lesser Spotted Eagle and The Honey Buzzard has its nests, the highest density being achieved at the south of the Hârtibaciu Valley. The Corncrake (*Crex crex*) population is globally significant (over 20 pairs).

Downstream of the city of Agnita, there are several areas where dozens of species of protected birds, five species of fish (*Barbus meridionalis, Cobitis taenia, Gobio kesslerii, Rhodeus sericeus amarus,* and *Sabanejewia aurata*) and the macroinvertebrates species food of fish are hosted but, due to increasing pollution, their numbers have decreased drastically. Riparian vegetation destruction, disposal of garbage and the building of various illegal constructions along the Hârtibaciu River banks led to additional pollution of the river and caused the disappearance of many habitats for various species of birds. Therefore, downstream of the city of Agnita, near the city, rectangular artificial wetlands to purify the polluted water from sewers must be constructed (Fig. 8). A part of the water entering the wetlands will reach the Hârtibaciu River through the connection channels (Fig. 8).

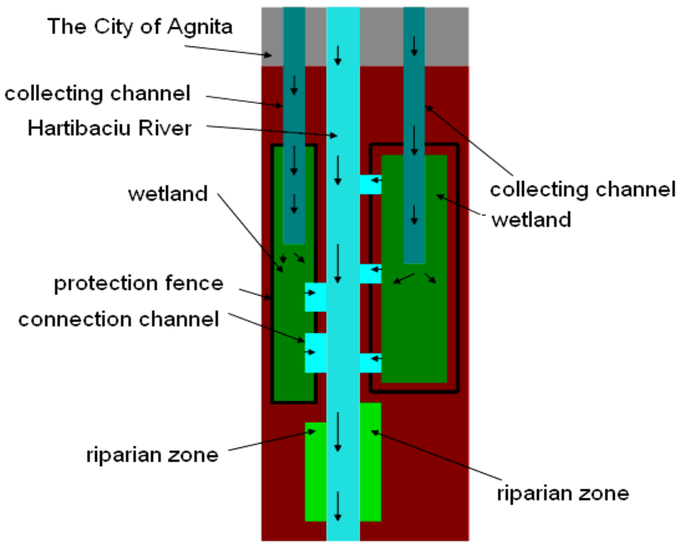

Figure 8: Ecotechnical arrangement of Hârtibaciu River downstream the city of Agnita - cross section (orientative scheme).

Downstream of the wetlands, riparian zones, extremely important to stabilize banks, will be developed (Fig. 8). All these ecotechnical arrangements using the ecological scrubber system of wetlands and riparian zones will cause a change in water quality of the Hârtibaciu River. This will generate an increase in local biodiversity of the river, which is essential to ecosystem functioning of these areas. Wetlands and riparian areas must be protected using metallic fences. An undeveloped ecotechnical arrangment of this river completely destroys the habitats of various species of birds and fish downstream the city. Ecotechnical arrangement of the Hârtibaciu River in the city of Agnita will lead to water quality improvement by the means of bioconversion and accumulation, production of organic matter for aquatic ecosystems and will safely preserve flora and fauna for the habitat (Fig. 9). Any ecotechnical arrangement of the Hârtibaciu River along the city of Agnita has no ecological value as long as there are sewer overflows into the river.

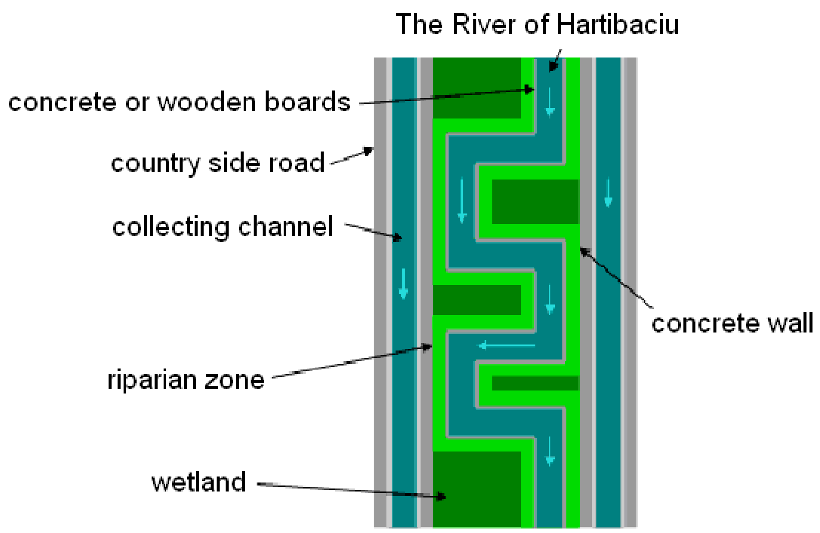

Figure 9: Ecotechnical arrangement of Hârtibaciu River in the city of Agnita - cross section (orientative scheme).

CONCLUSIONS

This ecotechnical method helps both to protect the SPAs into the Hârtibaciu River basin and to clean the river in the city of Agnita.

By the means of this method, the quality of Cibin River can be also improved as Hatibaciu River is a tributary of it.

SELECTIVE REFERENCES

1. Curtean-Bănăduc A. and Bănăduc D., 2012 – *Eco-sanitaţia alternativă pentru managementul durabil al nutrienţilor şi resurselor de apă*, în Apa resursă fundamentală a dezvoltării durabile, Metode şi tehnici neconvenţionale de epurare şi tratare a apei, I, Oprean L. (ed.), Editura Academiei Române, 433-437. (in Romanian)
2. Curtean-Bănăduc A. and Bănăduc D., 2012 – *Aspecte privind impactul deversării apelor uzate asupra sistemelor ecologice lotice receptoare*, în Apa resursă fundamentală a dezvoltării durabile, Metode şi tehnici neconvenţionale de epurare şi tratare a apei, II, Oprean L. (ed.), Editura Academiei Române, 393-416. (in Romanian)
3. Curtean-Bănăduc A., Schneider-Binder E. and Bănăduc D., 2014 – *The importance of the riverine ligneous vegetation for the Danube Basin lotic ecosystems,* in Cianfaglione K. (ed.), L'importanza degli Alberi e del Bosco, Cultura, scienza e coscienza del territorio, Temi Ed., Trento, Italia, ISBN: 978-88-973772-63-9, I-II, 187-210.
4. Curtean-Bănăduc A., Bănăduc D. and Bucşa C., Watershed Management (Transylvania, Romania) – implications, risks, solutions, Strategies to Enhance Environmental Security in Transition Countries, *NATO Security trough Science Series - C: Environmental Security, Springer*, 225-238, ISBN 978-1-4020-5995-7, 2007.
5. David L. R., 1994 – A classification of natural rivers, *Wildland Hydrology*, 157649 U. S. Highway, 160, Pagosa Springs, CO 81147.
6. Federal Interagency Stream Restoration Working Group, 1998 – Stream Corridor Restoration: Principles, Processes and Practices, 2-23.
7. Frothingham K. M., Rhoads B. L. and Herricks E. E., 2001 – Stream geomorphology and fish community structure in channelized and meandering reaches of an agricultural stream, Understanding Geomorphic Processes and Riverine Habitat, Washington D.C.: American Geophysical Union, *Water and Science Application*, 4, 105-117.
8. Galvánek D., Kadlečík J., Dostalova A., Dukaz I., Gruber T., Scmotzer A., Schmidt A., Pokorni F., Zsembery Z., Egri C., Szary A., Pokynchereda V., Gubko V., Felzbaba-Klushina L., Schneider E., Curtean-Bănăduc A., Bănăduc D. and Lazarevic P., 2014 – Development of Common Integrated Management Measures for Key Natural Assets in the Carpathians, in Development of Common Integrated Management Measures for Key Natural Assets in the Carpathians, Work Package 4, Integrated Management of Biological and Landscape Diversity for Sustainable Regional Development and Ecological Connectivity in the Carpathians, WWF Danube-Carpathian Programme, Vienna, Appleton M. R. and Meyer H., (eds), 72-103, ISBN 978-9958-021-01-3.
9. Kondolf G. M. and Micheli E. R., 1995 – Evaluating stream restoration projects, *Environmental Management*, 19, 1, 1-15.
10. Palmer M. A. and Bernhardt E. S., 2006 – Hydroecology and river restoration: ripe for research and synthesis, W03S07; 10.1029/2005, WR004354, *Water Resources Research,* 42, 3.
11. Power M. E., Dietrich W. E. and Finaly J. C., 1996 – Dams and downstream aquatic biodiversity: potential food web consequences of hydrologic and geomorphic change, *Environmental Management*, 20, 6, 887-895.
12. Rosgen D. L., 1996 – Applied River Morphology, Wildland Hydrology Books, Pagosa Springs, Colorado, 5-30.
13. Schiechtl H. M. and Stern R., 1996 – Water Bioengineering Techniques for Watercourse Bank and Shoreline Protection, Cambridge, Blackwell Science Inc. 223.
14. Stream Bank Erosion, NRCS Field Office Technical Guide, 2003 – United States Department of Agriculture, 2-20.
15. U.S. Environmental Protection Agency, Office of Water, River Corridor and Wetland Restorationhttp://www.epa.gov/owow/wetlands/restore/
16. U.S. Environmental Protection Agency, 2008 – Watershed Assessment of River Stability and Sediment Supply (WARSSS) website: www.epa.gov/warsss/sedsource/streamero.htm
17. * http://www.arpm7c.ro

RHODEUS SERICEUS AMARUS BLOCH, 1782; MONITORING ELEMENTS IN THE NEW NATURA 2000 CONTEXT IN CROATIA

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ABSTRACT

The action framework at the European Union level for the conservation of biodiversity was set up based on the Birds Directive (79/409/EEC) and Habitats Directive (92/43/EEC). One principal element of the implementation of these two significant Directives in Croatia is the set up of a Natura 2000 network of protected areas, a network which should be based on a specific monitoring plan at Croatian national level for each species which is considered of community interest. In this general context, this study suggests a set of monitoring elements for *Rhodeus sericeus amarus* for the Croatian Continental Biogeographical Region. The suggestions are based on eight selected criteria: Croatian national borders proximity sectors overlay; very good quality populations of *Rhodeus sericeus amarus* in terms of population density and structure (e.g. protected areas) in characteristic good habitats; habitats which need ecological reconstruction to allow this fish species populations structure ameliorate or natural repopulation; key sectors with importance for connectivity (e.g. lotic sectors between different important sectors, rivers confluence areas, etc.); sectors influenced by human impact like: industrial pollution point sources, sectors influenced by agricultural diffuse sources of pollution, sectors influenced by habitats modifications (watercourses remodeling, watercourses regulation, etc.), geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes.

RÉSUMÉ: *Rhodeus sericeus amarus* Bloch, 1782; des éléments de surveillance dans le nouveau contexte Natura 2000 de la Croatie.

Le cadre des actions pour la conservation de la biodiversité au niveau de l'Union Européenne a été établi en base des Directives Oiseaux (79/409/EEC) et Habitats (92/43/EEC). Un des éléments essentiels de l'implémentation en Croatie des deux directives a été l'établissement du réseau des zones protégées Natura 2000, un réseau qui devrait être basé sur un plan de surveillance adapté aux spécificités nationales et aux caractéristiques des espèces d'intérêt communautaire. Dans ce contexte, la présente étude propose une série d'éléments de surveillance pour *Rhodeus sericeus amarus* dans la région biogéographique continentale croate. Les suggestions ont été faites en fonction de huit critères sélectionnés: la position des secteurs à la proximité des frontières nationales; des populations de *Rhodeus sericeus amarus* de très bonnes qualités en termes de densité et de structure (i.e. des zones protégées) avec des habitats caractéristiques et de qualité; les habitats nécessitant des mesures de reconstruction écologique afin de permettre aux populations de ce poisson de se reconstruire naturellement ou d'améliorer leur structure; des secteurs clés pour la connectivité (i.e. des secteurs lotiques entre des secteurs importants, des confluences de rivières etc.); les secteurs à diverses impactes humains tels que des secteurs influencés par des apports ponctuels de pollution industrielle, par des sources diffuses de pollution agricole, des secteurs dont les habitats ont été modifiés (des systématisations et régularisations des cours d'eau, etc.), des secteurs de monitoring des extrêmes géographiques situés au plus près des deux extrémités des cours d'eau (sources et confluences) sur le territoire de l'espèce ainsi que les secteurs avoisinants.

REZUMAT: *Rhodeus sericeus amarus* Bloch, 1782; elemente de monitorizare în noul context Natura 2000 din Croația.

Cadrul de acțiune pentru conservarea biodiversității la nivelul Uniunii Europene a fost stabilit în baza Directivei Păsări (79/409/EEC) și a Directivei Habitate (92/43/EEC). Un element principal al implementării în Croația a acestor două Directive semnificative este stabilirea rețelei de arii protejate Natura 2000, o rețea care ar trebui să fie bazată pe un plan de monitorizare specific la nivel național pentru fiecare specie considerată a fi de interes comunitar. În acest context general, studiul de față sugerează o serie de elemente de monitorizare pentru *Rhodeus sericeus amarus* în Regiunea Biogeografică Continentală croată. Sugestiile/măsurile de management propuse se bazează pe opt criterii selectate: dispunerea sectoarelor situate în proximitatea frontierelor naționale; populații de *Rhodeus sericeus amarus* de foarte bună calitate în ceea ce privește densitatea și structura populațiilor (de ex. zone protejate) cu habitate caracteristice de calitate bună; habitate ce necesită măsuri de reconstrucție ecologică pentru a permite populațiilor acestei specii de pește să se refacă natural sau să își amelioreze structura; sectoare cheie importante pentru conectivitate (de ex. sectoare lotice între diferite sectoare importante, zone de confluență ale râurilor, etc.); sectoare influențate de impactul antropic precum: surse punctuale de poluare industrială, sectoare influențate de surse difuze de poluare agricolă, sectoare influențate de modificări ale habitatului (sistematizări și regularizări ale cursurilor de apă, etc.), secțiuni de monitorizare ale extremelor geografice din secțiunile cele mai din amonte și mai din aval ale râurilor din arealul speciei, precum sectoarele imediat următoare și externe acestora.

INTRODUCTION

Croatia entered in the European Union, which will induce supplementary obligations for this country regarding environment protection and conservation in a similar way with all the older EU countries.

The main objectives of the European Community in the nature field of interest are the conservation, protection and continuous improvement of the environment structure quality for an optimum use of nature resources and services, including that of the aquatic ecosystems. In the last decades, the biodiversity was one of the most important issue in this context.

The European Community action frame to manage the biodiversity was set up and supported mainly by the Birds Directive (79/409/EEC) and the Habitats Directive (92/43/EEC). These two crucial European Directives have essential objectives to preserve the biodiversity in the European Union territory supported by a protected areas network, the Natura 2000 net, to conserve key habitats and species characteristic for all the existent European biogeographic regions: Arctic, Boreal, Atlantic, Continental, Alpine, Pannonian, Mediterranean, Macaronesian, Steppic, Black Sea, and Anatolian (Fig. 1).

The Croatian territory has a relatively good biogeographic diversity in the context of the European Union countries, including four biogeographic regions: Continental, Alpine, Pannonian, and Mediteranean (Fig. 1).

One main element of the implementation of the Directives is the set up of a Natura 2000 network in Croatia as well, a network which should be based on a specific national monitoring plan for each species and habitat of European conservative interest. The joining of this country to EU makes this monitoring proposal a key element for future management related plans in Croatia.

The range of *Rhodeus sericeus amarus* in Eurasia is with a disjunct range of distribution. In Europe, it is present in some parts of the Baltic, North, Black, Caspian, Aegean and Mediterranean seas basins. It also exists in the Croatian national territory. Until now, distribution data about *Rhodeus sericeus amarus* in Croatia was not systematically/completely collected. This species often was not found in some zones but reappeared in nearby zones. The relatively sporadic presence/knowledge of this species in Croatia is known based on the last few decades of studies in Drava, Ilova, Kupa, Sutla and Una and their tributaries watersheds. In some of the Croatian Danube Basin areas this species is common or very common.

Regarding *Rhodeus sericeus amarus* there has been no Croatian national permanent/long term specific monitoring on the distribution of populations and their ecological status until now. Not all potential zones of existence were studied, including those which can be at least theoretically appropriate for establishment of Natura 2000 sites. Despite this situation of knowledge, it is considered by the Croatian ichthyologists as a relatively well spread and common species in the continental biogeographical region. The range and abundance of this species in Croatian continental biogeographical region can be considered as relatively high in the suitable habitats. In other biogeographical regions is an invasive species. That is why it is considered as needing a monitoring program only for the Continental Biogeographical Region.

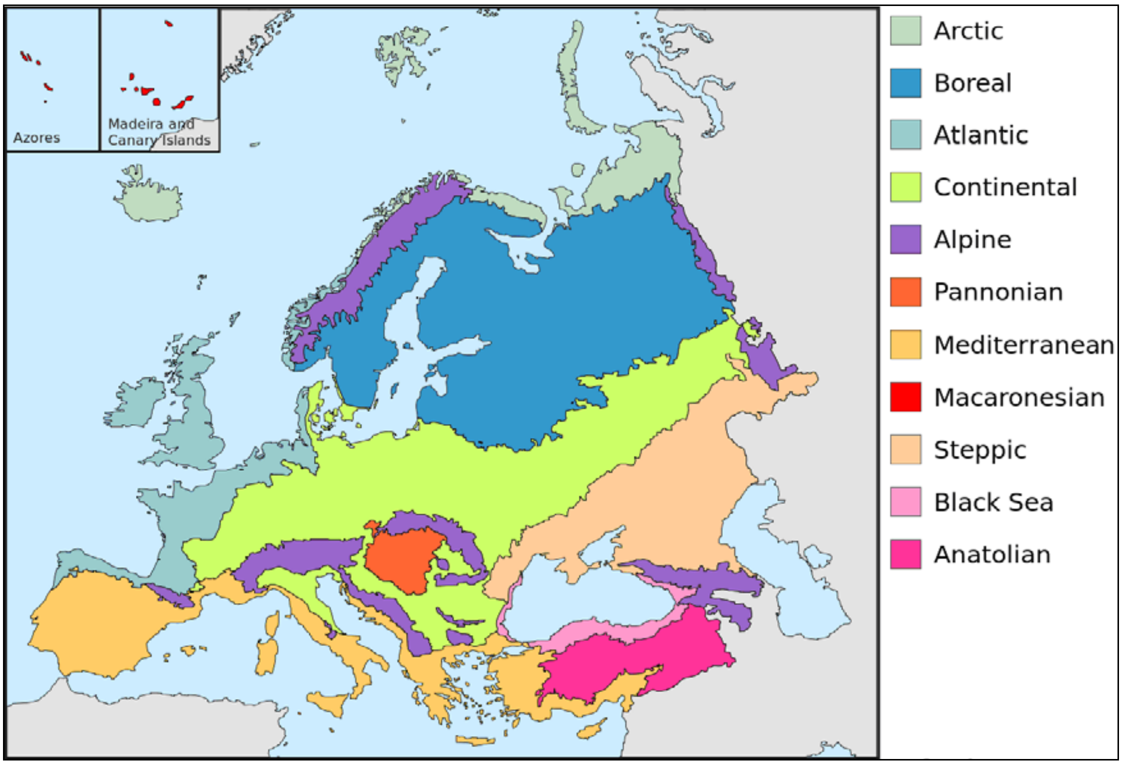

Figure 1: European biogeographic regions; European Environment Agency - www.eea.eu.in.

Assessments have been done in areas proposed as pSCI sites: rivers Drava (15-30% proportion of the population in relation to the size of the population at the state level), Ilova (2%), Kupa (15-30%), Sutla (2%) and Lonjsko polje (2-15%) and Kopački rit (2-15%) areas.

In the next three years through the Natura 2000 Integration Project (NIP), inventory of freshwater ichthyofauna is expected to be done completely in the areas with present data gaps.

Rhodeus sericeus amarus is a part of the Habitats Directive (92/43/EC) species Annex II. In Central and Eastern Europe, it is rather a common species with a high potential as an umbrella species; a similar situation exists in Croatia as well.

In spite of the fact that no complete data about *Rhodeus sericeus amarus* range in Croatia is acquirable today (a relatively frequent situation in other European countries too), the actual known data represent sure data for the proposal of a medium/long term monitoring elements proposal for this country.

Rhodeus sericeus amarus is a benthopelagic fish species, living in temperate areas, in fresh and standing or slow flowing waters, with aquatic vegetation and sand-silt bottom (canals, slow-flowing rivers, backwaters, oxbows).

This fish species food consists of unicellular filamentous algae and vegetation debris. The sexual maturity is reached at one year. Its reproduction is happening in the end of April until August. The roes are layed down in the *Unio* and/or *Anodonta* molluscs' gills cavity. The larval stage is also taking place in this cavity. It is a species well understood with respect to its biology and partially of its ecology in the studied Croatian areas of interest.

This species is listed in Annex II of the European Union Habitats Directive, in the Annex III of the Berne Convention, and IUCN Red List. In the Croatian territory, it is considered to be a vulnerable (VU) species.

Rhodeus sericeus amarus is threatened directly by human induced pollution and also indirect by pollution effects on freshwater mussels. The aquatic and semi aquatic (riverine) habitats degradation and river regulation, remodelling and flooding control, indirect contamination, influence this species negatively, directly and/or indirectly. Today there are noted important fluctuations in the number of this specie's locations and subpopulations.

Regarding this fish species conservation, protective measures should be done where the local situation require actions for that: preserving and improving the favorable ecological balance of the natural waters inhabited by this species, ichthyological protected areas (reserves) of conservative interest, preventing and avoiding of water and sediments flow regulation as much as possible close to the natural regime, construction of appropriate devices for water recycling, avoiding lotic fragmentations due to different categories of constructions presence in the river bed, etc. These elements cannot be realized on long term without a working monitoring system specific for this fish species.

RESULTS AND DISCUSSIONS

The result of this study is a proposal of elements of monitoring for *Rhodeus sericeus amarus* for the Croatian Continental Biogeographical Region. The proposed monitoring elements are based on the actual distribution data of this fish species and the main human threats. Based on the overlapping of the data of distribution of this fish species on the human disturbed lotic sectors, the scale of a spatial monitoring grid can be proposed and the monitoring frequency in space and time can be revealed. "Theoretical/blind" approach in proposing the temporal and spatial frame of this fish species monitoring can only be an intellectual exercise, which will fail in the future in terms of accuracy of the results, and bring many costly future adjustments of the initial monitoring system elements. Even if the lotic systems are one of the most dynamic ecological ecosystems on Earth, even in the most appropriate approached monitoring elements proposals, sooner or later, they will need adjustments.

The *Rhodeus sericeus amarus* monitoring sectors, at the Croatian national level/Continental Biogeographical Region, were proposed based on eight criteria: ❶ Croatian national borders proximity sectors overlay; ❷ very good quality populations of *Rhodeus sericeus amarus* in terms of population density and structure (e.g. protected areas) in characteristic good habitats; ❸ habitats which need ecologically reconstruction to allow this fish species populations structure ameliorate or for natural repopulation; ❹ key sectors with importance for connectivity (e.g. lotic sectors between different important sectors, rivers confluence areas, etc.); sectors influenced by human impact like: ❺ industrial pollution point sources, ❻ sectors influenced by agricultural diffuse sources of pollution, ❼ sectors influenced by habitats modifications (watercourses remodeling, watercourses regulation, etc.), ❽ geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes.

The potential future amelioration of the *Rhodeus sericeus amarus* species distribution data regarding Croatia can bring new monitoring proposals. The process of making better the monitoring of this species should be a continuous one.

Spatial monitoring elements

❶ Croatian national borders proximity areas of interest coverage.

These monitoring sectors were proposed due to their relevance for needed future transboundary European monitoring systems and methods intercalibrations, and for international data checking and exchange. Also, these sectors represent the limits of the Croatian national responsibility for improving this fish species conservation status. These monitoring sectors are proposed to be carried out once every year.

Based on this monitoring criterion, ten monitoring sections (Fig. 2, ❶) were proposed.

One sampling station should be on Mura River, under once per year monitoring plan, on the Croatian - Slovenian - Hungarian border, in the proximity of Novakovec locality.

One sampling station should be on Drava River, under once per year monitoring, on the Croatian - Hungarian border, at aproximatively 100 km downstream of the Novakovec locality (locality situated on Mura River).

One sampling station should be on Drava River, under once per year monitoring plan, on the Croatian - Serbian border, upstream of the confluence with the Danube River, upstream Aljmaš locality.

Two sampling sections should be on Sutla River, under once per year monitoring, plan on the Croatian - Slovenian border, (section one road number 205 access to Sutla River and bridge from Razvor locality through Razvor Street; section two road number 225 access to Sutla River and bridge from Harmica locality through Ivana Perkovca Street).

Two sampling sections should be on Kupa River, under once per year monitoring plan, on the 118 km long north-west Croatian - south-east Slovenian border, with an around of 50 km among them (section one aproximativelly 50 km downstream of Mandli locality; section two road access to a bridge over Kupa River from Cerje Vivodinsko or Preseka Ozaljska localities).

One sampling station should be on Glina River, under once per year monitoring plan, on the Croatian - Bosnia-Hertzegovina border (road access and bridge near Katinovac locality).

One sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Una River, in the Stanic Polje locality.

The second sampling station should be in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Una River, in the Hrvatska Dubica locality, with road access from the road number 47.

Some human impact from the upstream countries/regions which can induce negatively qualitative (species disappearance) and/or quantitative (relative abundance) changes of the monitored fish populations, will induce a negative future prospects related to this fish species range, habitat quality, long-term viability and conservation status, situation which is recommended to be evaluated once a year.

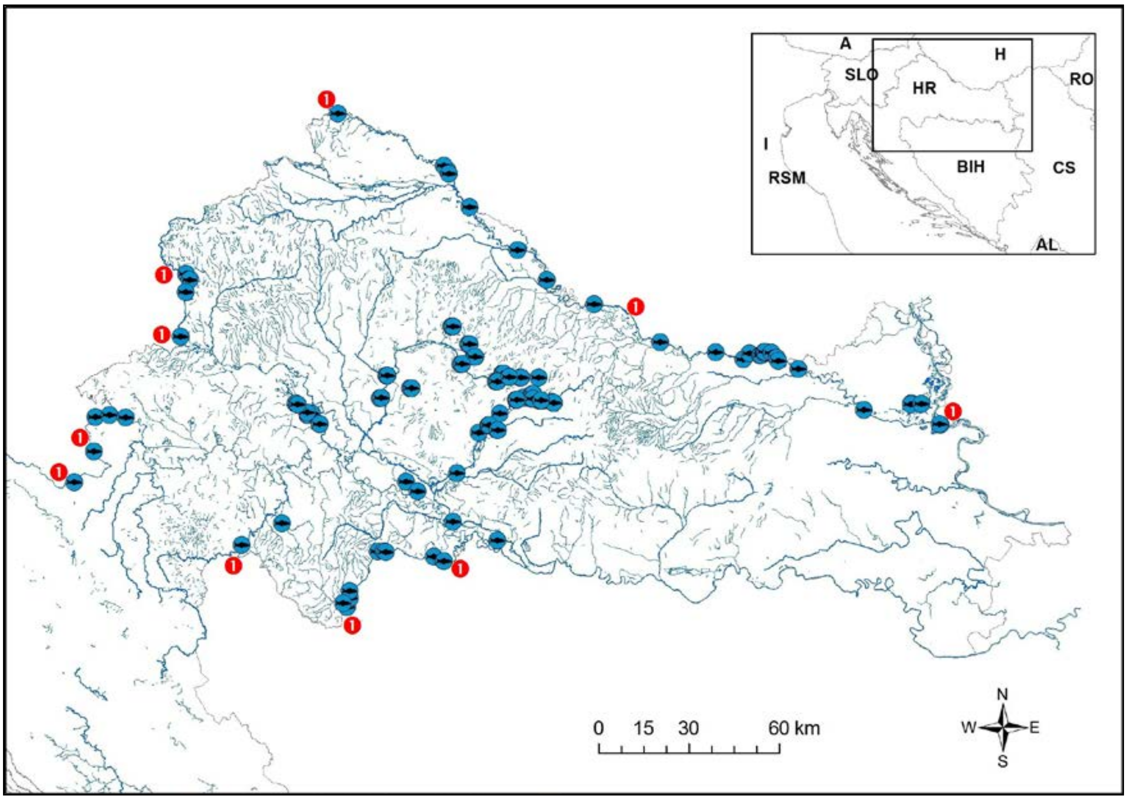

Figure 2: *Rhodeus sericeus amarus* proposed monitoring sectors (➊), in relation with the Croatian borders proximity areas of interest coverage criteria; *Rhodeus sericeus amarus* distribution , update situation (Duplić, SNIP, 2012).

➋ Very good quality populations of *Rhodeus sericeus amarus* in terms of population density and structure in characteristic good habitats.

This second category of monitoring sectors were proposed due to their genetic importance for a healthy status of this species populations on Croatian territory and also in neighbouring states' territories, and for the posibility of natural repopulation of basins sectors where this fish species can live and disperse. Based on this specific monitoring criteria, six monitoring sectors (Fig. 3; ➋) were identified.

One sampling section should be in the Nature Park Žumberak - Samoborsko gorje, at 30 kilometers south-west of Zagreb, with tributaries for Sava River. Sampling activities are needed once every six years if no extraordinary events should appear (natural and/or human events which have results of major or significant biocoenosis and/or habitats modifications). One sampling station in the proximity of the Southern Croatia - Bosnia and Herzegovina border on the Una River, downstream of the Stanic Polje locality. One station in the proximity of the Northern Croatian - Hungarian border on the Drava River, near the Donji Miholjac locality, road and bridge access on the road number 53. One sampling section should be on Sutla River, under once per year monitoring plan, on the Croatian - Slovenian border, from the road number 205 access to Sutla River and bridge from Razvor locality through Razvor Street. One station on the middle Česma River course, under once per year monitoring plan. One section should be in the Odransko Polje protected area proximity, in Sava River, samplings are needed once every six years if no extraordinary events should appear (natural and/or human events which have results of major or significant biocoenosis and/or habitats changes).

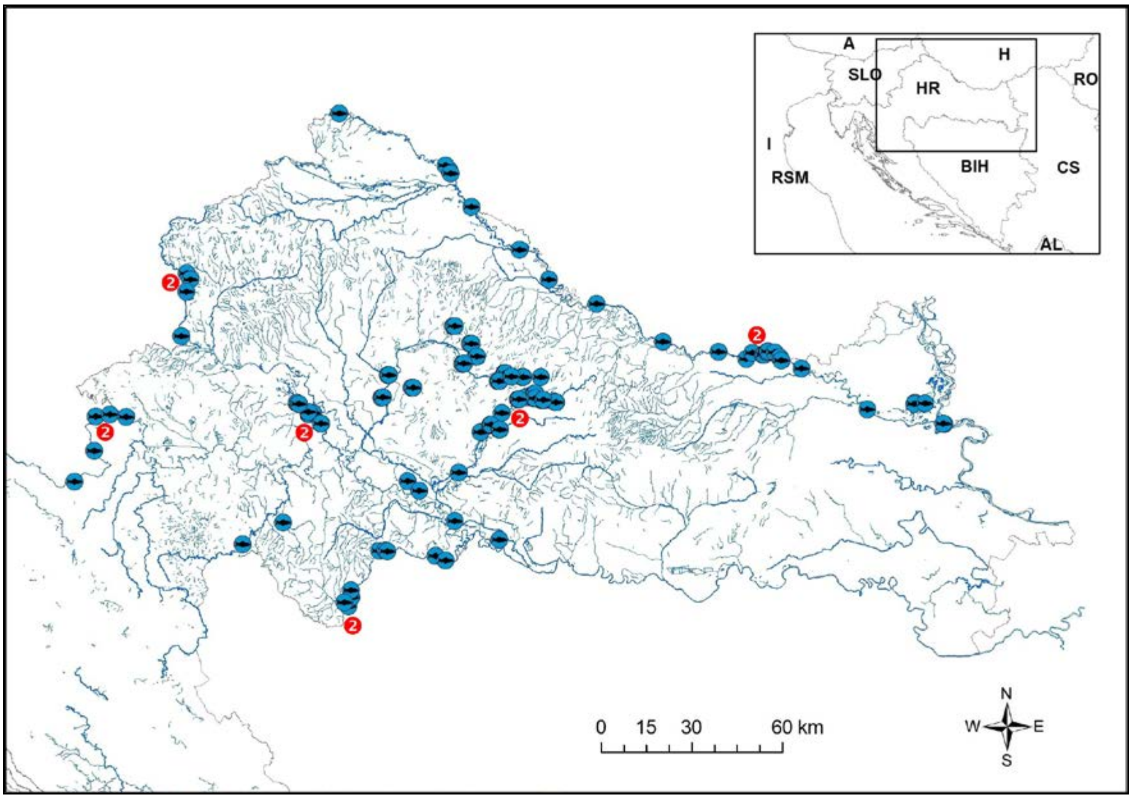

Figure 3: *Rhodeus sericeus amarus* monitoring sections ❷, based on the good quality populations of *Rhodeus sericeus amarus* in terms of populational structure/ density in characteristic habitats; *Rhodeus sericeus amarus* distribution, update situation (Duplić, SNIP, 2012).

Human impacts in these areas, which can generate qualitative (species disappearance) and quantitative (relative abundance and/or age structure modifications) changes of the assessed populations, will induce bad future prospects associated to the species habitat quality, range and conservation status, medium and/or long-term viability, situation which should be monitored once every six years at national level, if no exceptional events should happen (natural and/or human events which generate significant habitat or/and biocoenosis changings).

❸ Lotic habitats/sectors which need reconstruction to permit the *Rhodeus sericeus amarus* populations structure ameliorating for natural repopulation. This is an exclusive case, if the lack of data did not induce some false breaches in the distribution data/knowledge.

This third category of monitoring sectors was proposed due to the discontinuous distribution of this species, maybe as a consequence of human activities pressure, and also due to some breaches in the present knowledge. Based on this proposed monitoring criteria, three monitoring sections (Fig. 4; ❸) were selected.

One sampling section should be on Sutla River, under once per six years period monitoring plan, on the Croatian - Slovenian border, access on the road and bridge to Sutla River from Kraj Donji locality to the road number 676. One sampling section should be on Mura River, under once per six years period monitoring plan, on the Croatian - Hungarian border, in the proximity of the Hungarian locality Muraratka. One sampling section should be on Sava River, under once per six years period monitoring plan, downstream of Sisak, in the proximity of Sunja locality, road access from the road number 224.

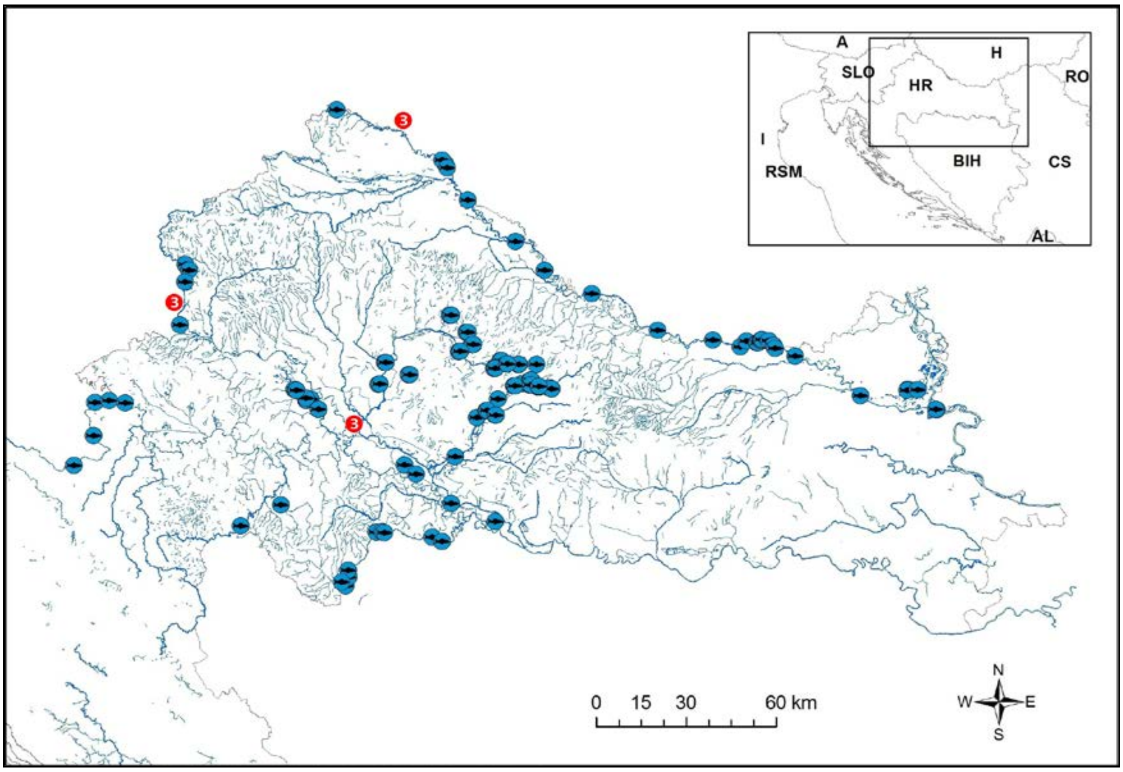

Figure 4: *Rhodeus sericeus amarus* selected monitoring sections (❸), based on the lotic sections which should be reconstructed, to allow *Rhodeus* sp. population structure amelioration or natural repopulation criteria, potential sectors to be proposed for ecological reconstruction. *Rhodeus sericeus amarus* distribution , update situation (Duplić, SNIP, 2012).

❹ Key sections with relevant importance for ichthyofauna connectivity (e.g. intermediate river sectors between diverse important fish populations' areas; rivers confluences).

This fourth category of monitoring sectors was proposed due to their potential positive role as connectivity coridors with relevant importance in the continuity of this species distribution, but they can also represent breaches in the present knowledge. If all these sectors prove to be only breaches in the actual knowledge, which will be covered with information in the future, they can be removed from the selected list of monitoring sectors.

Based on this monitoring criteria, five monitoring sections (Fig. 5; ❹) were proposed here.

One sampling section should be on Sutla River, under once per six years period monitoring plan, on the Croatian - Slovenian border, access on the road and bridge to Sutla River from Kraj Donji locality to the road number 676. One sampling section should be on Mura River, under once per six years period monitoring plan, on the Croatian - Hungarian border, in the proximity of the Hungarian locality Muraratka. One sampling section should be on the lower Česna Sava River, its "export of biodiversity" regarding Bitterling species too, being obvious. One sampling section should be on Sava River, under once per six years period monitoring plan, downstream of Sisak, in the proximity of Sunja locality, road access from the road number 224. The second sampling station in the proximity of the Southern Croatia - Bosnia and Herzegovina border on the Una River, in the Hrvatska Dubica locality, with road access from the road number 47.

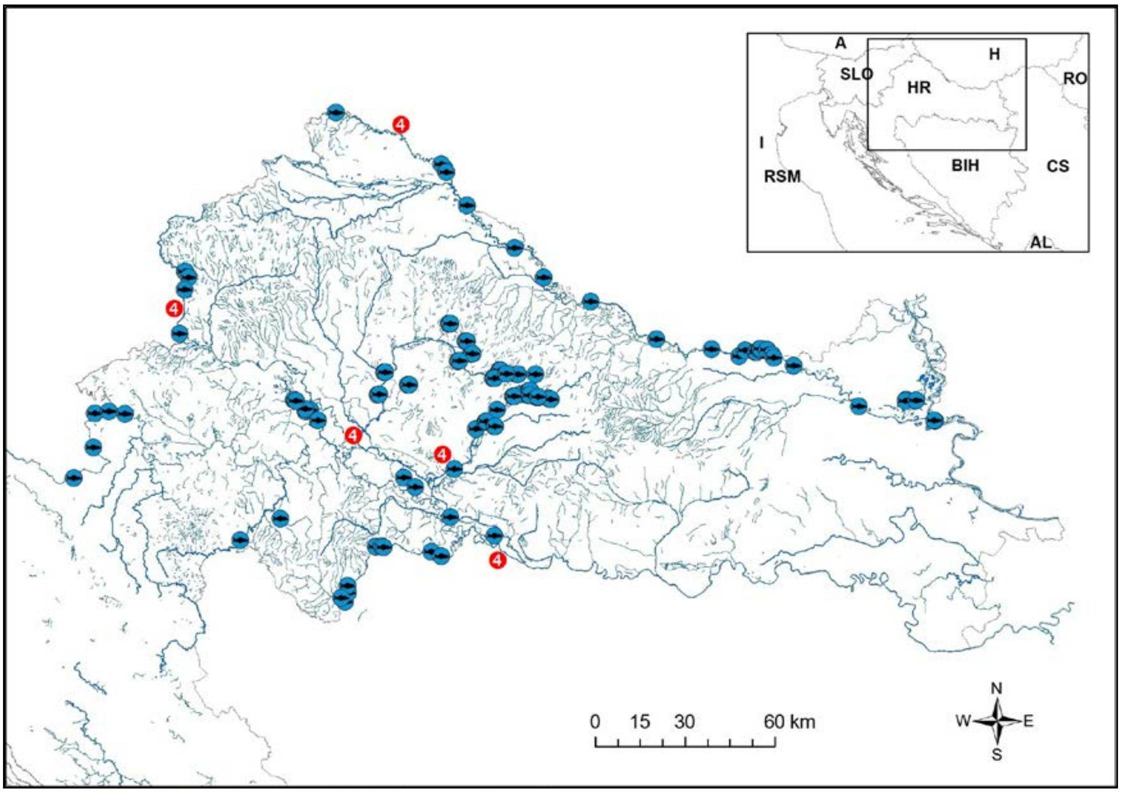

Figure 5: *Rhodeus sericeus amarus* selected monitoring sectors ❹,
based on key sectors with relevant importance for connectivity;
Rhodeus sericeus amarus distribution,
update situation (Duplić, SNIP, 2012).

Any human activities pressure in these river sectors which can induce the lacking of at least accidental presence of *Rhodeus amarus* individuals, generate negative future prospects associated with this fish species conservation status and range, a situation which should be monitored once in every six years at the Croatian national level.

❺ industrial and waste water pollution point sources areas (Fig. 6).

The Drava and Kupa rivers were approached regarding the industrial pollution point sources hot spots, which need once per year period monitoring sectors.

Drava River needs a once per year period of monitoring section downstream the Osijek locality, with road access from the road number 213.

Kupa River needs a once per year period of monitoring section downstream the Karlovac locality, which releases partially treated waste water.

Also in the confluence area of Kupa with Sava at Sisak locality (chemical, metal, leather, textile and food) where the industry negative impact brings a supplementary reason for monitoring this area.

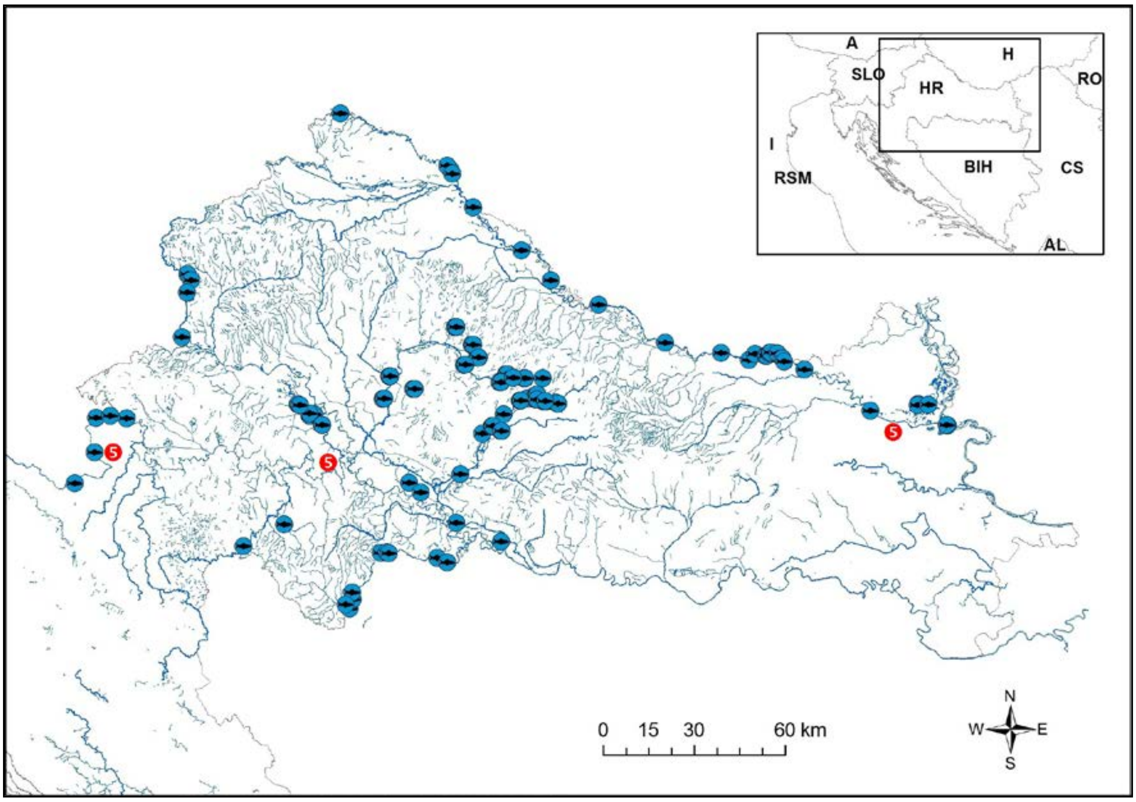

Figure 6: *Rhodeus sericeus amarus* selected monitoring sections ❺,
based on the industrial and waste water pollution point sources data criteria;
Rhodeus sericeus amarus ,
update situation (Duplić, SNIP, 2012).

❻ sectors influenced by agricultural pollution diffuse sources (Fig. 7).

The following Sava River tributary was approached in relation with the agricultural pollution diffuse sources, which needs monitoring sections.

Sutla, due to the proximity of large corn fields cultivation that has high heavy metals concentrations values in the water due to K_2O, Co, Cu sulphate and Ti used in chemicals fertilizer, needs a monitoring section in this river between the localities Ključ Brdovečki and Drenje Brdovečko. In this section, high values of enterococs numbers (coming from the farms situated in this basin), N total, P total, humic substances (including U complexes) from chemical fertilizers we also found.

Drava is one of the main collectors for agricultural waste waters, including organoclorurates, a monitoring section before the confluence with Danube River being necessary in these circumstances.

Sava is the main collector for agricultural waste waters in Croatia, including the organoclorurates, a monitoring section downstream the lower sector where *Rhodeus sericeus amarus* that was found on this river in Croatia (in the Una and Sava rivers confluence proximity) and is a necessity.

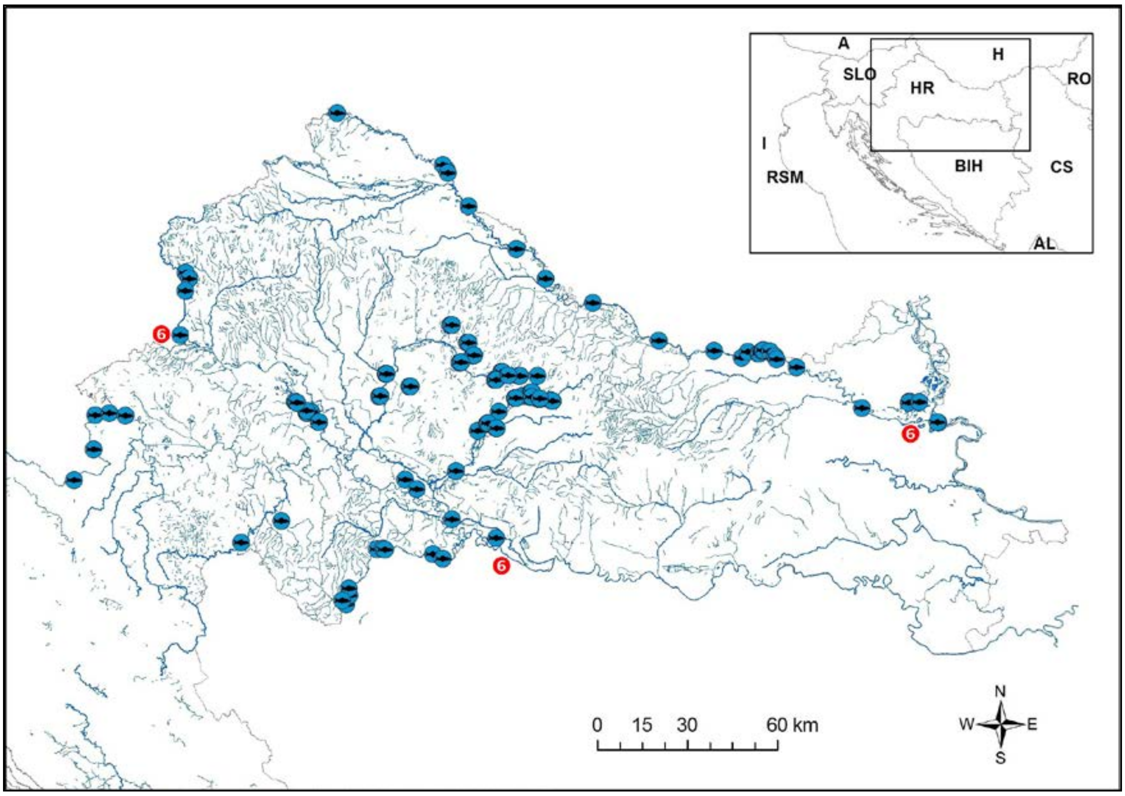

Figure 7: *Rhodeus sericeus amarus* selected monitoring sections ❻,
based on areas influenced by agricultural pollution diffuse sources data criteria;
Rhodeus sericeus amarus ,
update situation (Duplić, SNIP, 2012).

❼ changed sectors influenced by modifications of habitat (channeling, remodeling, dams, watercourses regulation, etc.) (Fig. 8).

On Sava River, downstream of the Trebez Dam, location from which *Rhodeus sericeus amarus* has not been present for over 50 km, a monitoring station for this species should be settled in the proximity of Trebez locality (road and bridge access).

On Drava River, upstream of Donja Dubrava locality, where hydroelectric power plant dams were built (Varaždin, Čakovec, Medmurje and Dubrava). Downstream Donja Dubrava locality, before the confluence with Mura River a monitoring section for this fish species should be settled, with access from the road number 20.

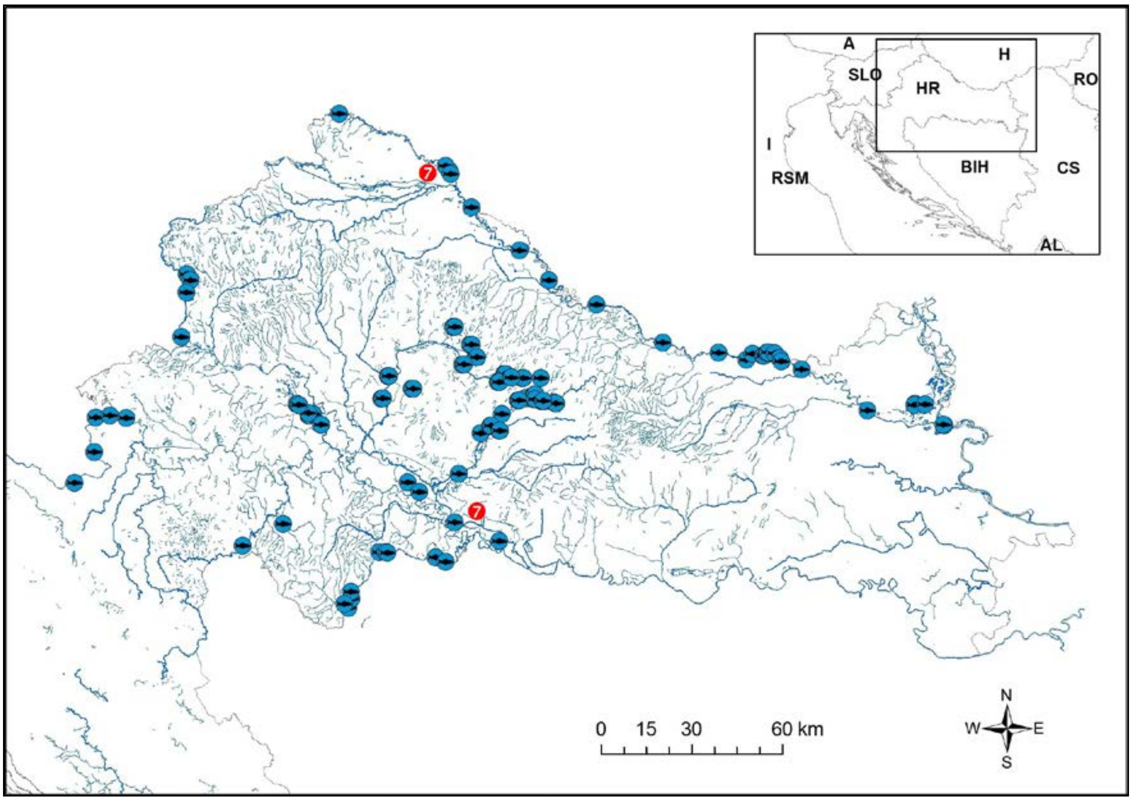

Figure 8: *Rhodeus sericeus amarus* selected monitoring sections (❼), based on the modification of habitats criteria. *Rhodeus sericeus amarus* distribution, update situation (Duplić, SNIP, 2012).

❽ geographically extreme monitoring sections (Fig. 9) in the most-downstream and upstream sectors, in this fish species range and in the near outer proximities of these extremes.

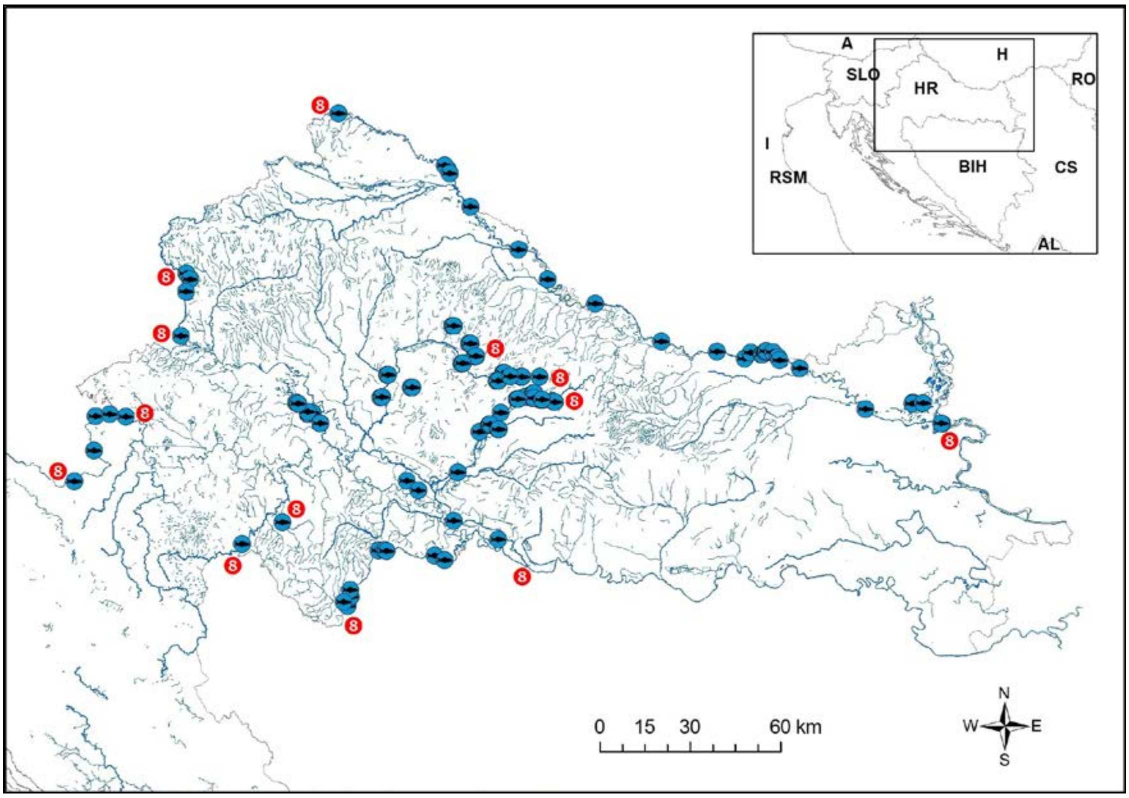

Figure 9: *Rhodeus sericeus amarus* selected monitoring sectors (❽),
based on the geographically extreme monitoring sectors;
Rhodeus sericeus amarus distribution, update situation (Duplić, SNIP, 2012).

Evaluation of the conservation status

First a systematic survey of this fish species distribution on the Crotian territory should be realised and the range of this species should be continuously compared by the future monitoring data.

Rhodeus sericeus amarus population units qualitative and quantitative elements, units proposed in the upper monitoring sections can rely on some fish biotic index criteria. The proposed combination of metrics was designed to reflect insights of communities and population comparable perspectives. Each selected metric value should be compared with the value estimated from other similar sites. It should be considered the fact that as the biotic integrity (found on the following selected metrics) decreases, the lotic ecosystem quality decreases too.

The selected categories of metrics are: I fish species richness and composition (with the following metrics: 1. total number of species; 2. proportion of benthic species; 3. proportion of water column species; 4. proportion of individuals of intolerant species; 5. proportion of individuals of typically tolerant species); II trophic composition (1. proportion of individuals as omnivores feeders; 2. proportion of individuals as insectivores feeders); III fish abundance and condition (1. numbers of individuals in sample; 2. introduced species will be assigned to each metric species, on zoogeographic basis).

Ratings of one to five should be assigned to every metric according to whether its assessed value approximates deviates little or much from the expected value of the best expert judgement at a comparable site that is relatively similar but also relatively undisturbed.

The total score for every assessed site should represent the all nine-metrics sum and the scores can be understood based on the next comparison intervals: 45-43-excellent, reflects comparable to natural conditions, exceptional communities of species; 42-36-very good, shows a decrease in species richness, in particular intolerant species, present sensitive species; 35-31-good, fair intolerant and sensitive species absent, skewed trophic structure; 30-24-fair, some expected species are rare or absent, dominant omnivores and tolerant species; 23-17-fairly poor, score which reveals few species and individuals, dominant tolerant species; 16-10-poor, very few individuals and species present, dominant tolerant species; 9-1-very poor, very few individuals and species present, tolerant species or fish absence.

An assessment of any fish species population conservative status can be done in the ichthyocenosys assessment context. Any other assessment approaches will have a low quality.

Using these fish metrics, it permits the possibility to assess the conservative status of the target populations in the local specific ichthyologic assemblage context and also of the habitat.

In every six years, supplementary sampling sectors should be done in all the downstream and/or upstream extreme (geographically speaking) areas to highlight the possible territorial extension of this species.

The reduction in range can be highlighted through the presence or absence of the species in the monitoring stations.

Evaluation Grid

A 50/50 km grid was used in the Danube Basin map of Croatia (Fig. 10).

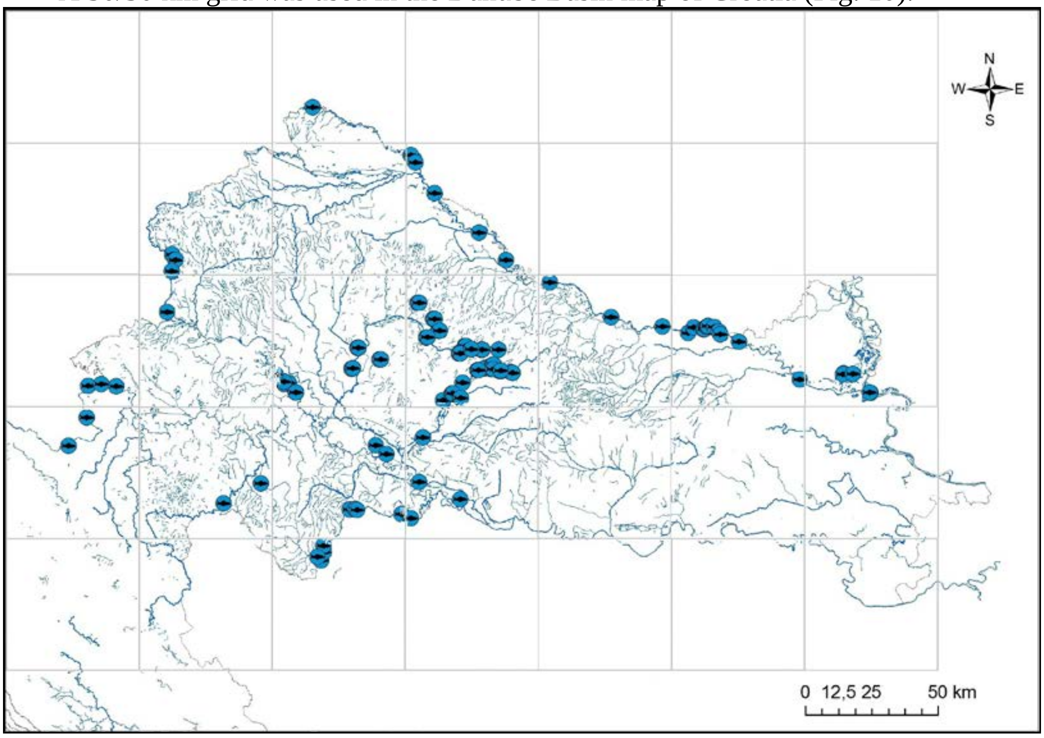

Figure 10: 50/50 km grid, used as a base for *Rhodeus sericeus amarus* monitoring areas; *Rhodeus sericeus amarus* distribution , update situation (Duplić, SNIP, 2012).

The minimum number of monitoring areas - 15, for *Rhodeus sericeus amarus* should be at least one monitoring sector in each 50/50 km plot (❋); these plots were proposed based on the previous eight selected criteria (Fig. 11).

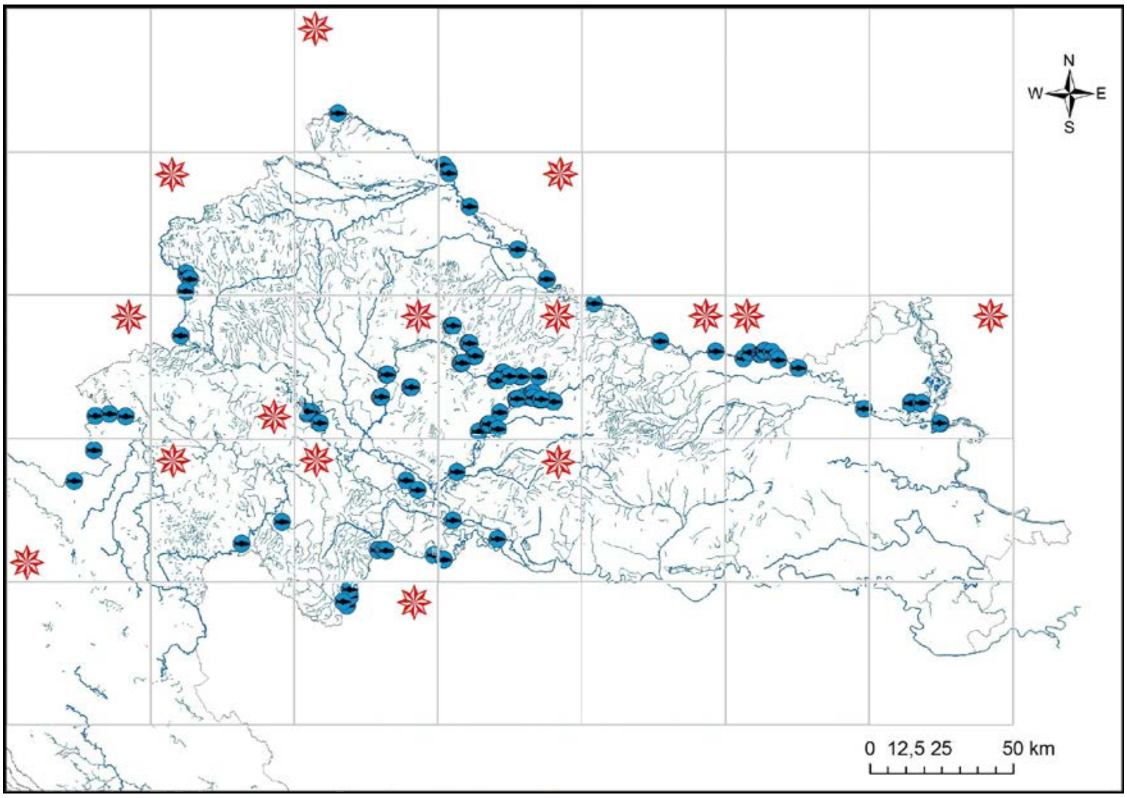

Figure 11: The minimum 15 sampling stations for *Rhodeus sericeus amarus* should be in the marked (❋) 50/50 km plots; *Rhodeus sericeus amarus* distribution, update situation (Duplić, SNIP, 2012).

The 15 minimum sampling monitoring sectors, one in every 50/50 km plots, were proposed based on the eight criteria overlapping; thus each of these 15 sampling areas correspond to as many criteria as possible, including the lowest possible effort, cost and time.

Depending on the available financial support, time and local/national working team potential, the number of the monitoring stations can be multiplied with 2, 3, 4, 5, etc., for every 50/50 km plot.

1. From the **qualitative** point of view, the presence of the *Rhodeus sericeus amarus* individuals in each of the 15 selected plots offer a first level of information in relation with its conservation status in Croatian Danube Basin, in terms of suitable habitats, future prospects, populations and range. The identification of this fish species in all selected 15 plots reveal an excellent conservation status in Croatia, in 11 plots a very good conservation status, in 10 plots a good conservation status, in nine plots a fair conservation status, in eight plots a fairly poor conservation status, in seven plots a poor conservation status, and in six plots or less a very poor conservation status.

2. The second proposed level is also a **qualitative** approach, in relation with: age structure, absence/presence of 0+ age fish individuals, absence/presence of 1+ age fish individuals, absence/presence of 2+ age fish individuals, absence/presence of 3+ age fish individuals, absence/presence of 4+ age fish individuals, absence/presence of 5+ age fish individuals. Each of the 15 proposed plots is evaluated based on the absence/presence of the proposed age classes. Any plot with all six age classes will be assessed in an excellent conservation status; five age classes present will highlight a very good conservation status, four classes reveal a good conservation status, three classes represent a fair conservation status, two classes represent a fairly poor conservation status, one class represent a poor conservation status. This approach should be made independently for each 50/50 km plot and in the end, an average for all the plots should be done, which represent the mean national conservation status.

3. The third needed level is also a **qualitative** approach, in respect of species composition; *Rhodeus sericeus amarus* presence reveal a poor conservation status; *Rhodeus sericeus amarus* + another native fish species highlight a fairly poor status of conservation; *Rhodeus sericeus amarus* + two native fish species highlight a fair conservation status; *Rhodeus sericeus amarus* + three native fish species highlight a good conservation status; *Rhodeus sericeus amarus* + four native fish species highlight a very good conservation species; *Rhodeus sericeus amarus* + five or more native fish species highlight an excellent conservation status. This specific approach should be made independently for each 50/50 km plot and finaly an average for all the plots should be done, resulting the mean national conservation status for *Rhodeus sericeus amarus*.

4. The fourth proposed level is an **integrated** approach. That is why, for every monitoring sector should be obtained results in terms of: fish biotic criteria score (45-43-excelent, 42-36-very good, 35-31-good, 30-24-fair, 23-17-fairly poor, 16-10-poor, 9-1-very poor), which reveal at quantitative level the conservation status for the *Rhodeus sericeus amarus* species population in the ichthyocenosys assessment context. This specific approach is made independently for each 50/50 km plot and in the end an average for all the plots, which means a national conservation status.

5. Finally an average among the previous four steps at the Croatian national level should be made, which is the final value for the national conservation status for *Rhodeus sericeus amarus*, as a result of the proposed monitoring activities programme.

CONCLUSIONS

The *Rhodeus sericeus amarus* monitoring sections, were selected and proposed based on the following eight criteria: ❶ Croatian national borders proximity sectors overlay; ❷ very good quality populations of *Rhodeus sericeus amarus* in terms of population density and structure (e.g. protected areas) in characteristic good habitats; ❸ habitats which need ecological reconstruction to allow this fish species populations structure ameliorate or for natural repopulation; ❹ key sectors with importance for connectivity (e.g. lotic sectors between different important sectors, rivers confluence areas, etc.); sectors influenced by human impact like: ❺ industrial pollution point sources, ❻ sectors influenced by agricultural diffuse sources of pollution, ❼ sectors influenced by habitats modifications (watercourses remodeling, watercourses regulation, etc.), ❽ geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes. All these criteria based monitoring sector selection is a relevant sum of influences which can negatively affect this fish species distribution, survival and abundance of its populations, and conservation status.

It was considered that all these proposed criteria elements can influence the future conservation status of this fish species in Croatia. The monitoring sectors selection was based on these specific criteria and the monitoring sectors were identified one by one on the maps, based on the existent fish related bibliography and data.

It should be stated the fact that the potential improvement of *Rhodeus sericeus amarus* distribution data on the Croatian territory in the future, can improve the monitoring sectors situation, the process of improving this proposed monitoring system being a flexible one.

The ecological and biological monitoring in this context cannot be replaced by the physico-chemical monitoring, not even in the monitoring sites selected for the human impact analysis; but some physico-chemical criteria of the fish species habitat quality should be included in the monitoring, if the fish monitoring sectors will overlap with the national Croatian integrated monitoring sectors in the future.

Rhodeus sericeus amarus conservation status elements

The ***future prospects*** as one of the four components of *Rhodeus sericeus amarus* conservation status are revealed using the following criteria for monitoring sector selection: national border proximity; habitats which should be ecologically reconstructed; and areas/sectors negatively influenced by human impact. Thus, also the trends regarding the human induced pressures and threats towards this species can be revealed.

The ***habitat*** of *Rhodeus sericeus amarus* is the second element of its conservation status, related to the area and quality of the suitable habitats. Thus, also the trends considering the occurrence areas of this fish species, increasing versus decreasing areas situations, increasing versus decreasing habitat quality situations can be revealed. For these aims, monitoring sectors criteria based on selection was done, including the following criteria: Croatian national borders proximity sectors overlay; very good quality populations of *Rhodeus sericeus amarus* in terms of population density and structure (e.g. protected areas) in characteristic good habitats; habitats which need ecological reconstruction to allow this fish species populations structure ameliorate or natural repopulation; key sectors with importance for connectivity (e.g. lotic sectors between different important sectors, rivers confluence areas, etc.); sectors influenced by human impact like: industrial pollution point sources, sectors influenced by agricultural diffuse sources of pollution, sectors influenced by habitat modifications (watercourses remodeling, watercourses regulation, etc.), geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes. In this context also the following metrics were proposed: I absence/presence; II age structure, absence/presence of 0+ age individuals, absence/presence of 1+ age individuals, absence/presence of 2+ age individuals, absence/presence of 3+ age individuals, absence/presence of 4+ age individuals, absence/presence of 5+ age individuals; III species composition; IV relative abundance.

The ***population*** is the third element of the conservation status for *Rhodeus sericeus amarus*. It is evaluated based on population size and structure in terms of age structure and reproduction. To cover this element, namely the favorable reference populations which are considered as appropriate to ensure the long-term viability of *Rhodeus sericeus amarus*, some metrics were proposed: I absence/presence; II age structure, absence/presence of 0+ age individuals, absence/presence of 1+ age individuals, absence/presence of 2+ age individuals, absence/presence of 3+ age individuals, absence/presence of 4+ age individuals, absence/presence of 5+ age individuals; II species composition; IV relative abundance in the local ichthyofauna.

The fourth component of *Rhodeus sericeus amarus* conservation status is the ***range***, which correspond to the spatial limits within which this fish species occurs. The trend of this species range increasing or decreasing can be revealed based on some criteria, which were proposed for the choice of some monitoring sectors: Croatian borders proximity sectors coverage; sectors with significant importance for fish populations connectivity; geographically extreme monitoring sections in the downstream-most and upstream-most sectors of rivers, in this fish species range and in the near outer proximities of these extremes.

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SELECTED REFERENCE

1. Baptist M. J., 2006 – Flood detention, nature development and water quality along the lowland river Sava, Croatia, *Hydrobiologia*, 565, 243-257.
2. Bačani A., Posavec K., Vlahović T. and Tucak-Zorić S., 2011 – The influence of the river dam TE-TO on the groundwater levels of Zagreb aquifer, Balint G. and Domonkos M. (eds), XXVth Conference of Danubian countries on the hydrological forecasting and hydrological bases of water management.
3. Bănăduc D. and Bănăduc A., 2002 – A Biotic Integrity Index adaptation for Carpathian River assessment, *Acta oecologica* IX, 1-2, 77-95.
4. Bănărescu P. M. and Bănăduc D., 2007 – Habitats Directive (92/43EEC) fish species (Osteichthyes) on the Romanian territory, *Acta Ichtiologica Romanica*, II, 2007, 43-78.
5. Bonacci O. and Oskorus D., 2008 – The influence of three Croatian hydroelectric power plants operation on the river Drava hydrological and sediment regime, 24th Conference of the Danube Countries on the Hydrological Forecasting and Hydrological Bases of Water Management.
6. Bošnir J., Puntarić D., Smit Z., Klarić M., Grgić M. and Kosanović L. M., 2007 – Organochlorine pesticides in freshwater fish from the Zagreb area, *Arhiv za Higijenu Rada i Toksikologiju*, 58, 2, 187-193, ISSN 0004-1254, Zagreb Public Health Institute, Zagreb, Croatia, *Archives of Industrial Hygiene and Toxicology*, 07/2007, 58, 2, 187-93.
7. Budihna N., 1984 – Ihtioloske raziskave reke Sava od prerade HE Moste do Krasnic, *Ichtyos*, 1, 18-25. (in Croatian)
8. Ćaleta M., Mustafić P., Mrakovčić M. and Marčić Z., 2009 – Studija inventarizacije ihtiofaune donjeg toka rijeke Une, PMF Zagreb. (in Croatian)
9. Current Practices in Monitoring and Assessment of Rivers and Lakes, 1996.
10. Dragun Z., Kapetanović D., Raspor B. and Teskeredzic E., 2011 – Water quality of medium size watercourse under baseflow conditions: the case study of river Sutla, *Ambio*, 40, 4, 391-407.
11. Dumbović V., Posavec V., Duplić A., Katušić L., Jelić D., Boršić I. and Partl A., 2009 – Studija inventarizacije flore i faune rijeke Une i priobalnog pojasa, Sisak: Sisačko-moslavačka županija. (in Croatian)
12. Fact sheet (Croatian Natura 2000 sites designation process) for Rhodeus sericeus amarus.
13. Fausch K. D. and Schrader L. H., 1987 – Use of index of biotic integrity to avaluate the effects of habitat, flow, and water quality on fish assemblages in three Colorado Front Range streams – Colorado Division and the Cities of Forth Collins, Loveland, Greelez, Longmont and Windsor, department of Fisheries and Wildlife Biologz, Colorado State Universitz, Fort Colins, Colorado.
14. Fausch K. D., Karr J. R. and Yant P. R., 1984 – Regional application of an index of biotic integrity based on stream fish communities, *Transactions of the American Fisheries Society*, 113, 39-55.
15. Frančišković-Bilinski S., Bilinski H. and Širac S., 2005 – Organic pollutants in stream sediments of Kupa River drainage basin, *Fresenius Environmental Bulletin*, 14, 4, 282-290.
16. Gvozdic V., Brana J., Puntaric D., Vidosavljevicl D. and Roland D., 2011 – Changes in the lower Drava River water quality parameters over 24 years, *Arh Hig Rada Toksikol*, 62, 325-333.
17. Habeković D., Mrakovčić M. I. and Bogdan M., 1986 – Ichtiofauna dijela rejeke Drave nakon izgradnje sustava HE Čakovec, *Ribarstvo Jugoslavje*, 4, 57-61. (in Croatian)
18. Inventory of Agricultural Pesticide Use in the Danube River Basin Countries, Annex 1.
19. ISRBC, 2009 – Sava River Basin Analysis Report, Secretariat of the ISRBC, Zagreb.
20. ISCDR, 2009 – Danube River Basin District: Urban Wastewater Discharges – Baseline Scenario - UWWT 2015, Vienna.
21. Karr J. R., 1981 – Assessment of biotic integrity using fish assemblages, *Fisheries*, 6, 21-27.
22. Karr J. R. and Dudley D. R., 1981 – Ecological perspective on water qualitz goals, *Environment Management*, 5, 55-68.

23. Karr J. R., Fausch K. D., Angermeier P. L., Yant P. R. and Schlosser I. J., 1986 – Assessing Biological Integrity in Running Waters A Method and Its Rationale, Illinois Natural Historz Survey, Special Publication, 5 September 1986, 1-20.
24. Mrakovčić M., Ćaleta M., Mustafić P., Marčić Z. and Zanella D., 2010 – Značajke ihtiofaune rijeke Sutle, PMF Zagreb. (in Croatian)
25. Mrakovčić M., Brigić A., Buj I., Ćaleta M., Mustafić P. and Zanella D., 2006 – Red Book of Freshwater Fish of Croatia/Cravena Knjiga Slatkovodnih Riba Hrvatske.
26. Mrakovčić M., Kerovec M., Mišetić S., Schneider D., Tomaskovic N. and Šurmanović D., 1996 – Ichthyofauna of Drava River, *Internationale Arbeitsgemeinschaft Donauforshung*, 1, 345-348.
27. Mrakovčić M., Mustafić P., Ćaleta M., Zanella D., Buj I. and Marčić Z., 2008 – Ihtiološka raznolikost rijeke Mure, PMF Zagreb. (in Croatian)
28. Mrakovčić M., Ćaleta M., Mustafić P., Marčić Z., Zanella D. and Buj I., 2010 – *Barbus balcanicus* iz Slatkovodne ribe, Izvješće za potrebe izrade prijedloga potencijalnih NATURA 2000 područja, PMF Zagreb. (in Croatian)
29. National Study - Croatia, 2010 – Transnational Strategy for the Sustainable Territorial International Commission for the Protection of the Danube River, Danube Facts and Figures.
30. Picer M., Perkov S. and Picer S., 1995 – Contamination of Bela Krajna, Slovenia with polychlorinated byphenyls, 1, Levels of some high molecular chlorinated hydrocarbons in the water and fish of the Kupa River in Croatia, *Water, Air and Soil Pollution*, 82, 3-4, 559-581.
31. Popović I., 2008 – Implementation of the Water Framework Directive and Urban Waste Water Treatment Directive in Croatia – Investments, operation-maintenance, adaptation.
32. Povz M. and Sket B., 1990 – Naše slatkovodne ribe, Založba Mladinska knjiga. (in Croatian)
33. Schwarz U. and Bloesch J., 2004 – GIS-supported mitigation of the impact of hydropower dams on the flood plains of the Drava-Mura rivers in Croatia/Hungary.
34. Šmit Z., Drevenkar V. and Kordić-Šmit M., 1987 – Polychlorinated biphenyls in the Kupa River, Croatia, *Chemosphere*, 16, 2351-2358.
35. Teskeredžić E. Z., Teskeredžić M., Tomec B., Kurtović B., Raspor D., Kapetanović D., Dragun I., Vardić D., Valić Z., Strizzak B., Španović Z., Šoštarić V. and Roman Z., 2009 – Programme for the monitoring of the freshwater fishery status in 2009 - Group D - Fishing area Sava, Sutla.
36. Vidaček Ž., Bogunović M., Sraka M. and Husnjak S., 1998 – Triazine herbicides in drained soils and water in the part of river Drava catchement area, in Abstracts 16th World Congress of Soil Science, Montpellier, France, CD, 1-8.
37. Znaor D., Pretty J., Morrison J. and Todorović S. K., 2005 – Environmental and macroeconomic impact assessment of different development scenarios to organic and low-input farming in Croatia, University of Essex.